OULU 2009
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ACTA UNIVERSITATIS OULUENSIS

Seppo Saari

KNOWLEDGE TRANSFER TO PRODUCT DEVELOPMENT PROCESSES

A MULTIPLE CASE STUDY IN TWO SMALL TECHNOLOGY PARKS

FACULTY OF TECHNOLOGY,
DEPARTMENT OF INDUSTRIAL ENGINEERING AND MANAGEMENT,
UNIVERSITY OF OULU

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Academic dissertation to be presented, with the assent of the Faculty of Technology of the University of Oulu, for public defence in Raahensali (Auditorium L10), Linnanmaa, on March 20th, 2009, at 12 noon

OULUN YLIOPISTO, OULU 2009

Acta Univ. Oul. C 319, 2009

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ISBN 978-951-42-9058-9 (Paperback)
ISBN 978-951-42-9059-6 (PDF)
http://herkules.oulu.fi/isbn9789514290596/
ISSN 0355-3213 (Printed)
ISSN 1796-2226 (Online)
http://herkules.oulu.fi/issn03553213/

Cover design
Raimo Ahonen

OULU UNIVERSITY PRESS
OULU 2009

Saari, Seppo, Knowledge transfer to product development processes. A multiple case study in two small technology parks
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Acta Univ. Oul. C 319, 2009
Oulu, Finland

Abstract

One of the roles of Technology Parks is to stimulate and manage knowledge transfer. Studies have been conducted on large Technology Parks, but studies on small ones are rare. However, small Technology Parks are of interest as innovation promoters, and thus regional developers.

This study explores how knowledge is transferred to the product development processes of firms, and how the local innovation system influences the transfer. First the existing research is examined to understand what kind of factors affect knowledge transfer in the product development processes of firms from and through a local innovation system with incomplete services. The framework resulting from the study consists of innovation enabler analyses, and process analyses. The enablers are the Technology Park and local innovation systems, and social capital. The processes are the product development processes, and interorganisational networking.

Furthermore, an empirical study was conducted on how knowledge is transferred in the product development processes of firms in two Technology Parks namely, Digipolis in Kemi in the North of Finland and Electropolis in Kalix in the North of Sweden.

A qualitative embedded multiple case study was chosen as the research approach. The study consists of two levels: the product development processes of the firms, the Technology Parks as single cases and cross case analyses; and the. The latter were based on one single case, a cross case within each Technology Park, and a cross-Technology Park cross case levels.

The results indicate that the characteristics of the firms have a higher influence on knowledge transfer processes than the local innovation systems, and higher education combined with an attraction strategy draws subsidiaries with minimal local links and knowledge transfer. Strong ties within local social networks favour knowledge transfer, but they have to be fostered.

Keywords: innovation systems, knowledge transfer, product development processes, Technology Park

Saari, Seppo, Tietämyksen siirto tuotekehitysprosesseihin. Monitapaustutkimus pienissä teknologiakylissä
Teknillinen tiedekunta, Tuotantotalouden osasto, Oulun yliopisto, PL 4610, 90014 Oulun yliopisto
Acta Univ. Oul. C 319, 2009
Oulu

Tiivistelmä

Yksi teknologiakylien tehtävistä on stimuloida ja hallita tietämyksen siirtoa. Suurten teknologiakylien osalta tutkimuksia on tehty, mutta pienistä hyvin vähän. Niillä on merkitystä innovaatioiden edistäjinä ja siten ne ovat aluekehittäjiä.

Tämä tutkimus selvittää, miten tietämystä siirretään yritysten tuotekehitysprosesseihin ja, miten paikallinen innovaatiojärjestelmä vaikuttaa siirtoon. Ensin tarkastellaan aiempaa tutkimusta tavoitteena luoda ymmärrys, mitkä tekijät vaikuttavat tietämyksen ohjautumiseen yritysten tuotekehitysprosesseihin paikallisesta heikommin resursoidusta innovaatiojärjestelmät. Johdettu viitekehys sisältää innovaation mahdollistajien ja prosessien analyysin. Mahdollistajia ovat teknologiakylä ja paikallinen innovaatiojärjestelmä sekä sosiaalinen pääoma. Prosessit ovat tuotekehitysprosessi ja organisaatioiden välinen verkottumisprosessi.

Seuraavaksi suoritettiin kokeellinen tutkimus siitä, miten tietämys siirretään tuotekehitysprosesseihin kahdessa teknologiakylässä: Digipoliksessa Kemissä Pohjois-Suomessa ja Elektropoliksessa Kalixissa Pohjois-Ruotsissa.

Tutkimusmenetelmäksi valittiin laadullinen tapaustutkimus. Siinä on kaksi tasoa: teknologiakylät tapauksittain ja tapauksien välillä analysoituna sekä yritysten tuotekehitysprosessit, jotka analysoitiin tapauksittain, tapausten kesken teknologiakylittäin ja tapausten kesken teknologiakylien kesken.

Tulokset ehdottavat, että yritystyyppi vaikuttaa tietämyksen siirtoon enemmän kuin paikallinen innovaatiojärjestelmä. Korkea-asteen koulutus yhdistettynä atraktiostrategiaan houkuttaa teknologiakylään sivutoimipisteitä, jotka toteuttavat hyvin vähän paikallisia yhteyksiä ja tietämyksen siirtoa. Vahvat siteet paikallisissa sosiaalisissa verkostoissa edistävät tietämyksen siirtoa, mutta verkostoja tulee ylläpitää.

Asiasanat: innovaatiojärjestelmä, teknologiakylä, tietämyksen siirto, tuotekehitysprosessi

Preface

I started my doctoral studies already in the 1990s but lack of time – among other things – delayed starting the research for the doctoral thesis. I got a second chance to start it in the year 2006 in a joint project between Luleå Technical University, the University of Oulu and Kemi-Tornio University of Applied Sciences.

I first wish to thank my supervisors, Professor Pekka Kess and Professor Harri Haapasalo for their guidance and encouragement during the work from the planning phase to finalising the thesis. I have learned a lot from them about conducting scientific research.

Professor Vesa Harmaakorpi from the Lahti Centre of the Technical University of Lappeenranta, and Professor Päivi Oinas from the Turku Business School were my official pre-examiners. I would like to thank them for their constructive feedback on my work.

I also thank Ms Hilary Keller for checking the English in my text and transforming my English language into a more sophisticated level.

I would like to thank the interviewees in the various firms in Kalix in the North of Sweden and in Kemi in the North of Finland for allowing me to use their valuable time, and giving me deep, confidential and thorough material which forms the base of my study. Without this data I would not have been able to prepare my thesis, and I hope to contribute further to the external processes that support firms' product development.

As mentioned before, the research was conducted in a joint project between three universities, and a parallel study was conducted simultaneously by the entrepreneurship research team at Luleå Technical University. I am grateful to Professor Håkan Ylinenpää and Mr. Joakim Vincent, Senior Researcher, for their advice and encouragement. I also thank my fellow researcher in the project Ms. Sara Thorgrén, Ph.D. student, for her cooperation and joint work.

Without the possibility to use part of my normal working hours from August 2006 to December 2007, I would not have had the possibility to conduct the research needed for this thesis. This was enabled by the project InnoCentra (Forskning av innovationsmiljöer som stöd för vidareutveckling av teknologicentra, i.e. study on innovative milieus to support further development of technology centres) that was partially financed by the Interreg IIIA North programme of the European Union. The other financers were Kemin Digipolis Oy and Kemi-Tornio University of Applied Sciences. I greatly appreciate all of their input, and I hope that the results of the study as well as the knowledge and capabilities I have identified during the process will justify their contribution.

While conducting my study I belonged to a local research team of Ph.D. students. To enable peer support, as well as support from senior researchers, we organised a study group with monthly meetings, and some courses and seminars in Kemi. On behalf of all the participants I would like to thank the financial support from the Provincial Government of Lapland using both national funding and the European Social Funds of the European Union, Kemin Digipolis Oy, and Kemi-Tornio University of Applied Sciences. Special thanks belong to professor Pekka Kess who mentored us in our monthly meetings on the last Wednesday evening of every month except July during several years. I would like to thank also my fellow students from several disciplines who could thus give feedback from very diverse points of view. The group still meets regularly even though without an external mentor. The most active participants are Ms. Seija Parviainen, in health care, Ms. Aino Bergman, in law, Ms. Soili Mäkimurto-Koivumaa, in business economics, and Mr. Eero Sirén, in theatre. I thank each of my fellow students for the support I have received, and I hope to be able to return the support while they prepare their theses.

I want to thank my parents who in the 1960s sent me to grammar school and thus laid the first stepping stones leading to this thesis over 40 years later. I would also like to thank my wife Maija-Liisa for her support and understanding during the process, as well as my daughters nowadays studying at the same faculty of the University of Oulu.

Kemi, February 2009 Seppo Saari

Abbreviations

ASIC	Application Specific Integrated Circuit
ARA	Actors-Resources-Activities model
CWC	Center for Wireless Communication
DFM	Design for Manufacturing
DSP	Digital Signal Processing
EMC	Electromagnetic Compatibility
ERDF	European Regional Development Fund
ERIS	Entrepreneurial Regional Innovation System
ESF	European Social Fund
EU	European Union
HEI	Higher Education Institution
HW	Hard Ware
IASP	International Association of Science Parks
ICT	Information and Communication Technology
IPR	Immaterial Property Rights
IRIS	Institutional Regional Innovation System
IT	Information Technology
IUC	Industrial development centre
KIBS	Knowledge Intensive Business Services
K-TUAS	Kemi-Tornio University of applied sciences
LTU	Luleå University of Technology
M-LI	Meri-Lappi Institute
NEO	Northern Enterprise Operations project
NIS	National Innovation System
OECD	Organisation for Economic Cooperation and Development
OEM	Original Equipment Manufacturer
R&D	Research and Development
SCM	Supply Chain Management
SECI	Socialisation–Externalisation–Combination–Internalisation
SITRA	Finnish Innovation Fund
SME	Small and Medium Size Enterprise
SW	Soft Ware
TEKES	Finnish Funding Agency for Technology and Innovations
UAS	University of Applied Sciences
UK	United Kingdom

UO	University of Oulu
USA	United States of America
VTT	Technical Research Centre of Finland

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1 Introduction

1.1 Background

The aim of this study is to examine and create knowledge on the functionality of small Technology Parks in remote locations – how they can support firms in their product development by creating conditions for knowledge transfer.

The International Association of Science Parks defines a Science Park as follows:

> A Science Park is an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a Science Park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities. (IASP 2002.)

The first Science Parks were founded in the 1950s, and Stanford Research Park founded in the year 1951 is mentioned as the first one (Stanford Management Company 2007). In the following decades a large number of technology, science, and research parks were founded in the United States and in Western Europe (Zhang 2005: 1338–139). In the 1980s and early 1990s many Technology Parks started in Finland and Sweden, also in the northern parts of the countries, including Oulu in Finland and Luleå in Sweden. Smaller towns also took up the trend, e.g. Kemi in Finland and Kalix in Sweden. In all of the cases the goal is, as the definition emphasises, to create wealth for its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. In other words, Technology Parks have been founded to improve innovation systems.

Innovation system theories vary from exact system descriptions (Fagerberg *et al* 2005, Feldman & Massard 2002) to dynamic models such as the Triple-Helix (Etzkowitz & Leydesdorf 2000). Whatever model is used to describe the system, innovation and innovation systems are phenomena that the authorities count on. For example the European Commission has defined a strategy of how to build a more competitive Europe by developing the innovation system (European

Commission 2005), and SITRA (the Finnish Innovation Fund) has formulated a similar strategy for Finland (SITRA 2005).

The theories cover also various geographic areas. The original application area, the national innovation systems, has been studied extensively (Lundvall 1998, 1999, Lundvall *et al* 2002, Edquist & Hommen 1999). Some scholars (Cooke 2004, Feldman 2002) argue that the regional dimension must be taken into consideration e.g. because of the proximity point of view, and they have started to use the regional innovation system model. Today the literature on the regional innovation systems is more extensive than on the national innovation systems. Malerba argues that there are differences between sectors, and presents a methodology for analysis and comparison of sectors; the framework of sectoral innovations systems. (Malerba 2001, 2005.)

Leydesdorff and Etzkowitz contend that – instead of the linear innovation model – a spiral model of innovation, especially in terms of university-industry-government relations, is required to capture the evolution of multiple linkages at different stages of the capitalisation of knowledge. The three institutional spheres (public, private, and academic) are increasingly working together, with a spiral pattern of linkages emerging at various stages of the innovation process, to form a "triple helix." (Leydesdorff & Etzkowitz, 1998.)

There are several types of innovation processes in a firm. The goals relate to e.g. the development of products, production, business processes, or a supply chain. The activities are usually conducted as projects to make them easier to manage. Some of the processes and projects are conducted by a firm alone but often external resources are used to complete a whole project, some specific stages, some specific tasks, or to transfer special knowledge into the firm. This study explores knowledge transfer to product development processes. The process itself can be described by several different models (O'Sullivan 2002, O'Sullivan 2003, Ulrich & Eppinger 2003, Cooper 2006a).

Collaboration in networks occurs on several levels: informally between individual persons; informally between managers and employees in firms; and in formal relationships between organisations including firms, municipalities, universities, etc. (Powell & Grodal 2005, Sprenger 2001). Connections and links between people form the basis for networking (Granowetter 1973, Powell *et al* 2004). One way to develop networks is to utilise social capital, and take actions that help to build social capital over the boundaries of an organisation (Müller-Prothmann *et al* 2005). In this study local social capital – especially bonding – is expected to enable networking for acquiring knowledge.

Moreover, interorganisational networking occurs on several levels (Ritter *et al* 2004): as a dyad relationship in a relationship between two organisations; as a portfolio relationship where one organisation has links to several other organisations; as a connected relationship where an organisation has links to several others who have further relations to other organisation; and as a networked relationship where the relations between other organisations and their effect on the organisation are focused.

Successful product development depends on the individual and collective expertise of employees (Leonard & Sensiper 1998). Teece (1998) claims that new products are more often merely components of broader systems or architectures. Another, even broader view, is introduced by Moore (2002) as his whole product concept enlarges the view of what is a product. Both the authors reflect on the need for partners and allies because the complexity of products makes it difficult for one firm to master all the knowledge. External sources of knowledge are often critical to the product development process, regardless of the organisational level where the innovating unit is located (Cohen & Lewinthal 1990).

Several knowledge transfer mechanisms between organisations have been described and studied in the literature. The transfer may occur on the individual, the group, or the organisational level. The mechanisms include training, observing the performance of experts, and providing opportunities for communication. Documents, blue prints, and the transfer of experienced personnel are additional mechanisms. Since some of the knowledge is embedded in the hardware, software, and products, providing those to recipient organisation facilitates the knowledge transfer. As a summary, knowledge can be transferred by moving people, technology, or structure to the organisation, or by modifying people (e.g. training), technology, and the structure of the recipient organisation. (Argote 1999.)

One of the main reasons why Technology Parks have been founded is to improve the innovation system to better support firms product development processes. In this thesis the goal is to study the knowledge transfer processes tothe product development processes of firms especially in small Technology Parks, and the innovation systems of which they are part.

1.2 The research problem and questions

Complex products, with several technologies and subsystems, lead to a situation where new knowledge has to be transferred to a firm in one or more forms: knowledge leading to learning processes; interorganisational collaboration in conducting product development processes; recruitment of new specialists; or transferring knowledge in the form of subsystems. Geographical proximity is often argued to be of importance in this type of collaboration (see e.g. Breschi & Malerba 2005, Cooke 2004, Feldman 2002). Social networks are one reason for this (e.g. Landry *et al* 2001, Owen-Smith & Powell 2004).

There is lack of research on knowledge transfer in small Technology Parks. Knowledge transfer to the product development processes of firms has mainly been studied either from the innovation system point of view, or on the firm level without reference to the milieu (Frishammar 2005).

This study focuses on how and from where the knowledge is transferred to the product development processes of firms in small Technology Parks with limited resources and services, and what is the influence of the local innovation system with its limitations. The main goal of these thesis is to create an understanding of the functionality of the small Technology Parks, and of the knowledge transfer processes inside them.

> *Research question 1: What kind of factors affect knowledge transfer from and through a local innovation system with incomplete services tothe product development processes of firms?*

The first research question is divided into four sub/questions. The two first ones seek answers to the questions on the enabling factors, the third one on the knowledge needs, and the last one on the knowledge transfer processes.

> *Sub-question 1:What is the role of innovation systems in enabling knowledge transfer tothe product development processes of firms in small Technology Parks?*

> *Sub-question 2: What is the role of social capital in enabling knowledge transfer tothe product development processes of firms in small Technology Parks?*

> *Sub-question 3: What kind of knowledge is needed in the various phases of product development processes in firms in small Technology Parks?*

> *Sub-question 4: How does interorganisational networking function in knowledge transfer to the product development processes of firms in small Technology Parks?*

The second research question searches the answer on how knowledge is transferred in practice. It is based on the analysis of empirical data, and the analysis framework defined in the answer of the first research question.

Research question 2: How is knowledge transferred in and through the local innovation system tothe product development processes in firms in small Technology Parks?

The question has two purposes. The first one is to find out how firms in small Technology Parks acquire the knowledge they need in their product development processes. The results can be utilised to develop further the activities in the Technology Parks. The second purpose is to test the analysis framework. The result will show whether the framework – based on the literature – is valid and useful in reality.

1.3 The research approach and method

According to Esterberg (2002), after choosing the research topic and framing the research question a research strategy has to be developed. For this, she recommends the use of the following questions:

- How will you gather the data?
- What kind of population or setting will you study?
- Will you use in-depth interviews, or do an observational study, or work with "texts"?
- How will you begin to analyse and make sense of the data you have collected?

According to Yin (2003) each strategy has peculiar advantages and disadvantages depending on the type of research question, the control an investigator has over actual events, and the focus on contemporary as opposed to historical phenomena. In qualitative research like this, the most obvious alternative strategies are grounded theory, action research, and case study (Järvinen & Järvinen 2004, Esterberg 2002, Yin 2003). According to Yin (2003) a case study is the preferred strategy when the research questions are in the "how" or "why" form, when the researcher has little control over the event , and when the focus is on a contemporary phenomenon within some real-life context. All these conditions match what Yin (2003) defines as favourable conditions for choosing a case study as the research strategy. Eisenhardt's (1989) process of inducting theory using case studies was chosen as the method in this study.

This consisted of building a theoretical framework – based on existing literature – to form the base of the study design and analysis. The data were collected with multiple methods applied in case studies. Then, the analysis was conducted inductively using divergent techniques.

In this study, the second research question asks how the knowledge is transferred to firms' product development processes in small Technology Parks with limited services. The processes are conducted by the firms in the Technology Parks and the investigator has no or very limited control over them, and they have been going on recently or are still going on. From an epistemological point of view, this means that the data are not perfect and there is some uncertainty, and the reality may change over time. Most of the data have been collected in interaction between the researcher and persons participating in the product development processes. Ontologically, as well as epistemologically, the approach is close to critical theory and constructivism (Metsämuuronen 2000).

1.4 Scope and limitations

The scope of this study is the functionality of small Technology Parks with limited services in remote locations. In the context of this study a small Technology Park is a Technology Park with less than 50 firms and 500 jobs. Limited services means the lack of knowledge based institutions, such as research universities. Remote location means in the chosen cases that the towns have less than 25 000 inhabitants, and the surrounding regions less than 70 000. The distance to larger towns with research universities is between 50 to 100 km.

One of the main purposes for the existence of a Technology Park is to promote innovation and competitiveness of its associated businesses and knowledge-based institutions, and to stimulate and manage the flow of knowledge and technology (IASP 2002). Product development is essential to most firms and the functionality of knowledge transfer to firms' product development processes is an important measure of the functionality of a Technology Park. The unit of analysis is the product development process, and the analysed phenomena are the knowledge transfer processes tothe product development processes of firms in small Technology Parks.

The Technology Parks are studied as parts of the local innovation systems. While the focus is on knowledge transfer, the innovation systems are studied with the focus on knowledge related activities. From the perspective of the whole system, important, actors such as financers and venture capital organisations (Etzkowitz 2002, Cooke 2004) are not within the scope of the study.

According to the literature review, social networks enable interaction and networking. This does not mean that the relationships should be at the level they are in a family but to some degree personal level relationships create trust and thus enable the transfer of even tacit knowledge. Social capital is a component of an innovation system and is given a separate chapter in this thesis for clarity. In networking for knowledge transfer the analysed factors are social networks, brokerage, ties, links, and the level of and activation of social capital. Norms, sanctions etc. are important for social capital research but they are outside the scope of this study. (Powell *et al* 2004, Sprenger 2001, Granowetter 1973.)

In the product development processes, the focus is on subjects that illustrate the knowledge needs in various phases of the process. The scope is limited to studying the process phases, knowledge needs in the phases, and from where the knowledge is transferred. Other innovation processes, enlarged models such as the whole product concept, and an open innovation model are outside the scope of this thesis. (O'Sullivan 2002, O'Sullivan 2003, Ulrich & Eppinger 2003, Cooper 2006, Moore 2002.)

While networking is discussed, the focus is limited to dyad, one-to-one, relationships and portfolio, one-to-many relationships. The interest is in trust and adaptation with other actors both on local and other geographical levels. Indirect and networked relations have been excluded because the identification of their characteristics is not essential in a knowledge transfer study. Relations to organisations that are not important for knowledge transfer to product development process have also been left out of this study. (Ritter *et al* 2004, Lambert *et al* 2006, Ford & Håkansson 2006, Håkansson & Snehota 1995.)

External knowledge transfer to the products development process is the main focus of this study. Therefore, the studied phenomena include knowledge types, absorptive capacity, transfer mechanisms, knowledge sources, brokerage, and, from the process point of view, indirect knowledge transfer. Internal knowledge transfer and management are not included in this study. Organisational learning is a result of knowledge transfer, but it is excluded from this study because its time dependency and dynamics would need a different type of data collection. (Nonaka & Konno 1998, Cohen & Lewinthal 1990, Nieminen 2005, von Hippel 1988a, Argote 1999, Lubit 2001.)

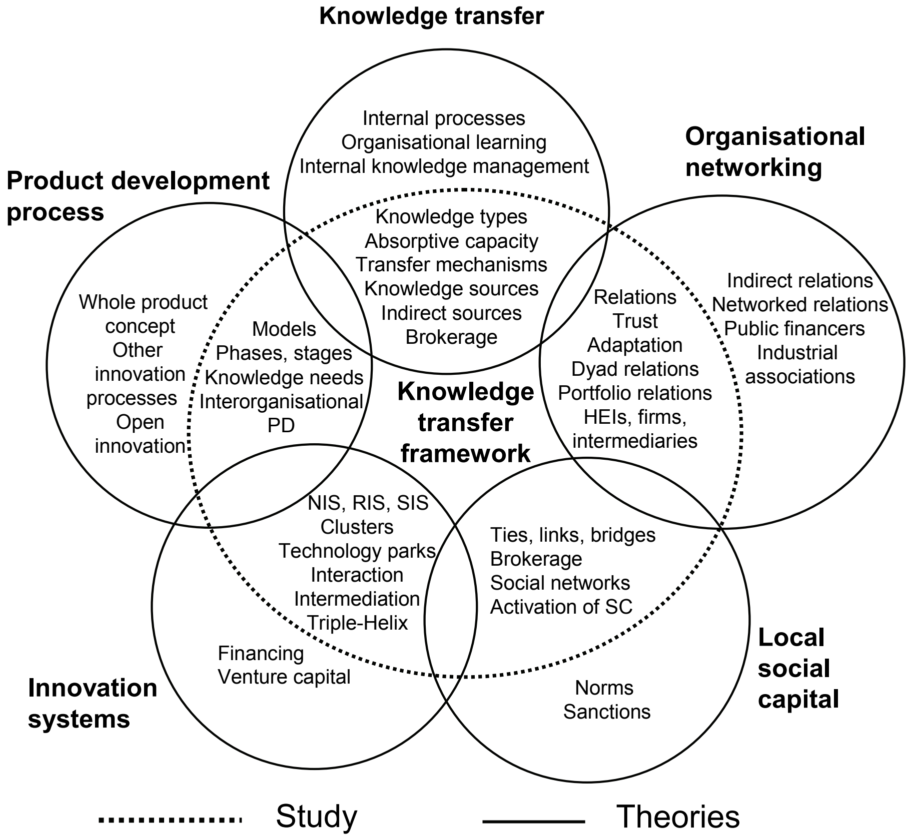


Fig. 1. The topics included and excluded in the framework of analysis.

1.5 The structure of the thesis

The study consists of six chapters. The first chapter introduces the background to the research topic and presents the research problem, questions, approach, methods, and describes the scope and limitations. The second chapter presents the theoretical foundations for knowledge transfer to product development processes. The chapter summarises the implications from the theory and provides the answers to the first research question; and its sub-questions. The third chapter is a detailed description of the research approach, methodology, and how the study was carried out. The fourth chapter is a description of the empirical cases. Chapter five consists of the analyses and results, and provides the answer to the secondary research questions. Chapter six sets out the theoretical and empirical contribution, theoretical and managerial implications, evaluation, suggestions for further research, and a summary.

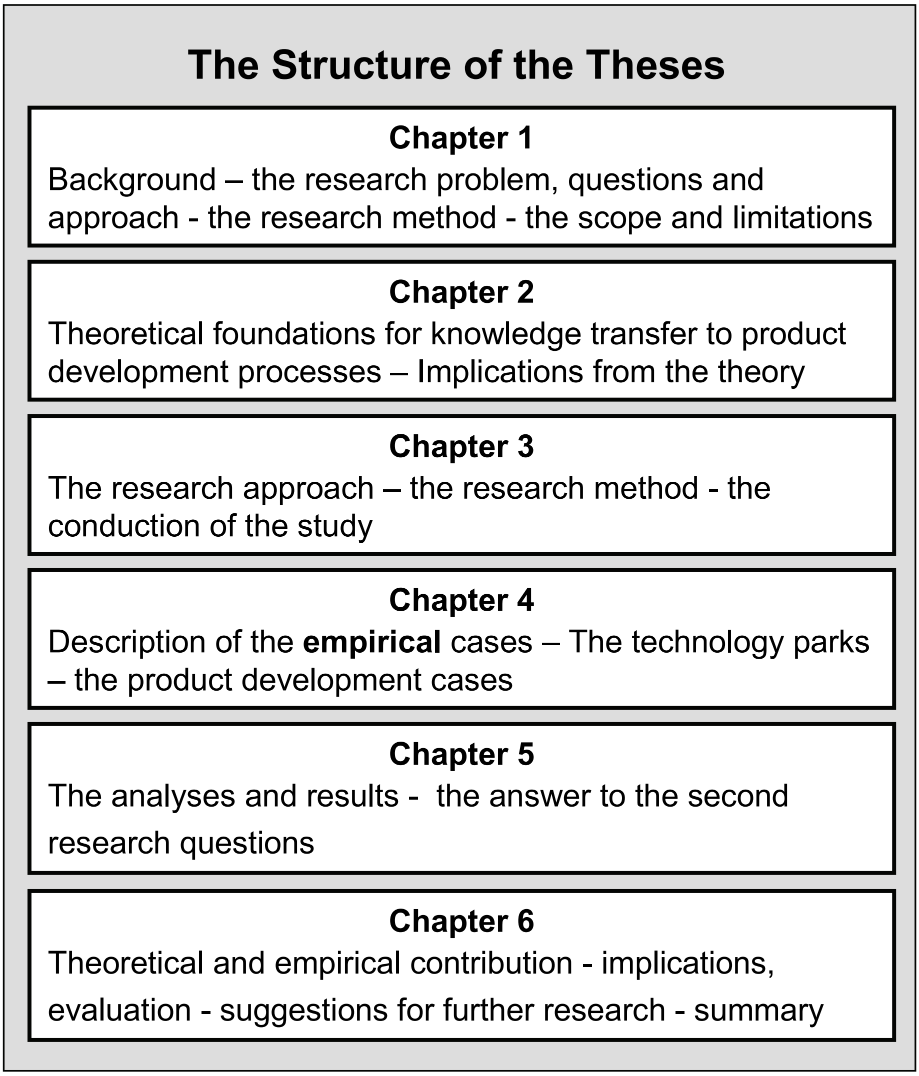


Fig. 2. The structure of the thesis.

2 The theoretical foundation for knowledge transfer to product development processes

2.1 Framework for theoretical construct

The innovation system in which a firm operates influences how and from where it finds the knowledge it needs in its product development processes. The social capital and social networks affect how the organisational networks are formed and how they function. This study explores the knowledge transfer to product development processes in firms in small Technology Parks with incomplete services.

The first enabler is the local innovation system including the Technology Park, actors and structures, regional and national links, and connections to sectoral innovation systems. The second enabler is the local social capital with its links and bridges to other locations with the focus on interpersonal networking. The product development processes determine what type of knowledge is needed in each of the project phases. The knowledge needed in the process phases is transferred to the process through inter-organisational networks. The knowledge transfer is the summation of the four factors. Fig. 3 illustrates the theoretical framework.

The structure of this chapter follows the theoretical framework. Section 2.2 *Innovation systems* reviews the innovation system and cluster theories and research. The literature on Technology Parks is also summarised. Section 2.3 *Social capital* reviews the theories and research on social capital. In Section 2.4 *Innovation and product development processes*, the innovation processes and research on knowledge transfer to them are examined with a product development process view. Innovation systems, social capital, and product development process are the base for organisational networking for knowledge transfer that is reviewed in the Section 2.5. *Organisational networks*. In the Section 2.6. *Knowledge transfer and management* theories on knowledge, knowledge transfer, and knowledge management are reviewed. Finally Section 2.7. *Implications from the theory* presents the detailed theoretical framework to analyse the knowledge transfer processes in small Technology Parks.

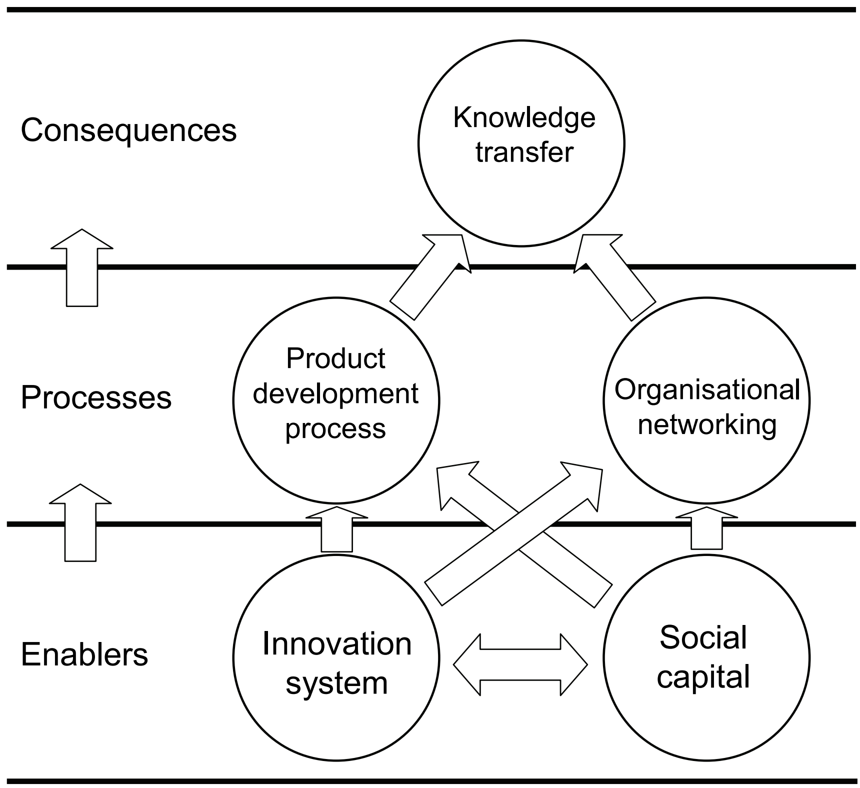


Fig. 3. The phases of the research framework.

2.2 Innovation systems

The innovation system approach is of particular interest in order to answer the research questions of this study. Alfred Marshall launched the term industrial district to describe the "thickly populated" industrial towns in England with several firms located there (Marshall 1920). Some of the main features of a Marshallian industrial district are the domination of small locally owned businesses, intra-district trade, local decision making, local co-operation between firms and the existence of "patent capital" within the district. Economists have later used the word for a variety of different types of industrial regions. The most commonly used version in the literature is the Italianate industrial district, the main characteristics of which are: a high level of personnel exchange between customers and suppliers; co-operation between competitors to share risks, stabilise markets and share innovation; a number of workers in design and innovation; a strong trade association; and a strong local government role. (e.g. Markusen 1996, Alberti 2004).

Another well known model is Porter's cluster model. The model describes the factors which create the competitive advantages of firms: the context for firm strategy and rivalry; demand conditions; related and supporting industries; and factor conditions (Porter 1991).

In recent years, the innovation system models have gained more space in the literature. The difference, compared to industrial district and cluster models, is that the focus is more on innovativeness, while the others take into account all the possible elements which have an influence on a firm's capability. Charles Edquist defines an innovation system on a common level to be the determinants of product development processes: all the important economic; social; political; organisational; institutional; and other factors that influence the development, diffusion, and use of innovation (C Edquist 2005).

Other approaches include the Mode 2 approach which emphasises the production of knowledge in a context of application (Nowotny *et al* 2003), while the Triple-Helix approach highlights the state-academia-industry tri-lateral networks and hybrid organisations (e.g. Etzkowitz & Leydesdorf, 2000).

The following Sections provide a review of the literature on clusters, national and regional innovation systems, sectoral innovation systems, mode-2, and the Triple-Helix model as well as the Quattro Helix model.

2.2.1 Clusters

The cluster model was first introduced by Michael E. Porter (1991). He studied national and regional competitive advantages and defined his famous diamond model. He found that the conditions affecting firms' competitive advantage are the firms' strategy and rivalry, demand conditions, factor conditions, and related and supporting industries. (Porter 1991.) Since the introduction of the theory extensive research has been carried out, and literature and guides to promote cluster development have been produced in many countries as well as the European Union (e.g. Rosenfeld 2002; OECD 2001c; Breschi & Malerba 2005; Mohan *et al* 2002).

In the extensive literature by the OECD, cluster theory has been used to enlarge the understanding of innovation systems. Most of the literature deals with local clusters but also national ones have been studied. The OECD studies use the concept of reduced national innovation system (NIS). The concept of national innovation system is reviewed later. A reduced-NIS has more than one interpretation. A reduced-scale NIS means that the full system is faithfully replicated on the cluster level which is more likely in small countries with a single cluster dominating the national innovation system activities. The term reduced-form NIS refers to a re-specified system of endogenous relationships, which enables an understanding of the system essentials, identifying their key functions, or extract practical findings. In this model, cluster concepts retain the essential features of endogeneity and the key agents in reduced form, but leaves certain contextual conditions and detailed interactions of a larger system unexamined. (Bergman *et al* 2001.)

In the OECD report on "Innovative clusters, drivers of national innovation systems" report (2001c), an analysis of 20 different mainly national level clusters is presented with a focus on innovative actions. In the report, Paija adopts the following order in a study of the Finnish ICT cluster (Paija 2001: 20–36):

- identification of the cluster including the key industry sectors, supporting industries, associated services and related industries which consists also education and public services;
- cluster mapping including the economic relevance of the domestic market as well as foreign trade and international market position;
- components of the cluster system;
- the facets of competitive advantage including firm strategy, structure and rivalry, factor conditions, demand conditions, supporting and related industries, government and coincidental factors; and
- cluster innovation patterns including R&D activities, industrial co-operation and industry-science interaction.

The author's conclusion, with regard to the national innovation system, is that the emergence of the Finnish ICT cluster is the outcome of a dynamic interaction within the innovation system, in which the government has had the role of facilitator and coordinator. The settings for industrial policy design is characterised by intensive and informal communication between the government, industry, academia, and the labour market. The system is based on a clear definition of the role of each actor as well as a shared view of the policy objectives and tools. (Paija 2001: 36–40.)

In an analysis of the Dutch multimedia, the cluster researchers used a method called "a toolkit" – named ClusterMonitor, developed for the Dutch Ministry of

Economic Affairs. The analysis takes the following approach (den Hertog *et al* 2001: 149):

1. Basic characteristics: a) structure, b) framework conditions, and c) international context;
2. Functioning: a) cluster dynamics, b) innovation style and, c) quality of demand;
3. Performance: a) economic performance, b) innovation success, and c) adaptation capability.

The main bottlenecks found in the study are the low level of industrial organisation, the underdeveloped links between the regional clusters, the level of cooperation between the core and "rim" actors, and the balance between the formal and informal cooperation in innovation (den Hertog *et al* 2001: 147).

Breschi and Malerba summarise the recent knowledge on clusters, networks and innovation to set the following demands on the study of regional clusters (Breschi & Malerba 2005: 22–25) as follows:

- various research traditions and tools have to be used in order to examine the topic in a complete way;
- different types of networks and their relationships have to be examined;
- the analysis of the emergence and dynamics of a cluster has to become one of the major items;
- knowledge and learning of the variety of different actors are the key elements to understanding the rise, growth and transformation of a cluster;
- the accumulation of capabilities in key (large) actors is a fundamental process in the growth and development of a cluster;
- sectoral specificities have to be taken into consideration;
- labour-market characteristics and spin-offs are major elements in cluster development;
- change is needed from studying proximity to deeper concepts such as face-to-face contacts, social networks, and labour mobility;
- international specialisation and demand linkages have a major influence on the growth of clusters;
- the coexistence of localisation and globalisation in a cluster;
- the effect of the national context on clusters is often significant and may be crucial for its growth and success;

– the emergence of local institutions in the initial and growth phases of a cluster; and
– co-evolution and path dependence are key elements in the explanation of the emergence and growth of clusters and their differences.

Breschi and Malerba (2005: 22) summarise that the replication of successful clusters by public policy is doomed to fail, as the public policy should be sensitive to the life cycle and success of the clusters.

2.2.2 Innovation systems

As product development is one part of a firm's innovation processes, the various innovation system approaches are of interest for the theory building in this study. There are rival innovation system theories varying from exact system level descriptions (Fagerberg *et al* 2005, Feldman & Massard 2002) to dynamic models such as the Triple-Helix (Etzkowitz & Leydesdorf 2000). Some scientists argue whether there is such thing as an innovation system (e.g. Bateira 2005). Whatever model is used to describe the system, innovation and innovation systems are a phenomena that the authorities count on. For example the European Commission has defined a strategy of how to build a more competitive Europe by developing the innovation system (EU 2005). SITRA (the Finnish Innovation Fund) has formulated a similar strategy for Finland (SITRA 2005).

A system has two kinds of constituents: components, and the relation between them. The function and its boundaries must be identifiable. The main components of an innovation system, the actors, are the organisations which have formal structures and an explicit purpose. Some important actors are firms, universities, venture capital organisations and public agencies responsible for the innovation policy, competition policy or e.g. drug policy. These institutions have common habits, norms, routines, established practices, rules, or laws that regulate the interaction between individuals, groups and organisations. (Edquist 2005)

Edquist presents a list of activities important to most innovation systems (Edquist 2005: 190–191) – probably also to those studied in this thesis:

1. the provision of research & development (R&D), creating new knowledge;
2. competence building in the labour force to be used in innovation and R&D activities;
3. formation of a new product market;

4. articulation of quality requirements emanating from the demand side with regards to new products;
5. creating and changing of organisations needed for the development of new fields of innovation;
6. networking through markets and other mechanisms, including interactive learning between different organisations involved in the innovation processes. This implies new knowledge outside of what is already available in the firms;
7. creating and changing institutions that influence the innovating organisations and innovation processes (IPR laws, tax laws, R&D investment routines, etc.);
8. incubating activities;
9. financing of innovation processes and other activities that can facilitate the commercialisation of knowledge and its adoption;
10. consultancy services relevant for innovation processes (technology transfer, commercial information, legal advice, etc.).

Edquist describes the list as provisional. Lundvall criticises the list by partially arguing that points 3 to 7 are difficult to view as activities and organised by any specific type of organisation. He claims that five candidates that might enter the top ten as 'factors influencing innovation' are: competition, openness to international trade and capital flows, labour market dynamics, social welfare systems, and the quality of social capital. (Lundvall 2005: 13).

Edquist identifies three kinds of learning that happens in an innovation system (Edquist 2005: 191–192):

- innovation in new products and processes that takes place mainly in firms;
- R&D that is conducted in universities and public research organisations as well as in firms leading to publicly available knowledge owned by firms, organisations and individuals;
- competence building that occurs in schools and universities but also in firms, and leads to the creation of human capital.

According to the OECD, the relation and interaction between organisations and institutions are important as follows:

- competition, which is the interactive process where the actors are rivals and which create the incentives of innovation;
- transaction, which is the process by which goods and services, including technology embodied and tacit knowledge are traded between economic actors;

– networking, which is the process by which knowledge is transferred through collaboration, co-operation and long term network arrangements. (OECD 2002 a: 15).

When defining a certain innovation system it is crucial to make a distinction between what is inside and outside the system. There are three dimensions in which the boundaries can be identified: spatial, sectoral, and activities. When defining the spatial boundaries the main criterion should be the high "coherence" or the "inward orientation" with regard to the innovation processes instead of e.g. the administrative boundaries between regions. Such a coherence can appear as the level of localised learning spillovers, mobility of skilled workers or the proportion of the innovation-related collaborations among organisations. The sectoral boundaries are neither that clear. In some cases the system can easily be limited to e.g. one technological sector, but is difficult with regard to new sectors or sectors going through a radical technological shift. The whole socio-economic system within a geographical area cannot be considered to be included in the innovation system. (Edquist 2005: 200–201.)

National innovation systems

The study objects – the Technology Parks in Kemi and Kalix – are local but also parts of their national innovation systems, the original application area of the innovation system theory. Thus it is necessary to understand their functionality. Lundvall (1998, 1999, Lundvall *et al* 2002) and Edquist (Edquist & Hommen 1999) argue on behalf of the national innovation system approach. According to Lundvall, focusing purely on resource allocation would result in a stagnant economic development, and a vibrant economy is one where innovation takes place. This shifts the focus from national decision-making to learning and recognition that the future has an uncertain outcome. Learning involves four institutional components: the time horizon of the agents; the role of trust; the actual mix of rationality; and the way authority is expressed. The research shows a strong correlation between specialisation in trade and specialisation in the knowledge base. The national innovation system approach concludes that important parts of the knowledge base are tacit and emerge from routine basic learning-by-doing, learning-by-using and learning-by-interacting rather than from science and technology search activities. (Lundvall 1998.)

OECD has conducted a lot of research on the topic (OECD 1997, 2001a, 2001b, 2002, 2005a, 2005b, 2005c). According to them the national innovation system approach emphasises that the flows of technology and information among people, firms, and institutions are the key to the innovation process. Innovation and technology are the result of a complex set of relationships among actors in the system, which includes firms, universities and government research institutes. (OECD 1997: 9–12.) Innovation is a complex process which has technological, economic, social, and cultural dimensions. It involves scientists, developers, marketers, and customers and it relates to processes, products, and services. Governments may devise broadly-based policies and support schemes that touch on many aspects of innovation; on the other hand they may concentrate on precisely-targeted measures designed to tackle a particular problem; or they may do both. (Frinking *et al* 2002: 8.)

TEKES, the Finnish Funding Agency for Technology and Innovation, has published a benchmarking study on national innovation systems with a focus on public financing. The researchers found three different models. One is the dominant player model where one organisation is responsible for a large part or the entire chain of policies or their implementation. The second is the "division of labour" model where there are two national separate systems supporting innovation from different perspectives. One system focuses on education and research, while the other is oriented towards technology and economic development. The third one, the pillar model, represents a very focused approach on the different aspects of innovation-related policies. This means that – for science, technology, information and communication, economic and business development – separate organisations are responsible for policymaking in each specific field, having specific implementation or managing agencies. The result is a specialised but very fragmented structure. (Frinking *et al* 2002.)

The actors in the national innovation system are e.g. universities, research institutes, firms, and different types of intermediaries that are active also in the case Technology Parks.

Regional innovation system

The two case Technology Parks are part of regional innovation systems. According to the literature, the regional dimension must be taken into consideration e.g. because of the proximity point of view (Cooke 2004: 17). The research on regional innovation systems has increased and today the literature on regional innovation systems is more extensive than the literature on national innovation systems.

According to Cooke "a regional innovation system consists of interacting knowledge generation and exploitation sub-systems linked to global, national and other regional systems for commercialising new knowledge" (Cooke 2004: 3). Feldman argues that a location close to the source of technology allows firms to translate information into a usable form. Firms using complex and dynamic technologies attempt to locate near the knowledge sources. When a technology is standardised and reasonably stable, knowledge can be expressed with standard codes, and long-distance knowledge transfer can take place at low costs. On the other hand, when technology is complex and evolving rapidly, long distance standardised transfer is not possible. (Feldman 2002: 3.)

Cooke identifies two different types of regional innovation systems according to who governs them. Some of them are led by associations, chambers of commerce, or public authorities with executives ill-attuned to innovation support, risk-averse, and used to facilitate "rent-seeking" businesses by grant-hungry businesses rather than more innovative financial packages, as Cooke describes. One type is called the Institutional Regional Innovation Systems (IRIS) because it is based on public knowledge generation and exploitation institutions, such as public laboratories, universities, technology transfer organisations, incubators, investors, trainers, and other intermediates. The alternative is the Entrepreneurial Regional Innovation System (ERIS), also referred as "new economy innovation systems", and "private innovation systems". (Cooke 2004: 4–5.) It is of interest to identify in which category the case Technology Parks belong.

Cooke uses further divisions of grassroots, network and dirigiste regional innovation systems. In the grassroots model the technology transfer initiation process is local. Funding is a local mixture from banks, the government, and possible chamber of commerce in forms of capital, grants, and loans. The research competence is likely to be applied or near market. The technical specialisation level is low as well as the level of supra-local coordination. In the network model the initiation of technology transfer is multi-level: it can include local, regional, federal, and supranational levels. Funding is more likely guided by agreement with banks, government agencies, and firms. The research competence is likely to be a mixture of basic and applied research based on the firms' needs. The system coordination is likely to be high because of the large number of stakeholders. Specialisation is likely to be flexible because of the wide range of demands from global to small firm scale. In a dirigiste innovation system model the technology transfer activities are activated mainly from outside and above the region itself. Initiation of actions is typically a result of central government policies. Funding is mainly centrally determined although the agencies may have local offices. The research conducted is often rather basic or fundamental and it may relate to the needs of larger firms or beyond the region. The coordination level is high, at least potentially, since the system is state-run, and the level of coordination is high. (Cooke 2004: 10–13.)

The third classification by Cooke is based on the extent of domination by large firms, and is vertical compared to the previous grouping: division to localist; interactive; and globalised regional innovation systems. In the localist model there are few or no large firms, and relatively few branches of externally controlled firms. In a localist business innovation culture, the firms' research scope is not very high, although there may be suitable local research organisations. Amongst entrepreneurs, and between them and local policy makers the degree of association is reasonably high. The interactive model is dominated by a rational balance between small and large firms. There is widespread access to regional research resources as well as to foreign innovation sourcing. Such regions are highly associative vertically and laterally. A globalised system is dominated by global corporations, often supported by supply-chains of rather dependent SMEs. (Cooke 2004: 13–16.)

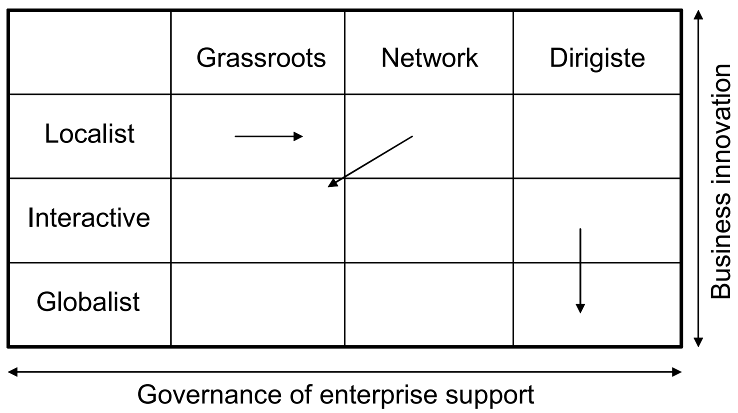


Fig. 4. Regional innovation system typology (Cooke 2004: 15).

The two vertical classifications of regional innovation systems can be used to evaluate the systems and also to describe its evolution (Fig. 4).

Mariussen and Asheim categorise analytical, synthetic, cultural, and industrial innovation systems. Analytical systems produce explicit scientific knowledge that is processed for a product in a specified market. In synthetic systems, the innovation takes place mainly through the application of existing knowledge, or through new combinations of knowledge. The industrial system integrates the other systems. The output of cultural innovation systems is aesthetic attributes of products, designs, images and the economic use of various forms of cultural artefacts. (Mariussen & Asheim 2003: 20–23.)

Local clusters form the base for a regional innovation system: 'The region is increasingly the level at which innovation is produced through regional networks of innovators, local clusters and the cross-fertilising effects of research institutions. The development of high-tech regions in different parts of the globe is a positive example of this trend" (Lundvall & Borrás 1997: 19). The two theories are thus not competing but fulfilling each other.

The regional innovation systems have been studied extensively. The problem is not to find articles but to evaluate the large amount of them, and choose the relevant ones. There are several scientific journals which focus on regional innovation systems and the technology transfer as the main content. Also several conference series focus on these topics. Cooke illustrates the regional innovation system (Fig. 5), which provides a basis for the literature review.

The firms are the core of a regional innovation system. The SMEs' – which many of the case companies belong to – most usual partners are other SMEs in the same region (Tödtling & Kaufmann 2002: 24–25). In small regions the reality can be that firms develop products and processes but there is no or little interaction between the firms (Wiig & Wood 1995: 23). Many papers suggest that the promotion of interregional and intraregional cooperation and collaboration between SMEs, and between SMEs and larger firms, is one of the main measures to be taken in the further development of a regional innovation system (Wiig 1995, Hyvärinen 2005, Harmaakorpi 2004, Tödtling & Kaufmann 2002, Belis-Bergougnan & Carrincazeaux C 2003, Asheim & Isaksen 2002, Cooke 2002). Joint inter-firm projects are found to have more than just a project lifetime influence on trust, knowledge transfer, and cooperation (Tödtling & Trippl 2003: 25, Asheim 2003).

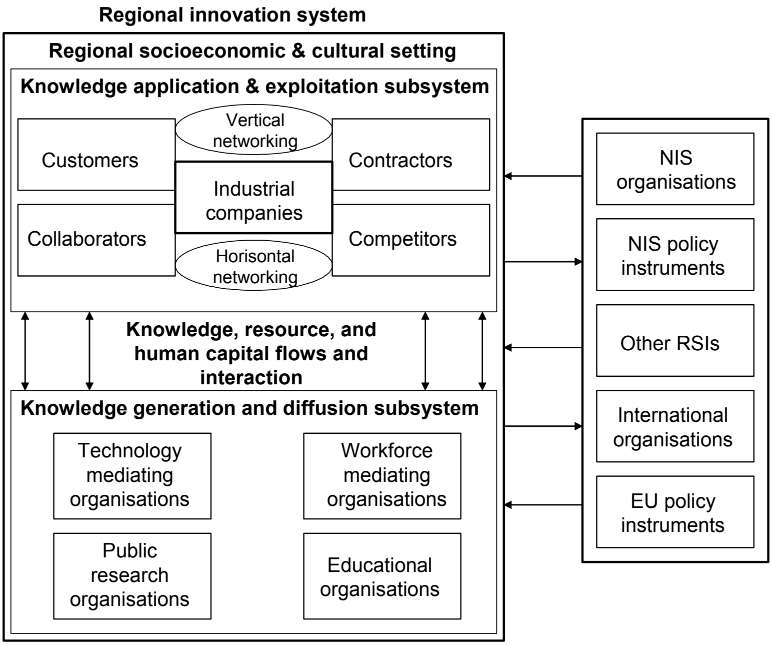


Fig. 5. Regional innovation system illustration (Cooke 2002: 137).

The links and relations between firms, and the knowledge generation and diffusion subsystem, have been studied extensively, and are of great importance also in this study. The empirical results from Germany show that universities add the most information and knowledge within the innovation processes, and public research has also a boundary-spanning function for the firms due to its integration into the international scientific community (Kauffeld-Monz 2005: 11–12). Where public research is locally available – like in Kemi to some degree – it is found in the most important functions that the innovation system can supply to firms (Kautonen *et al* 2002, Hyvärinen 2005). On the other hand, in small and medium sized regions, where local research is not available – like in Kalix – strong links to universities in other regions are seen as important (Andersson & Karlsson 2004: 23–25). Even if the research is localised, links to national and international levels are needed (Hyvärinen 2005, Kautonen *et al* 2002, Tödtling & Kaufmann 2002, Asheim & Isaksen 2002).

The importance of access to educated personnel has a high influence on innovative activities. This has been found to be the most important reason for the attractiveness of the Finnish university cities (Kautonen *et al* 2002). For (small and medium sized) regions, that have one or several higher education institutions, it is important to take special measures to adapt the educational profile to fit the need of the regional innovation system (Andersson & Karlsson 2004). If there is no education present, strong links to universities are needed to secure access to experts; often special measures are needed to facilitate the recruitment of qualified personnel (Herstad 2003, Andersson & Karlsson 2004: 23–25).

Based on three case studies, Asheim and Isaksen conclude that ideal-typical regional innovation systems – i.e. regional clusters 'surrounded' by supporting local organisations – are rather uncommon in Norway (Asheim & Isaksen 2002). The same deduction about several other locations can be drawn from the reviewed literature.

Studies especially on smallish peripheral regions show that the systems do not function like they should (e.g. Wiig 1995, Andersson & Karlsson 2004). As described earlier, a regional innovation system consists of private and public actors, and the processes between them. A regional innovation system functions when '*all these pieces fall into place and form a coordinated space of competencies*' (Herstad 2003: 310).

Harmaakorpi identifies five regional dynamic capabilities needed to reconfigure the regional resources to sustain or achieve regional competitiveness: the leadership capability, the visionary capability, the learning capability, the networking capability, and the innovative capability. He has developed a tool – the regional development platform method – for regional innovation policy development, and used it to develop new strategies for the Lahti region in Finland. The idea is to direct available resources in core processes. (Harmaakorpi 2004.)

Andersson and Karlsson summarise the conditions and actions for formulating regional innovation policies especially in small and medium-sized regions (Andersson & Karlsson 2004: 21) which are interesting from this study's point of view and are as follows:

- the region must have either one or several clusters of SMEs, or one or several larger leading firms surrounded by clusters of suppliers and/or customers;
- if the region does not have public research institutions, strong links to research universities in other regions are important;
- if higher education exists, its profile should be adapted to fit the needs;
- if there are problems to recruit qualified personnel, special measures are often needed;

- for the collective learning, the arenas and meeting places should be improved and new ones created;
- all the innovation policies should be based on careful studies of the existing regional innovation systems' weaknesses and strengths;
- the administrative and functional regions do not normally coincide. The regional innovation policies should be formulated and executed for functional regions.

Cooke and Leydesdorf have defined the concept of constructed advantage, which highlights the dynamics of regional development economics. They contend that this knowledge based construction requires interfacing developments in various directions (Leydesdorf & Etzkowitz in Cooke & Leydesdorf 2006: 10) as follows:

- economy: regionalisation of the economic development; open inter-firm interactions; integration of knowledge generation and commercialisation; smart infrastructures; strong local and global business networks;
- governance: multi-level governance of associational and stakeholder interests; strong policy-support for innovators; enhanced budgets for research; vision-led policy leadership; global positioning of local assets;
- knowledge infrastructure: universities, public sector research, mediating agencies, professional consultancy, etc. have to be actively involved as structural puzzle-solving capacities;
- community and culture: cosmopolitanism; sustainability; talented human capital; creative cultural environments; social tolerance. This public factor provides a background for the dynamics in a Triple-Helix of university-industry-government relations.

Philip Cooke argues that regional innovation systems are broader than single sectors and clusters, but some of these will be strategically privileged recipients of policy support because of their growth performance or potential (Cooke 2002: 133). On the other hand, Feldman and Audretcsh (1999: 427) report that their study provides considerable support for the diversity thesis but little support for the specialisation thesis.

Sectoral innovation system

Another model of interest to this study is the sectoral innovation system model. According to Malerba there are differences between sectors. He presents a methodology for the analysis and comparison of sectors: the sectoral innovations system model. The framework focuses on the following three main dimensions in the sector: (Malerba 2001: 19–25, 2005: 384–395.)

- knowledge and technological domain;
- actors and networks;
- institutions.

Malerba's definition for a sectoral innovation system includes both an innovation and production system: "A sectoral system of innovation and production is a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products. A sectoral system has a knowledge base, technologies, inputs and a demand, which may be existing, emerging or potential. The agents composing the sectoral system are organizations and individuals (e.g. consumers, entrepreneurs, scientists). Organisations may be firms (e.g. users, producers and input suppliers) and non-firm organizations (e.g. universities, financial institutions, government agencies, trade-unions, or technical associations), including sub-units of larger organizations (e.g. R&D or production departments) and groups of organizations (e.g. industry associations). Agents are characterised by specific learning processes, competences, beliefs, objectives, organizational structures and behaviours. They interact through processes of communication, exchange, cooperation, competition and command, and their interactions are shaped by institutions (rules and regulations). Over time a sectoral system undergoes processes of change and transformation through the coevolution of its various elements." (Malerba 2001: 4–5).

Compared to other, geographically defined, innovation systems a sectoral system may be local, national, or global, or it may have all the dimensions. Another difference is that a sectoral system is based on evolutionary theory: the emphasis is on dynamics, innovation processes, and economic transformation. Learning and knowledge are the key elements in the change of the economic system. Cognitive aspects – beliefs, objectives and expectations – are emphasised. A variety of creation, replication and selection processes is central. (Malerba 2005.)

The demand has a major role in sectoral systems as Porter has shown (Porter 1991: 115–129). When the demand changes simultaneously with some basic features of knowledge and technology, the effect on firms can be significant. The basic technology and the demand limit the diversity in firms' behaviour and organisation: they define what kind of problems firms have to solve. In addition to technology and demand, links and complementarities have a major role in defining sectoral boundaries. They are mainly static but there are also dynamic ones, which cause the transformation and growth in sectoral systems. They also change and differ among sectors and influence the strategies, organisations, and performance of firms. They affect the rate and direction of the technological change, the type of competition, and the networks among agents. (Malerba 2001.)

Knowledge is central in innovation. The knowledge base and innovation related learning processes differ greatly between sectors and technologies. Also the knowledge domains differ similarly: in one sector the domain may refer to scientific and technological fields, while in another to applications, users and demand. This causes differences in accessibility and to opportunities. In one sector the opportunity may require a scientific breakthrough, in another advancement in the equipment and instruments, while in a third one suppliers and users may be the source. If external knowledge is easy to access innovative entry is possible, but if integration is demanding the industry probably will concentrate. (Malerba 2001: 19–21.)

The knowledge can be more or less cumulative in three different ways (Malerba 2005: 388):

- cognitive: the learning processes and the past knowledge constrain current research, but also generate new questions and new knowledge;
- the firm and its organisational capabilities: Organisational capabilities are firm-specific and generate highly path-dependent knowledge. They implicitly define what a firm learns and what it can hope to achieve in the future;
- feedback from the market, such as in the "success-breeds-success" process: innovative success yields to profits that can be reinvested in R&D, thereby increasing the probability to innovate again.

When agents are concerned, firms are the key actors in a sectoral innovation system. They are involved in innovation, production, and sales – and they adopt and use new technology. Also users and suppliers are firms. Users are extremely important in several sectors, and focusing on them emphasises the role of demand. The heterogeneity of the firms is a key feature. The non-firm organisations include universities, financial institutions, government agencies, local authorities etc. Often the most appropriate units of analysis in a sectoral system are – not necessarily the firms – but individuals, the firms' sub-units, and groups of firms. (Malerba 2001: 10–11, 21–25.)

In a sectoral system, heterogeneous agents are connected in various ways through market and non-market relationships. According to the evolutionary theory approach, a wide range of formal and informal interaction emerges because the agents are different. The networks may integrate complementarities in knowledge, capabilities and specialisation. The relationship between firms and non-firm organisations are emphasised. The types and structures of relationships differ greatly by sectors. (Malerba 2001, 2005.)

The sectoral systems may differ with respect to their typical institutions, which include norms, routines, common habits, established practices, rules, laws, standards etc. that shape the agents' cognition and action and affect the interaction among them. The research addresses the emergence of sectoral institutions: they may result from planned decisions or they may emerge unpredictably. Another topic is the effect of national institutions on sectoral systems, e.g. property rights and antitrust regulations. If the national institutions favour specific sectors, they become predominant in the country. (Malerba 2001.)

Based on the heterogeneity of firms, two key evolutionary processes take place: the variety creation process, and the selection process. Variety creation processes refer to products, technologies, firms, and institutions as well as to strategies and behaviour. They are related to several mechanisms: entry, R&D, innovation, etc. These mechanisms interact at various levels. For example, the emergence and growth of new sectoral institutions and organisations – such as new specialised departments at universities and new scientific, technological and educational fields – increase variety and can be associated with the emergence of new technologies and new knowledge. The creation of new actors – both firms and non-firms organisations – is particularly important for the dynamics of sectoral systems. For example, new firms bring a variety of approaches, specialisation and knowledge in the innovation and production processes, and they contribute to the major changes in the population of agents and in the transformation of technologies and products in a sector. Selection processes play the key role of reducing the heterogeneity and may refer to different environments: firms, products, activities, technologies, and so on. Selection may be intense and frequent. It greatly differs across sectoral systems. (Malerba 2001.)

Change, a characteristic feature of sectoral systems, does not mean simply quantitative growth of the variables, but it means also transformation and evolution. During the evolution of sectoral systems, change may occur in the technological and learning regimes and in the patterns of innovations. Over time, a change in regimes may transform a Schumpeter Mark I pattern of innovative activities to a Schumpeter Mark II. In the presence of major knowledge, technological, or market discontinuities, a Schumpeter Mark II pattern of innovative activities may be replaced by a Schumpeter Mark I. The knowledge base of innovative activities may change in two different ways: an evolution towards a dominant design; or a drastic change. From the claim that the elements of a sectoral system are closely connected, it follows that their change over time results in a coevolutionary process of its various elements. This process involves technology, demand, a knowledge base, learning processes, firms, non-firm organisations and institutions. The processes are sector-specific. Often coevolution is related to path-dependent processes. Local learning, interaction among actors, and networks may generate increasing returns and irreversibilities that may lock sectoral systems into inferior technologies. The transformation of sectors involves the emergence of new clusters that span over several sectors, such as internet-software-telecom, biotechnology-pharmaceutical, and new materials. A big role is played by the integration and fusion of previously separated knowledge and technologies and by the new relations and overall dynamics among different types of users and consumers, firms with different specialisation and competences, and non-firms organisations and institutions grounded in previously separated sectors. (Malerba 2001: 12–13.)

Geographical boundaries are an important element in most sectoral system analyses. National boundaries are not always the most appropriate ones for an examination of the structure, actors, and dynamics of these systems. Often a sectoral system is highly localised and frequently defines the specialisation of the whole local area. (Malerba 2001: 14–15.)

The sectoral innovation system approach can be used to analyse existing structures, and it also provides a design for innovation and technology policies (Malerba 2005 p 398–400) which is of interest in this study. Earlier research has been conducted from several points of view (Breschi & Malerba 2001). Also numerous cluster studies on innovation are close to sectoral innovation studies even though the methodologies may be partly different (OECD 2001a). An example of the conducted analysis is Högselius's study on Estonian telecommunication sector. It follows the historical process starting from Soviet time and ending with the conclusion that the Estonian sectoral innovation system in telecommunication is becoming a part of the Swedish and Finnish telecommunication clusters and innovation systems (Högselius 2002). In this study it is of interest how the Technology Parks and case product development cases are situated in sectoral innovation systems.

2.2.3 Non-linear innovation systems

Mode-2

The basic idea in the introduction of 'Mode 2' in the knowledge production is that the knowledge production and the research process have been transformed. The older 'Mode 1' paradigm of scientific research is characterised by the hegemony of theoretical and experimental science, by an internally-driven taxonomy of disciplines, and by the autonomy of scientists and universities. This paradigm was being superceded by a new paradigm of knowledge production ('Mode 2'), which was socially distributed, application-oriented, trans-disciplinary, and subject to multiple accountabilities. (Nowotny *et al* 2003: 109.)
The first element in the transformation of research is the increasing desire to 'steer' priorities. This operates at the three following levels (Nowotny *et al* 2003: 181–182):

- the supranational level: e.g. the successive European Community Framework programmes;
- the national level: although highly prescriptive research and development programmes have existed for some time, there has been a growing tendency for all ministries to develop dedicated research programmes;
- the system level: in many countries, research councils have increasingly adopted more pro-active (or top-down) research priorities in place of essentially reactive (or bottom-up) policies, whereby the best research proposals – as identified by peer review – are funded.

The second element is the commercialisation of research, or conducting more 'engaged research'. This has two main forms. As the public research funding has become less adequate, researchers have increasingly turned to alternative sources of funding. Universities (and similar organisations) have also become more aware of the value of the 'intellectual property'. The third element is the growing emphasis on the management of research and, particularly, upon efforts to evaluate its effectiveness and assess its quality. (Nowotny *et al* 2003.)

Characteristics of 'Mode 2' knowledge production are the generation of knowledge in a context of application, 'trans-disciplinarity' meaning the use of a range of theoretical perspectives and practical methodologies to solve problems, diversity of knowledge production sites, dynamics of research communities in interaction with communication technologies, reflexivity of knowledge, and new forms of quality control (Nowotny *et el* 2003).

Edquist studied the Swedish research funding system. He argues that 'Mode 2' has been the traditional mode of practice, and has always been the dominant one in Sweden. (Edquist 2003.) However, a Norwegian study shows little evidence of any significant change in research practice: the university researchers maintain the conventional definitions of 'good research' (Gulbrandsen & Langfeldt 2004).

The Triple-Helix

Universities and industries – earlier relatively separate and distinct institutional spheres – have adopted tasks that were formerly largely the province of the other. The governments' roles in relation to these two spheres are changing in apparently contradictory directions. According to Leydesdorff and Etzkowitz the former contract between universities and industry was based on a linear model of innovation, presuming academic knowledge has only long term contributions to the economy. Now both long and short term contributions are seen as possible, based on examples of firm formation and research contracts in e.g. biotechnology and computer science. (Etzkowitz & Leydesdorff 1995.) Universities have become more dependent on industry and government, and industry and government more dependent on universities (Nilsson & Uhlin 2005). In Kemi there is no traditional research university, and Kalix has no university at all. This makes the analysis of the interaction in these two areas of particular interest.

Leydesdorff and Etzkowitz argue that a spiral innovation model – in terms of university-industry-government relations – is required to capture the evolution of multiple linkages at different stages of the capitalisation of knowledge. In a knowledge-based economy, the distribution of research locations provides a focus of strategic opportunities for both research and policy-making. The three institutional spheres (public, private, and academic) – which formerly operated at arm's length – are increasingly working together, with a spiral pattern of linkages emerging at various stages of the innovation process, to form a "Triple Helix." (Leydesdorff & Etzkowitz 1995, 2000.)

The Triple Helix model argues that the universities can have an enhanced role in innovation in increasingly knowledge-based societies. It focuses on the network overlay of communications, and expectations that reshape the institutional arrangement among universities, industries and governmental agencies. (Etzkowitz & Leydesdorff 2000: 111–112.)

The evolution of innovation systems is reflected in the varying institutional arrangements of university-industry-government relations. First, a specific historical situation is called the Triple Helix I. In it the state encompasses academia and industry, and directs the relations between them (Fig. 6). The strong version of this model was used in the former Soviet Union and in Eastern European countries. A second policy model consists of separate institutional spheres with strong borders dividing them, and highly circumscribed relations among the spheres. Finally, Triple Helix III is a knowledge infrastructure with overlapping institutional spheres, with each taking the role of the other, and with hybrid organisations emerging at the interfaces. (Etzkowitz & Leydesdorff 2000: 111–112)

The dynamics are nonlinear. Both the interaction terms and the recursive terms have to be declared. There is ongoing transformation in each of the helices. These reconstructions are seen as a level of continuous innovations under pressure of changing environments. When two helices are increasingly shaping each other mutually, coevolution may lead to a stabilisation along a trajectory. If more than a single interface is stabilised, the formation of a globalised regime can be expected. At each level, cycles are generated. They guide the phasing of the developments. (Etzkowitz & Leydesdorff 2000: 112–113.)

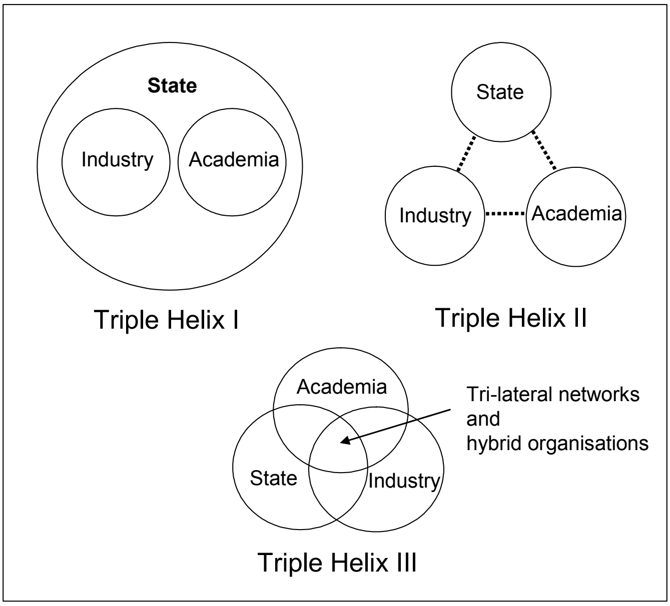


Fig. 6. The three Triple Helix models (Adapted from Etzkowitz & Leydesdorf 2000: 111).

The Triple Helix overlay provides a model at the social structure level for the explanation of Mode 2 as a historically emerging structure for the scientific knowledge production, and its relation to Mode 1. The arrangements between industry and government do not need to be conceptualised as exclusively between national governments and specific industrial sectors. The driving force of the interactions is specified as the expectation of profits. ‘‘Profit’’ means different things to the various actors. The foundation of the model in terms of expectations leaves room for uncertainties and chance processes. The expansion of the higher education and academic research sector provides society with a realm in which different representations can be entertained and recombined in a systematic manner. The model also explains why the tensions need not to be resolved. The crucial question of the exchange media — economic expectations, theoretical expectations, assessment of what can be realised given its institutional and geographic constraints — have to be related and converted into one another. (Etzkowitz & Leydesdorff 2000.)

The main institutions in a knowledge-based system are the university, industry, and government. The system has two layers: one of institutional relations, and the other of functional relations. The functions – that have to be recombined and reproduced – are wealth generation in the economy, and novelty generation by organised science and technology. These two functions provide local control for the retention and reproduction of the system. The layers are expected to feed back on each other and thus change the institutional roles, the institutional environments, and therefore potentially the evolutionary functions of the various stakeholders in the next round. (Leydesdorff 2006:194–200.)

According to Leydesdorff, two mechanisms are important for understanding structural change as a mechanism: the possibility of a 'lock-in' between subsystems; and the possibility of a bifurcation within an evolving system. A bifurcation generates an interface e.g. between a production and diffusion system, while a 'lock-in' dissolves an interface in coevolution: e.g. between a specific technology and a market. The locked-in system may bifurcate in the next stage, but the two mechanisms are independent of each other. (Leydesdorff 2006:197–198.)

The geographic level (multinational, national and regional) can be taken into account in the Triple Helix model.

It is possible to study the overlapping of institutional spheres as well as the knowledge, consensus, and innovation spaces that are created at the intersection of the spheres. These spaces are created as a result of change in values of the regional economic development promoters. One indicator of this shift is the increasing involvement of universities – and other knowledge producing and disseminating institutions – in the regional development. The first step in a three-stage process of knowledge-based economic development is the creation of 'knowledge spaces', or related R&D activity concentrations in a local area. The second step is the creation of a 'consensus space', a venue that brings together persons with different organisational backgrounds and perspectives for the purpose of generating new strategies and ideas. The third step is the creation of an 'innovation space', a new organisational mechanism that attempts to realise the goals shaped in the consensus space. Hybridisation of organisational roles and functions is an expected development arising from the interaction in the consensus space. The result is typically a 'hybrid organisation' synthesising theoretical and practical elements of the different spheres. A summary of the conceptual framework for knowledge-based regional development is presented in Fig. 7. (Etzkowitz 2002: 5–10.)

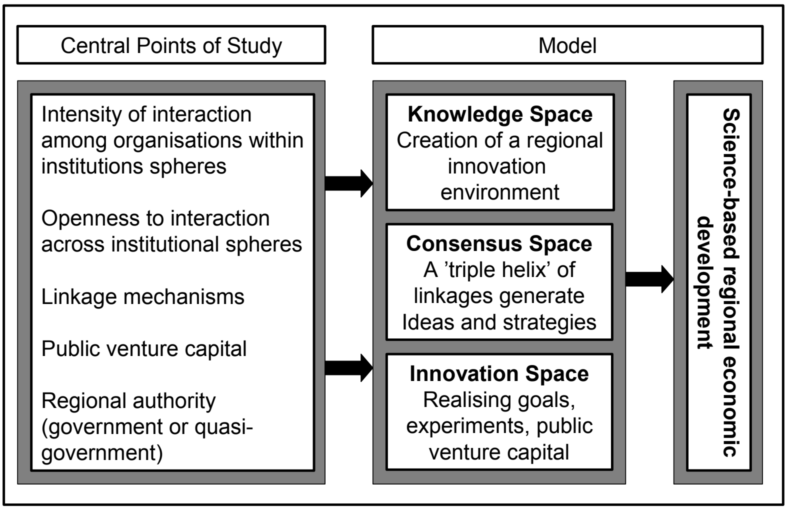


Fig. 7. The Knowledge-based regional development process (Etzkowitz 2002: 9).

Etzkowitz discusses the methodology of achieving a Triple-Helix transition through the three spaces in a case concerning the Eastern Europe transition. He gives the following suggestions from previous international experience: spread entrepreneurial education throughout the university, network incubators and incubator firms, courage regional actors to collaborate and cooperate, create an array of venture capitals, develop multiple knowledge bases, and create an entrepreneurial academic entity. (Etzkowitz 2003: 7–14.)

A lot of research on the influence of various factors on economic development has been conducted with the help of the Triple-Helix theory. Many of the studies are comparative, analysing how different conditions in certain factors affect directly or indirectly the economic performance of countries or regions. In some studies the focus is on finding out if some chosen variables indicate the development. Leydesdorff and Meyer emphasise the use of statistics in evaluating how, for how long, and to what extent institutional arrangements enhance synergies among different selection environments – the knowledge base of regional economics (Leydesdorff & Meyer 2006: 1443).

The three sources of variance – created by the model – may enforce one another in a configuration. Leydesdorff, Dolfsma and Van der Panne tested if it is possible to reduce this uncertainty at systems level in a statistic study based on data from over 240 000 Dutch firms. They proved it was possible. They also returned the following findings (Leydesdorff *et al* 2006: 196):

– the knowledge base of a (regional) economy is carried by high, but more importantly by medium-technology manufacturers. High technology services favourably contribute to the knowledge-based structuring but to a smaller extent;
– medium-technology manufacturing provides the backbone of the techno-economic structure of the Netherlands;
– the not high-technology knowledge intensive services have a relatively unfavourable effect on the regional knowledge based economy. They uncouple the knowledge base from its geographical dimension;
– the Netherlands is highly developed as a knowledge-intensive service economy, but the high-technology end of these services has remained more than an order of magnitude in smaller numbers of firms.

In another study, based on German data, Leydesdorff and Fritsch tested the conclusions from the Netherlands. Again the result was that the configuration of medium-technology manufacturing could be considered a better indicator of the knowledge-based economy than that of the high-technology manufacturing. (Leydesdorff & Fritsch 2006: 1546).

A Finnish article analyses the development of the Finnish science and technology policy system and policy. It concludes that both systemic transition and integration perspectives are essential for understanding changes in science and technology, but do not yet cover the whole range of relevant issues. The international dimension is crucial for a small country. (Kaukonen & Nieminen 1999.)

Ylinenpää has studied the cross-border cooperation between Northern Finland and Sweden. He emphasises the understanding of, and adaptation to, cultural differences along with different administrational structures and language questions. (Ylinenpää 2001.)

Coenen and Asheim have analysed how a regionally contextualised Triple Helix model can contribute to the formation of regional innovation systems. As an empirical illustration they have made comparisons between three contrasting clusters representing different knowledge bases, and their actual and potential linking to regional innovation systems of different types. The clusters were the furniture cluster in Salling in Denmark with a synthetic knowledge base and a market-driven, grass-root RIS; the agrofood cluster in Saskatoon, Canada, analytically based on a dirigiste, science-driven RIS; and the food cluster of Scania, Sweden, that is under construction but with the aim of shaping a networked RIS with both analytical and synthetic knowledge bases. The researchers argue that the construction of a regional innovation system takes place within a dynamic Triple-Helix set-up with a differing role for the actors dependent on the industrial and territorial-institutional context. (Coenen & Asheim 2005.)

The earlier research results and the used methodologies will be utilised when planning the field studies and methods of analysing in this study.

The Quadruple Helix

The product development process and its participants will be discussed in its own Section. The role of the end-user has been emphasised also in the innovation system research and planning of public actions. The term Quadruple Helix was first launched by Kanninen (2005: 5) in a report on partnerships and roles in the development of suburban regions.

While the Triple Helix model defines academic, public and private actors as members of the interaction, the Quadruple Helix model identifies groups of actors: enablers including public actors; utilisers including firms and communities; developers consisting of universities, research institutes, knowledge intensive business services and organisations; and users who are normal citizens whose experiences, views etc. are needed in the development throughout the process. (Rönkä *et al* 2007: 29–30.)

Compared to the Triple Helix model the users have been added as the fourth actor, and the interaction is enhanced to continuous exchange of knowledge with the users. In this study, the firms have their users elsewhere, or the user is a firm or organisation instead of private persons.

2.2.4 Technology Parks

As this study explores Technology Parks, they should first be defined. Several slightly different definitions are available in the literature, and in the official material of various national and international Technology Park associations. The International Association of Science Parks defines the term Science Park in the following way (IASP 2002):

'A Science Park is an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a Science Park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities.'

IASP argues that its definition embraces the different models which exist all over the world. They have made an effort to identify the main common denominators of the different existing models, as well as to set the minimum standards and requirements that any project must have in order to be acknowledged as a "Science Park". The IASP has studied the models and experiences of science, or Technology Parks in the 63 countries – in which its members are located – to ensure the global character of the definition. The definition encompasses other terms and expressions such as "Technology Park", "technopolis", "technopole", "technology precinct", "research park" etc. Although there may be certain differences between them, projects under these labels share many goals, elements and methodology, and therefore fulfil the definition. (IASP 2002.)

Various models to describe, and methods to examine the Technology Parks have been developed, and could be applied in this study. One research line focuses on the conditions for setting up a park. Many of them are based on the cluster theory, although social networking and the Triple-Helix model are also used. Another line of studies explore one or more factors influencing the functionality of one or several Technology Parks.

Phillips and Yeung see the question of spatial scale as one of the major problems confronting the analysis of the parks: it can be defined to cover a whole city, even a whole region, or it can be defined as an intra-urban scale Technology Park property development with the explicit aim to provide a physical place for the commercialisation of new ideas and knowledge resulting from R&D activities. (Phillips & Yeung 2003: 708.)

In his study Ylinenpää has identified two separate and distinct Technology Park development strategies. The 'incubator strategy' focuses on creating favourable conditions for the commercialisation of research-based ideas in the form of spin-off firms from universities. The most important success factor is to be a commercial and business oriented seed-bed. Basic support systems for start-up firms – e.g. management support, mentor systems, and training – are necessary. Additionally, an effective organisation for identifying and promoting the development of research-based new products and businesses is important, as well as flexible and functional premises. The other strategy is the 'attraction strategy', in which the goal is to attract established and larger corporations to locate knowledge-intensive divisions or units in a Technology Park close to the expertise and the recruitment base, i.e. a university. In this strategy the key success factors are recruitment from, and co-operation with its host university. Other influencing factors are value-added services including e.g. healthcare, day-care and travel agencies, and measures linking firms to the university including seminars, specific events, etc. Ylinenpää has also identified two basic park structures: vertically oriented 'firm constellation' where one large firm is dominant, and a horizontally oriented 'network' structure. (Ylinenpää 2001: 8–11.) Ylinenpää is a professor at Luleå Technical University, and has studied the Technology Parks in Oulu and Luleå.

A Technology Park may form a cluster, or be part of a cluster. Lai and Shyu use cluster analysis in their comparison of the innovation capacity of two Technology Parks: one in Taiwan, and one in China (Lai & Shyu 2005). They base the analysis on the definition of the innovation orientation of national industry clusters, presented by Furman, Porter and Stern, who used the model to evaluate national innovative capacity (Fig. 8) (Furman *et al* 2002). Lai and Shyu (2005: 812) found out that many of the determinants for a science park's innovation capacity are different depending on the country.

A large international multiple-case study explored the determining factors of success of Technology Parks, or regional clusters of entrepreneurship and innovation, such as Silicon Valley. The project examined how different forces – including public policy, business strategy, and institutions at regional and national level – combined to encourage the emergence, growth, and maintenance of clusters. The researchers claim that the processes of starting and sustaining a cluster have different economics. Starting a cluster involves first building the economic fundamentals for an industry or technology, and then finding the spark of entrepreneurship to get it going. It was concluded that Silicon Valley 40 years ago, in its starting phase, was closer to today's nascent clusters than to today's Silicon Valley. Founding a cluster, or the early firms in a new cluster, is a very different entrepreneurial and economic activity than founding a firm in an established cluster. New clusters offer less support to entrepreneurship. External effects – benefits of particular technology firms that arise from the presence of other firms or of support structures like venture capital – play only a small role in the early phases. (Breshanan *et al* 2001.)

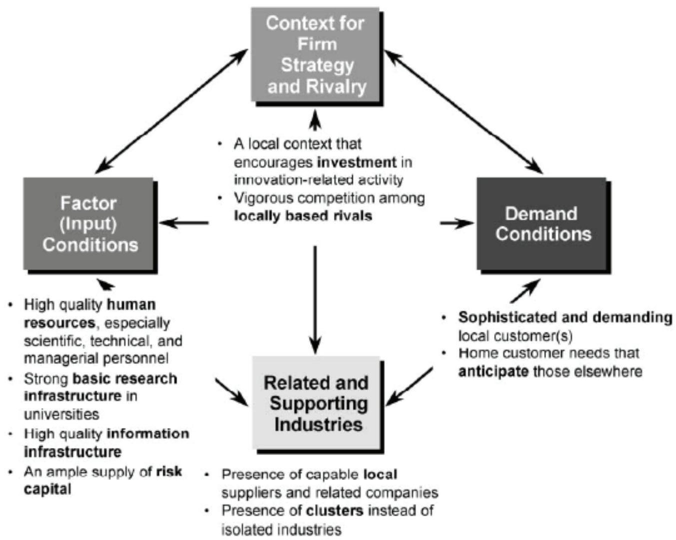


Fig. 8. The innovation orientation of national industry clusters (Furman *et al* 2002: 903).

One similarity between the new clusters is that they have taken advantage of new technological and market opportunities that had not already been exploited. In a new cluster, entrepreneurs have to turn away from the saturated market and complete the existing technologies and clusters rather than compete. Finding the source of demand can be critical for cluster's rise and it should be one of the policy focuses. (Breshanan *et al* 2001: 842.)

Comparing the regularities between clusters in the starting phase, the importance of highly skilled technical labour increases. The study emphasises that access to skilled labour does not automatically require a local university – as Kalix does not have – but there are alternative mechanisms to achieving a skilled labour pool. A university is not essential to the emergence of a successful cluster. Another important group of labour is the managerial one. In a new cluster there typically is a lack of these skills before the scientists or engineers learn a second skill. Also firm-foundation and firm-building capabilities are important elements. Connections to markets and sources of demand are essential. There can be two kinds of those. The first one is the relationship with the main market, and how products complement existing leading technologies. The second model is to position the firms in areas which are not covered by the existing leaders. (Breshanan *et al* 2001: 846–852.) For example, Hsinchu region in Taiwan demonstrates that connections between clusters may be as important as connections within a cluster (Saxenian 2000: 28–37).

A study of Singapore's science park strategy proposes and tests another analytical framework for Science Parks. Koh *et al* (2003: 7–15) ask what it takes for a Science Park as a system to evolve and grow. They identify three primary aspects critical for understanding how a science park operates and grows over time:

- growth mechanism: the factors and capabilities that sustain a science park and enable growth over time;
- technological capabilities: the development and strengthening of capabilities in R&D, and the creation of competitive advantages in specific technology sectors; and how different regions specialise in the chain of technology production;
- global role and market integration: the linkages between the region and the global or national economies, the degree of integration with regional or global markets, and the creation of the region's niche in the global system.

The authors classify the growth factors into two sub groups: gestation and takeoff factors needed in the starting phase; and growth-sustaining factors which are the capabilities that enable a science park to renew and sustain itself (Koh *et al* 2003: 8). Compared to the previous study (Breshanan *et al* 2001: 856–858) the finding is identical.

Etzkowitz has used the Triple-Helix model to analyse Technology Parks. According to him, a first step in the shift of a hands-off linear model was the recognition that publications were insufficient to insure the utilisation of research results, at least in the short and even medium term. Government programmes have become a significant source of resources for technology start-up firms – the government has taken the role of a venture capitalist. Etzkowitz labels the model as 'demand-side assisted linearity', in which the public authorities finance research and start-up firms to develop technology and products, for example to the needs of the army or space agencies. A 'supply-side assisted linearity' includes e.g. university technology transfer offices. Another form is the development of hybrid organisations, for example joint university-industry research centres. (Etzkowitz 2006: 315–316.)

From the knowledge transfer point of view the links between firms, as well as the links between firms and university are of high importance, and an object to be studied also in this research. Vedovello has conducted an interview-based study on the firm-university links in Surrey Science Park in the UK (Vedovello 1997) while Phillimore has used questionnaires, but with the same taxonomy, in a study on the Western Australian Technology Park in Perth (Phillimore 1999). In the British case both the Technology Park management, firm owners or R&D managers, and university researchers were interviewed. The sample included 21 of the 60 firms in the park. The links used in the firm interviews were the following (Vedovello 1997: 497–498):

- informal links: personal contacts with university academic staff; access to specialised literature; access to university department research; attendance at seminars and conferences; access to university equipment and attendance at education/training programmes;
- human resources links: students involvement in projects; recruitment of recent graduates; recruitment of more experienced scientists and engineers; and formally organised training of firm's personnel at university;
- formal links: engagement of university academic staff for consultancy; analysis and testing in university department; establishment of research contracts; and establishment of joint research.
- establishment of joint research.

The majority of firms had some kind of link with the local university: 19 of the 21 firms (90%) had one or more links in the informal category; 52% had human resource links; and 7 (33%) had one or more formal links. 62% of the firms had links also to other universities: 50% informal; 35% human resource-related; and 35% formal links. The results show that the less structured organisational approach the links require for their establishment (personal contacts, access to literature, and attendance to seminars and conferences), the higher the number of firms involved. On the other hand, the most common informal links to the other universities were personal contacts, access to research, and attendance at seminars and conferences. This implies that expertise, quality and adequacy of the research matter more than the physical proximity. (Vedovello 1997: 499–500.)

Of human resource links, the recruitment of graduates and students' involvement in projects were the most usual ones (9/21 and 8/21 firms), although none had recruited experienced scientists and none had undertaken staff training. Training was sourced from other universities as often as from the local, but recruitment and student involvement in projects were not as usual. 7 of 21 firms had formal links as well to the local as to other universities. 4 firms used local testing services and 3 of those came from other universities. Joint research was more usual with the local university (3 cases) while only one had such a link to other universities. With regard to using academic staff for consultancy, 6 firms used the expertise of non-local universities' and only 1 a local university. With respect to the establishment of only one category of links at the same time, 8 firms established links with the local university while only 4 firms developed links with other universities. In the case of multiple simultaneous links, 12 firms chose the local partner and 8 other universities. When all three types of links are concerned, 5 firms chose the University of Surrey and 4 other universities. The results suggest that geographical proximity facilitates mainly the establishment of informal and human resource links. (Vedovello 1997: 499–500.)

Unlike Vedovello, Phillimore used mailed questionnaires. 38 firms (65%) answered questions on local collaboration and 52 (90%) of the total of 58 firms answered the simpler questions about all collaboration. According to the survey, 63% of the firms had at least one link with a local university. A higher number of firms had formal links to the local university more than to others. According to this result, proximity counts. The number of firms with all three types of links to the closest university is double the number with such linkages to other local universities. Research based collaboration (joint research and shared equipment) was not widespread or important, with only 5 and 6 firms respectively reporting these types of links. The same survey studied also inter-firm cooperation that was more important with 55% of the firms involved. Phillimore concludes that one should not assume that technology transfer would work in the same way around Technology Parks. Firms differ in the type and pattern of interactive behaviour they are engaged in: some are mainly park-focused while others are more university-linked; some are both, and very few are neither. (Phillimore 1999: 676–679.)

Fukugawa has come to similar conclusions as Vedovello in his study on Japanese new technology based firms. He indicates that on-park firms participate in joint research with research institutes more than other firms, but the collaboration is not localised. (Fugukawa 2006: 393.) A Swedish study covering 273 firms confirms the finding that on-park firms are more likely to have a link with a local university than other off-park firms (Löfsten & Lindelöf 2001: 870–

871). Löfsten and Lindelöf have also studied the differences in academic and corporate spin-off firms. Of the 74 university spin-offs 70% cooperate with universities, as well as 59% of the 60 corporate spin-offs. There were no significant differences in the growth of sales or profitability between the two groups. (Löfsten & Lindelöf 2005: 1032–1035.) A study on Greek Technology Parks indicates that informal links have been developed between firms and the local university, but formal links have been developed only in one of the three Technology Parks. Synergies between on-park firms are limited to commercial interaction and social interaction. Research synergies were not found at all. (Bakouros *et al* 2002: 126–127.)

A Finnish study – covering the five largest Science Parks in Tampere, Espoo, Jyväskylä, Oulu, and Turku – compared the different operational models and the effects of the Technology Parks. In a sample of 297 firms, 55% had some kind of cooperation with research centres and higher education institutions. The local ones were the most common partners. In 50% of the cases the cooperation had led to one or more innovations. (Mäki & Sinervo 2003: 8.)

In Taiwan's Hsinchu district the cluster was mainly based on a combination of collaborative and competitive interactions instead of collaboration and dependencies, but – according to the researchers – it still functions as a local innovative milieu (Hu *et al* 2005: 379).

Hansson and his colleagues have conducted two in-depth case studies, based on interviews and other material, on Technology Parks in Denmark and the UK. They found that in one Technology Park the university-industry collaboration did not work even though there was an intermediary institution to transfer research results to firms. The researchers suggest that by building that type of intermediary organisation, it may in fact institutionalise and cement a low interaction between universities and industry. They form the illusion of bridging the gap between science and economy, while in fact such intermediaries contribute significantly to keeping the institutions of science and economy apart. In the other model – the 'Newcastle model' – the vision is, instead of transferring research results with commercial potential from the university to the regional economy, to make the university itself an active player in the regional economy. The difference is that the traditional model is tailored to help commercialise the research, whereas the Newcastle model seeks to build an institution that is capable of producing commercialisable research. The classic Science Park model is strong enough to give birth to innovations already developed or in embryo, but to meet the demands in a complex knowledge economy with a high degree of uncertainty a new type of science park is needed. According to the authors, the Newcastle model – which may be termed the 'campus model' as opposed to the traditional 'greenhouse model' – represents second-generation science park thinking: universities as science parks. (Hansson *et al* 2005: 1047–1048.)

Sinervo and Mäki – whose study of Finnish Technology Parks was cited above – contend that, according to the data, the role of Technology Parks in advancing cooperation is mainly passive. Interviewees emphasised that the services a centre provides should fit the firms' needs. The authors argue that it is unlikely that a Technology Park itself can have all the needed expertise. Therefore the park should create a network of service providers to fulfil the firms' requirements. (Mäki & Sinervo 2003: 10–11.)

Lehtimäki has studied the strategy configuration of the Hermia Technology Park in Tampere. The study covers the development from the start in the year 1986 to the year 2004. The Triple-Helix model has been used as the main analysis tool. In the discussion of his dissertation he lists the most important outcomes and insight, of which the most valuable are (Lehtimäki 2005: 221–226):

- institutional, organisational, and individual levels should be carefully considered when innovation systems are inspected, evaluated or developed. The human level is especially crucial;
- specific locations are needed for innovativeness. Information and communication technologies cannot replace the human factors: the face-to-face communication; and trust;
- in the academic research the focus is on direct and formal links between Technology Parks and their environment, neglecting the informal and personal networks;
- a communicative strategy process of good quality should be employed between all the important stakeholders;
- the strategy process and strategic thinking of the Technology Park should consist of careful analysis of the actors and their resources and competencies, the balanced mix of stakeholders representing different objectives is needed, although it is very challenging to direct these actors toward common objectives;
- the driving factor has been the world-class research in selected specific areas;
- as high-technology becomes everyday life, developers have to explore and adopt other driving factors for future success;

– a team of powerful individual actors from important stakeholder organisations is needed in the starting period of a science park.

The reviewed literature includes studies on individual Technology Parks or local clusters. An additional possibility for Technology Parks to develop the access to knowledge and other factors, is to collaborate with other Technology Parks i.e. form networks. In Northern Finland 15 Technology Parks of various sizes cooperate in the frame of the Multipolis network. The basic idea is specialisation in some activities, such as research and special laboratory equipment, and cooperation in tasks that would be e.g. financially difficult for one Technology Park to realise alone. One of the basic ideas is knowledge transfer between the Technology Parks but especially from Oulu – the largest one with the strongest research and education resources – to the smaller Technology Parks. Jauhiainen has studied the functionality of the Multipolis network on assignment from the Finnish Ministry of the Interior (Jauhiainen *et al* 2004). In an article, Jauhiainen argues that despite the strong public claims of Multipolis as a high-technology network, there is no direct model upon which it has been consciously developed. It is a flexible combination of the 'technopolis' and the 'learning region' models. The former is based on advanced scientific high-technology knowledge in Oulu, and the latter on the possibility to enhance human resources related to high technology in the rest of the Northern Finland. He summarises that Multipolis has enhanced cooperation, acquisition of new information, social networks, and joint projects, but the management of the network requires more attention. (Jauhiainen 2006: 1424–1426.)

The reviewed research concerns mainly large Technology Parks. The contribution of this study is to create knowledge about small Technology Parks with limited services – e.g. where the existence of a local university is not certain.

2.3 Social capital

2.3.1 Theoretical base

The importance of interorganisational networks has risen in the last decades because of the contribution networks create in production as well as in other business processes but especially in the innovative capabilities of firms (Powell *et al* 2004: 59–60). Castells concludes that: "as a historical trend, dominant functions and processes in the information age are increasingly organised around networks" (Castells 2000: 500). Collaboration in networks occurs in several ways: informally between individual persons; informally between managers and employees in firms; and in formal relationships between organisations including firms, municipalities, universities, etc. Formal inter-firm networks can be based on various types of contracts: e.g. purchase contracts; subcontracting; licensing; and joint ventures. The possibilities are many. Innovation networks may be based on formal contractual relations – such as subcontracting relationships, strategic alliances or participation in an industry-wide research consortium – or on informal ties based on a membership in a professional or a trade association, or on an even looser affiliation in a technological community. Networking leads to benefits with respect to information diffusion, resource sharing, access to specialised assets and interorganisational learning. (Powell & Grodal 2005: 60–62.)

Connections and links between people form the basis of networking. Even if the cooperation between firms is built on specific contracts, the negotiations and connections are dependent on the interaction between persons working in the firms. These interpersonal ties can be strong or weak. A strong tie means that persons interact on a regular basis. Strong ties are important for the social support. A weak tie is the opposite, 'a friend of a friend' type of interaction that is valuable as a source of novel information. (Granowetter 1973, Powell *et al* 2004.)

Another type of link is a bridging tie via a third person who makes a weak tie possible. The question 'how a link can be built' – instead of asking who bridges two persons – defines a structural hole. These holes are potential connections that can be used to broker gaps in the network. (Powell & Grodal 2005: 61–64, Burt 2004: 386–394.)

Burt uses the term "brokerage" with persons, who are situated in a network so that they form a link to several other groups or organisations. People connected across groups are more familiar with alternative ways of thinking and behaving. Brokerage across the structural holes provides a vision of options otherwise unseen (Burt 2004: 354–356).

Ahuja (2000: 448–452) studied the impact of direct ties, indirect ties, and structural holes on the innovation activities of a firm. Direct ties serve as sources of resources and information, indirect ties as sources of information, and structural holes between partners expand the diversity of information that the firm has access to, but also increase the firm's exposure to potential malfeasance. In his study Ahuja found that direct and indirect ties influence the innovation output positively but the impact of indirect ties is moderated by the firm's level of direct ties. He also found that – at least in inter-firm collaboration networks – increasing the number of structural holes decreases the innovation output.

The term social capital has been given very different meanings in the literature, and there seems not to be any agreement on the definition. According to Robert Putnam – inventor of the idea of social capital – the central idea of the social capital is that networks and the associated norms of reciprocity have a value (Putnam 2001: 41). In Halpern's definition the social capital consists of *"social networks and the norms and sanctions that govern their characteristics*", and "*it is valued for its potential to facilitate individual and community action, especially through the solution of collective action problems*" (Putnam 2001: 10). Halpern contends that the social capital has three basic components: the network, a cluster of norms, values and expectations shared by group members, and sanctions that help to maintain the norms and the network. The sub-types of the social capital are bonding, bridging, and linking. Bonding can refer to strong ties and bridging to weak ties while linking is an even weaker connection including e.g. norms like the mutual respect. (Halpern 2005: 10–27.)

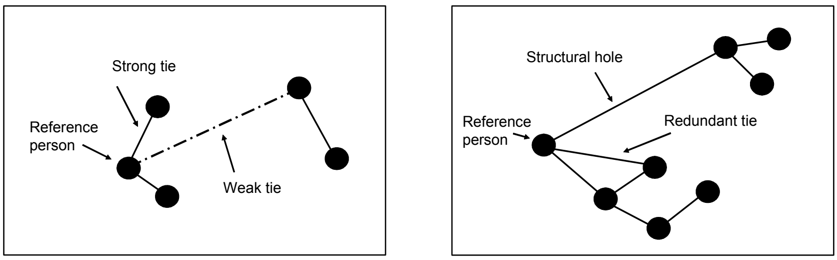


Fig. 9. Strong and weak ties, structural holes and redundant ties (Powell & Grodal 2005: 61–62).

A Canadian study measured the effect of social capital on innovativeness. In the survey – covering over 400 manufacturing firms – six components of social capital were defined: the business network, the information network, the research network, the participation, the relationship, and the trust capital. The network and the relationship capitals affect the innovativeness, and the relationship and the research network capitals have the biggest influence on how radical the innovations are. The differences between the types of social capital were big. The researchers claim that marginal increases in the social capital indexes have a greater impact on decisions regarding innovations than marginal changes in an advanced technology. The groups or networks with the highest effect functioned in geographically limited regions, or were professional communities at least at nationwide level. (Landry *et al* 2001.)

Researchers do not agree on the role of local social structures – or bonding local social capital. While Halpern (2005) emphasises the positive role of bonding social capital, Florida argues that social structures, that in earlier years were important for prosperity, now work against it. He argues that today the weak ties are of higher importance. (Florida 2002: 266–282.) Castells (2000: 22, 50, 386–393) emphasises the role of virtual communities in innovation. Thus, a high local bonding social capital is not necessarily positive for innovation and transfer of the knowledge that is really needed in product development.

2.3.2 Research on social capital

The previous Section focused mainly on the definition of social capital. The following text reviews actions taken by firms, universities and other organisations to build networks and especially a higher level of social capital. Also some attempts to utilise them for a better innovativeness is analysed.

One possibility for a firm or some other organisation to develop its network is to take actions that help to build social capital over the organisational boundaries. The German nationwide organisation for contract research, Fraunhofer Gesellschaft, has established a knowledge management community. The goal was to integrate knowledge sharing within the innovation processes into an organisational practice. Several methods – e.g. on-line platforms, telephone calls, emails and mailing lists – were used. Müller-Prothmann studied the relationships in the knowledge transfer over formal organisational boundaries, and the informal inter-organisational network structures. The study showed that the measures taken proved to be effective to overcome organisational boundaries even if the changes were marginal within the first four month period. A small number of members was of critical importance and key to knowledge flows within the various discipline related networks. The results also showed that relationships between the community members tend to be based on personal ties (personal email, telephone) rather than on institutionalised communication channels established for the purpose (mailing-lists, on-line platform). (Müller-Prothmann *et al* 2005).

Scarbrough (2003) has conducted a case study on the implementation of a knowledge management practice and a system in a worldwide organisation, Ebank. The bank is located in 70 countries. The main problem was that each country and each department operated independently with their own systems, services, and processes. The knowledge management implementation project was managed so that there was very little interaction between top managers, developers, and users. All this led to a failure. The ultimate problem was the lack of intra-organisational networks that could have linked the divisions. The conclusion was that if the intra-organisational network and knowledge transfer do not function, neither does a technology based knowledge management system.

University-firm collaboration has significant importance for new innovations. Chakrabarti and Santoro (2004) studied the interaction in 21 university–industry research centres in the USA. According to them the role of the universities has a resource-based view in the recent literature. They indicate that building social capital is an often overlooked contribution that a university can make to industrial firms. Chakrabarti and Santoro found that individuals committed to promoting relationships are important, the presence of a dedicated champion from both the university and the firm affects the building of trust, and especially the presence of a firm champion is important for the problem-solving dimension of the collaboration. A certain individual commitment is needed also to develop and maintain the bridge. The geographical proximity helps in relation to building, developing the problem-solving dimension of the collaboration, and in developing and maintaining the bridge. This implies that localised university research centres bridge gaps. On the other hand, the authors found that a university's high reputation is negatively associated with problem solving. With respect to the networking dimension the academic ranking of the university is an important variable while the geographic proximity is not, at least for large firms.

On a smaller scale, social capital and links between experts can be built e.g. on the product development team level. Hellström conducted a study on new models of arranging product development teams (Hellström & Malmquist 2000, Hellström *et al* 2002). Both of the cases are from telecommunication industries. In the first case an informal competence network was created within the firm, while in the other the team worked in an inter-organisational network context. The teams were not placed in the line organisation and thus it was easy to exchange experts when the needs in projects changed. The management was light and the teams were encouraged to network informally for competence and knowledge inside the firm. According to the researchers, the projects succeeded well which shows the model works well.

In the next case, the focus was on the influence of the network collaboration on the performance of an organisation. Sobrero (2000) analysed 173 new product development projects accomplished by 24 R&D units of a profit oriented organisation, using mixed regressive-autoregressive models. The results confirm the importance of network effects on the performance of a unit. The magnitude and the direction of the effect are dependent on the project characteristics. While networking in the client direction, the influence on the performance is positive when the project tasks are highly complex, negative with a medium complexity, and with low level tasks the negative effect increases. In server relations the effect is – in the same way – positive for high complexity tasks, lower for medium level tasks, and negative when the tasks are simple. A major reason for the results may be that the percentage of coordination costs is higher for simpler projects.

This study examines on a firm level product development projects in relation to knowledge transfer from both local and broader networks. The previous cases discussed the networking and social capital from the firms' point of view while the next ones are studies on the firm network level.

Owen-Smith and Powell (2004) studied formal inter-organisational networking in a regional network, the biotechnology community of the Boston region. They found two important non-relational features of formal interorganisational networks: geographic proximity and organisational form. These characteristics alter the information flow through the network. They show that the spillovers resulting from alliances are a function of institutional commitments and practices of the network members. When the dominant nodes in an innovation network are committed to openness, the network structure is characterised by less monitored ties.

A contrary study on the importance of intra-regional ties to the growth rate and the innovative activities of a firm has been conducted by Arndt and Sternberg (2000). The study is based on the results of a survey carried out in 10 European regions. The results verified that in spite of numerous network relationships on the national and international level, small businesses most likely cooperate with others in their vicinity also when high technology ventures are concerned. Additionally, the more knowledge intensive the innovation activities are, the more important the spatial proximity, in particular, and networking, in, are.

Singh (2005) examined whether interpersonal networks help to explain two well known patterns of knowledge diffusion: the geographic localisation of knowledge flows; and the concentration of knowledge flows within firm boundaries. In his study he explores the knowledge flows between the inventors of any two patents, and compares the results with the existing ties between those two inventors. Singh argues that the existence of a tie is associated with a greater probability of a knowledge flow. The probability decreases when the geographic distance increases. The geographical proximity has a positive effect on the knowledge flow because persons living in the same region are more likely to know each other on a personal level. The intraregional knowledge flows can be stimulated by building a geographically larger social network by promoting participation in collaborative networks.

Elfring and Huisink studied the innovative activities in young entrepreneurial start-up firms. They examined whether the degree of innovation is dependent on how the network ties support the entrepreneurial processes. They concluded that a particular mix of strong and weak ties is valuable for two processes: discovering opportunities; and gaining legitimacy. Firms engaged in radical innovations benefit from weak ties in the opportunity discovery process, while strong ties are needed for tacit knowledge exchange and trusted feedback. Strong ties are negative in obtaining socio-political legitimacy. Weak ties are needed for a more approval of the new products. (Elfring & Huisink 2003.) Bell (2005: 292) suggests that locating in an industrial cluster, as well as the centrality in the managerial tie network, enhances firm innovation, while centrality in an institutional tie network does not.

The third context level is the local innovation system level, linking more actors in the network. A Swedish study examines the local social capital in two Swedish rural districts with economic problems. The districts are different from each other and also take different kinds of measures to overcome the problems. In one of the two cases, attention is paid to the development of social networking. The results show that private and public actors in collaboration can change the social capital. (Westlund *et al* 2002.)

The studies mainly concur that relatively strong interpersonal networks enable collaboration between local firms, especially when SMEs are concerned. At the same time, weak ties are needed to acquire knowledge. A typical innovation network has a local and regional focus with a strong social capital, and it is supplemented by larger geographical networks and electronic interaction (Polt & Schibaly 2001: 324).

Local networking and its role in the knowledge transfer processes will be discussed further in the context of innovation systems.

2.4 Innovation and product development processes

2.4.1 Product development processes

Knowledge transfer to product development processes – both new products and improvements – is the main topic of this study. In addition, there are also other types of innovation processes in a firm. The goals may be related to e.g. the development of production, business processes, or supply chain management. The activities are usually conducted as projects to make them easier to manage. Some of the processes and projects are conducted by the firm alone but in many cases also external resources are utilised to perform a whole project, some specific stages, some specific tasks, or to transfer special knowledge into the firm. Innovation projects are not easy to conduct: 2 out of 5 has been found to fail (Cozijnsen *et al* 2000: 158).

On the common level an innovation process is often illustrated by an innovation funnel (Fig. 10). The model has also been advanced further to describe the factors affecting the process: controls by customers, feedback from results, and resources including teams, budgets and models (O'Sullivan 2002: 80, O'Sullivan 2003: 111). The whole funnel is included in the area of this study.

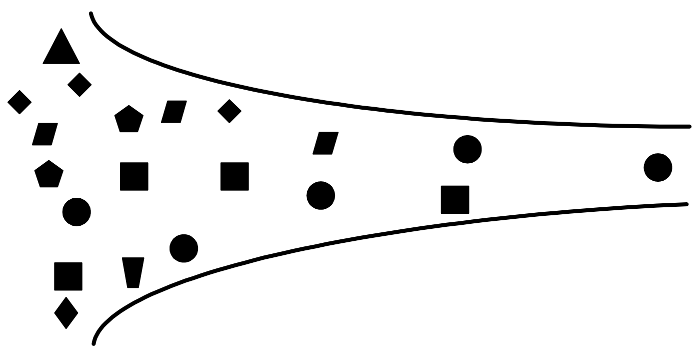


Fig. 10. The innovation funnel (Hayes *et al* 1988 in O'Sullivan 2002: 80).

Apilo and Taskinen have illustrated the product development process elements: i.e. the front end, product development stages, and concept development between them as one process model in Fig. 11. According to them the front end of the product development process is the most demanding part. The front end is important because in it the firm forms the understanding of the future development of the market, technologies and customer needs, and chooses the base for future innovations – e.g. emerging technologies. The front end has usually been thought of as the chaotic fuzzy front end that cannot be modelled as a process. Today the understanding is that, although it cannot be tightly modelled, the tasks can be identified and classified. Apilo and Taskinen apply Koen *et al*'s classification and divide it into opportunity identification, idea generation, idea refinement and idea evaluation. (Apilo & Taskinen 2006: 43–44, Koen *et al* 2001.)

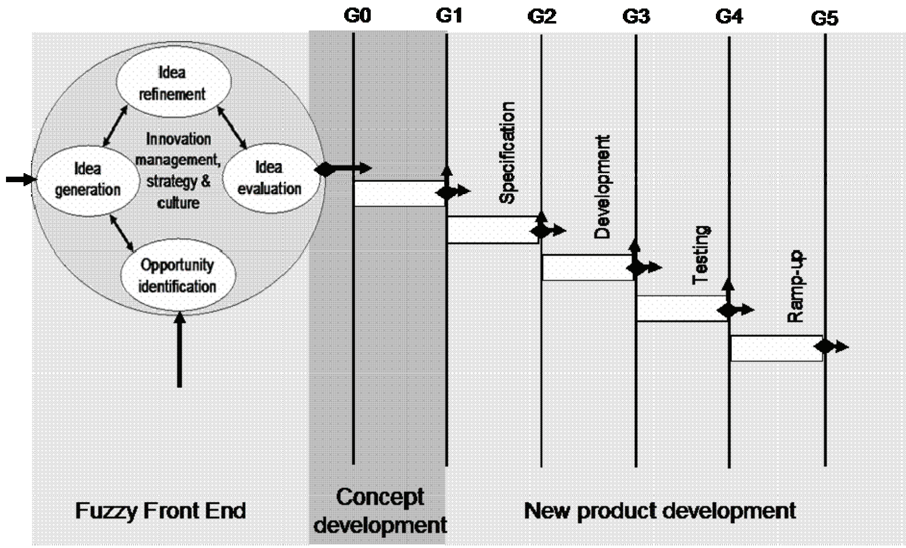


Fig. 11. The innovation process (Apilo & Taskinen 2006: 43).

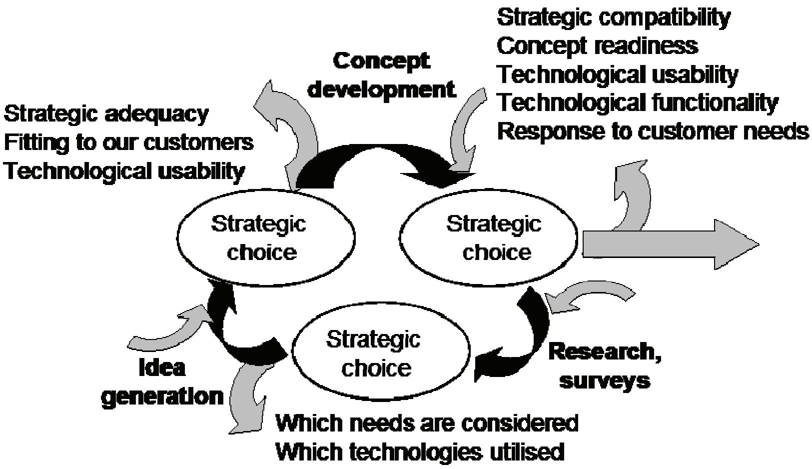


Fig. 12. The strategy circle of the concept development process (Apilo & Taskinen 2006: 45).

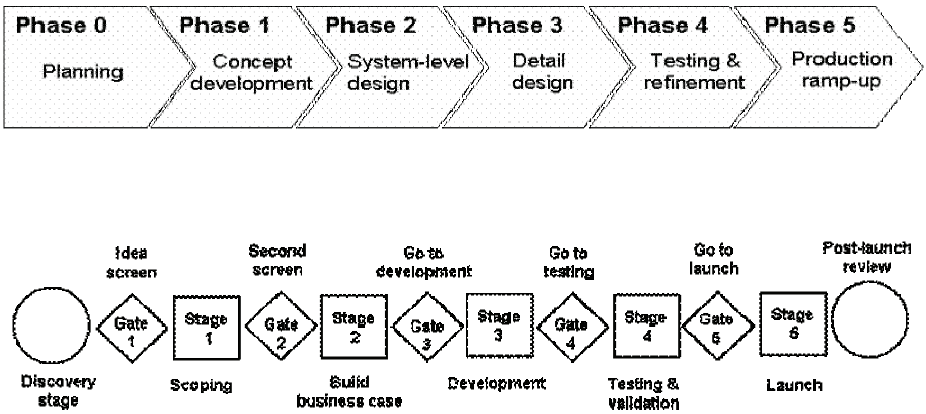


Fig. 13. Ullrich-Eppinger –model and Stage-Gate model of product development process (Ulrich-Eppinger 2003: 9, Cooper 2006: 22).

When a managed product development process is concerned, the next stage after the front end is the concept development. Koen et al (2001) include it in the fuzzy front end while Apilo and Taskinen define it separately as a circle of idea generation, concept development and research with strategic choices between the elements (Fig. 12).

As the illustrations by Apilo and Taskinen show, knowledge and information is needed in the front end of the innovation process. R&D, logistics and production personnel's intermediate knowledge of technologies, marketing, planning and service personnel bring in the needs from users, and management about the business environment (Apilo & Taskinen 2006).

Product development process can be illustrated in several ways. Ulrich and Eppinger use a six phase model illustrated in Fig. 13. The phases are planning of the product development project, concept development, system-level design, detail design, testing and refinement, and production ramp-up emphasising the participation of all the functions of the firm. They define several process variants: generic (market pull), technology-push, platform, process-intensive, customised, high-risk, quick-build, and complex. (Ulrich & Eppinger 2003: 18–21.) The stage-gate model presented by Cooper differs from the Ulrich-Eppinger model to some extent especially in the front end. He identifies five stages (i.e. discovery, scoping, build business case, development, testing and validation, and launch), but he has also introduced modified processes where the number of stages is reduced to two and three. (Cooper 2006.) The concept development phase is involved in the products development process differently from Apilo and Taskinen (Apilo & Taskinen 2006, Ulrich & Eppinger 2003, Cooper 2006). The Ulrich-Eppinger model defines the design phase more detailed than the Stage-Gate model.

Moore has widened the view of product development by introducing the whole product concept. He suggests that the first market – with technology enthusiastic innovators or early adopters as customers – can be taken with the technology and the core product, but that getting over the chasm to the early majority demands the use of the whole product concept (Fig. 14). Additional features and services are added to the generic product in collaboration with other firms. (Moore 2002.) This emphasises the importance of the networking and the knowledge transfer with other firms.

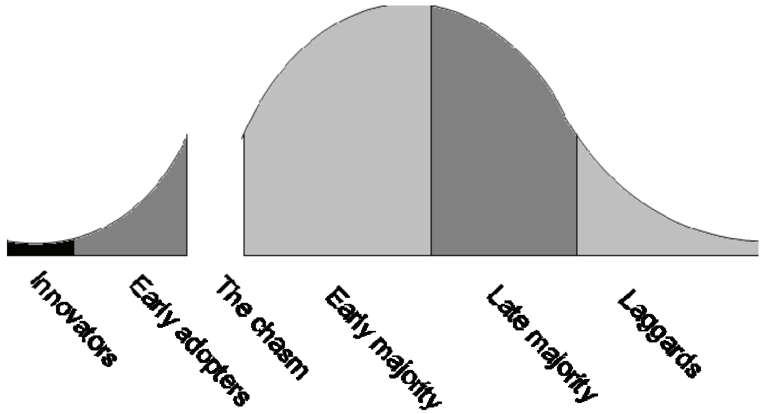


Fig. 14. The revised technology adoption life cycle (Moore 2002: 17).

Product development processes have been studied from various points of view. Several researchers studied the processes on a common level (Cavone *et al* 2000, Canticani 2006, Carbonara & Scozzi 2006, Ottosson 2004, Scott 2000, Galanakis 2006), some studied and developed the stage-gate model further (Cooper 2006b, Cooper 2006c, Ettlie & Elsenbach 2007), and some studied the processes in small and medium size firms (March-Chorda *et al* 2002, Edwards *et al* 2005). The processes were also been form the complex system point of view (Chapman & Hyland 2004, Galanakis 2006). Colarelli, O'Connor and DeMartino (2006) have worked on radical innovations. Also the effects of discontinuity in technology, market, and political conditions were studied (Bessant *et al* 2005) as well as the effect of turbulence in the market and technology (Suikki 2007). Chanal has studied the design of project oriented organisations to better serve the product development process (Chanal 2004), and Drejer the tailoring of innovation management (Drejer 2002). Some researchers indicate that the management of the new product development is not enough but the whole innovation process must be managed (e.g. Apilo & Taskinen 2006). A significant amount of research was done on the success factors (Drejer 2002, Balachandra & Friar 1997, Balbontin *et al* 2000, Cooper & Kleinsmith 1995, Jensen & Harmsen 2001) as well as the effect of national culture based differences on the product development process and performance (Balbontin *et al* 2000, Bobe & Bobe 1998, Lee *et al* 2000, Tsuji 2001, Oliver *et al* 2004).

2.4.2 *Interorganisational knowledge transfer to innovation processes*

In this study the focus is on knowledge transfer to the firm, and especially to its product development process. Knowledge is transferred when the firm is in interaction over its boundaries with customers, suppliers, subcontractors, knowledge intensive business services, higher education and research institutes etc. as described in the Sections on knowledge management, networking and the role of external actors. According to Schibany and Polt (2001: 321–325) firms rarely innovate alone, the importance of knowledge-intensive services is growing, informal networks and trust are important, and internationalisation goes hand-in hand with strengthening domestic networks.

Firms seek collaboration in product development processes to share risks (Littler *et al* 1995) and find complementary resources (Littler *et al* 1995, Becker & Dietz 2004: 216–221, Emden *et al* 2006: 334–340, Ebersberger & Lehtoranta 2005: 66–67). The collaboration enhances the R&D intensity and, when the parties are heterogeneous, the productivity (Becker & Dietz 2004: 216–221, Littler *et al* 1995: 24–31). The probability of new products grows as a function of the number of partners (Becker & Dietz 2004: 218). The innovation system affects the cooperative behaviour (Dachs *et al* 2004: 28).

According to Emden *et al* (2006) the partner selection process has three phases: technical alignment, strategic alignment, and relational alignment. First, firms recognise the potential partner's unique technical ability, complementary technical resources and market knowledge, and a complementary knowledge base. When partners develop a mutual understanding of technologies and their implications in the market, they continue to the second phase: strategic alignment. If motivations and goals correspond, they start to specify an initial co-development project. The third phase – relational alignment – involves finding if the cultures are compatible, firms are ready to adapt processes, and make short term sacrifices to get long term results. After the third phase firms have to determine the financial and legal feasibility of a co-development project and create organisational acceptance. When all the phases and decisions have been accomplished, the partnership with potential to create synergistic value can be started. (Emden *et al* 2006: 334–338.) The results are supported by Rycroft & Kash (2004: 191–193) concerning the adaptation of processes. The technical alignment argument is supported by several studies (Littler *et al* 1995, Becker & Dietz 2004, Emden *et al* 2006, Ebersberger & Lehtoranta 2005). For many features the results by Emden *et al* (2006) get support from the ARA model (Håkansson & Snehota 2005).

The customers' role in product development has been emphasised in the literature. Von Hippel has introduced the term "*lead user*". According to him, lead users have two distinguishing characteristics: "*(1) They are at the leading edge of an important market trend(s), and so currently experiencing needs that will later be experienced by many users in that market. (2) They anticipate relatively high benefits from obtaining a solution to their needs, and so may innovate.*" (Von Hippel 2005: 22.) Also several other studies show the value of collaboration with users or customers in the product development process. Baglieri and Zamboni (2005: 11–13) claim that the partnership can be successful if the relationship is a long term one with high interaction frequency – thus also emphasising the strength of the tie – when the actors have complementary competencies, and little overlapping in their value chains. Specific users can have a dominant role also in the development of radical innovations (Lettl *et al* 2004: 8–18). In some cases high technology firms have been found to neglect the lead user concept because the product development personnel may evaluate the product concepts as too simplistic and less valuable (Olson & Bakke 2001: 391–392). Anyhow customer as well as supplier relationships are understood to have less impact on the innovation performance than knowledge and creativity management (Prajogo *et al* 2004: 183–184). Customers' knowledge is used most frequently both at the early and late stages of the product development process, but at the same time customer relationships can have a negative impact on innovation success (Knudsen 2007: 127–133).

Suppliers are involved in product development to improve product cost and quality as well as development cost and time (Wynstra & ten Pierick 2000: 55–56). According to Hartley *et al* (1997: 2264–266) the timing is important: early supplier involvement is significant for the contribution regardless of whether they are providing standard or custom components. Sharing technology information with a supplier results in higher levels of supplier involvement and improved outcomes, while supplier involvement in teams ly results in a higher achievement of product development team goals, especially when a technology is complex (Petersen *et al* 2003: 291–296). An intermediary firm specialised in the tailoring of new technology to certain types of applications raises the probability of succeeding (Tomes *et al* 2000: 123).

The role of knowledge transfer from universities – as well as other higher education and research institutions – in innovation processes is evident e.g. in the

Triple-Helix theory (e.g. Etzkowitz & Leydesdorf 1995, Etzkowitz & Leydesdorf 2000). Simonen argues that cooperation relations with government and private non-profit research institutes is crucial only for process innovations, but different types of collaboration networks can have a positive effect on the innovativeness of high technology firms (Simonen 2007: 138–140). Nobelius has studied knowledge transfer from in-house applied research to product development. He argues for strategic and operational synchronisation – strategic alignment of the technology and product strategy; and the direction of applied research tasks towards product development – as well as knowledge transfer management. (Nobelius 2004: 329–332.)

Outsourcing was originally used for cost saving in peripheral business functions but is today part of strategic management and concerns also product development tasks and projects (Hoecht & Trott 2006: 672). Outsourcing of the pre-development phase has been found to improve the level of proficiency and thus shorten time-to-market (Veflen Olsen 2006) and be successful (Kumar & Snavely 2006, Veflen Olsen 2006, Perrons & Platts 2005: 854–859) even in high clockspeed industries (Perrons & Platts 2005: 854–849). Some research results indicate that significant radical innovations are mainly developed inside the firm, while contracted development is more utilised in incremental innovations (Beneito 2006: 513). As shown in the networking context, trust and managing the risks for knowledge leakages have a major role in intra-organisational development processes (Hoecht & Trott 2006: 675–677).

The above section describes mainly dyad collaborations between parties. Major innovations are said to be made in complex networks with several types of partners (Hämäläinen & Schienstock 2001: 22–25). The existence of a lead firm in a network enhances the innovative capacity of the focal network (Badir *et al* 2005: 131, Carbonara 2001: 26–27). The probability of collaborating with other firms (Torbett 2001, Basri 2001) as well as with universities (Schibany & Schartinger 2001) is proportional to the size of the focal firm. The structure of the collaboration is independent of the country (Basri 2001) but the country and the framework of the national innovation system affects the network formation probability (Christensen *et al* 2001).

Knowledge flows, transfer and management have been studied both as intra-organisational and inter-organisational phenomena both in national and cross-border contexts. Collaboration is claimed to enhance innovativeness. Knowledge sharing and management themselves are seen to have the same influence (Hislop 2003: 169–170, Hong *et al* 2004: 105–110, Jantunen 2005: 345–346, Knudsen

2007: 133–135, Scarbrough 2003: 513–514, Subramaniam 2006: 551–553). Various researchers have studied knowledge management in product development from several points of view including e.g. social interaction (e.g. Hislop 2003) and knowledge management systems (e.g. Cooper LP 2003). As a summary, according to the literature new knowledge through and from interorganisational networks is needed to succeed in product development. The knowledge flows will be analysed in the interviewed cases, and the review helps in planning the interview protocols.

2.5 Organisational networks

2.5.1 Networks and networking approaches

Interorganisational links can be studied on several levels (Fig 15, Ritter *et al* 2004: 179). In a dyad relationship the studied phenomenon is a relation between two organisations. In a portfolio relationship one organisation has links to several other organisations. The first tier of a supply chain is an example of portfolio relationships. When connected relations are observed, one organisation has links to several others; and these ones have further relations to other organisations. Typical examples of these types of relations are supply chains (e.g. Lambert *et al* 2006, Rogers *et al* 2006). In the network mode also the relationships between other organisations are relevant; as well as their effect on the organisation. The ARA-model (activities – resources – actors) focuses both on the direct and indirect effects of network actions. Research on inter-firm networking is made on a large scale by the IMP group (International marketing and purchasing group) having over 900 articles on its website, arranging annual conferences since 1984, and publishing its own journal. The IMP group’s core idea is to challenge the atomic view of businesses, and suggest a network and interaction view instead (Ford & Håkansson 2006).

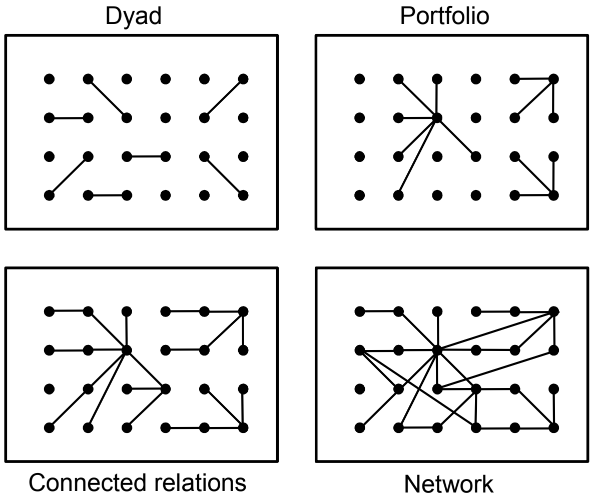


Fig. 15. Levels of relationship and network management (Ritter *et al* 2004: 179).

According to Ford *et al* networking is interactive, it is based on restricted freedom, defined by conventional firm categories, involves combined cooperation and competition, and bases on incomplete knowledge. A firm must choose within existing relationships about its position, and how to network. Networks are broad and complex. (Ford *et al* 2002.) When network levels are discussed, the first management level is the individual actor, and the second one the individual dyad between two actors. The third management level includes connected relationships in which the actor is not directly involved, such as in a typical supply chain. The fourth level is that of the network itself where the network identity becomes relevant. The ability to develop and maintain effective and productive relationships is a fundamental property that varies between firms. The management challenge is to develop a networking ability that enables actors to connect their resources to those of other actors. (Ritter *et al* 2004.)

A dyad between two organisations

Personal contacts and social capital are an essential role in interorganisational cooperation. Halinen and Salmi identified four basic functions necessary for a business relationship to exist and develop: exchange of information, assessment, negotiation and adaptation, and service production and transfer. Personal contacts may either promote or inhibit these functions. Additionally they find six dynamic functions of personal contacts: the role of door opener and gatekeeper, the role of door closer and terminator, and the role of peace maker or trouble maker. (Halinen & Salmi 2001: 14–15.)

Blomqvist and Ståhle have studied networks in a turbulent telecommunication market where both possibilities and risks are high, and the time to learn is minimal. Many of the case firms in this study are in a similar market. According to Blomquist and Ståhle the actors are forced into constant strategising, partnerships are decided fast, many of them are short, and networks are constantly changing. Additionally firm sizes differ considerably. These factors force firms to use managerial practices and processes to foster trust building. The writers present a conceptualisation of trust having three dimensions: competence; goodwill; and behaviour. The organisational base for trust is realised in organisational actions. Similarly the individual base for trust is realised in individual actions. Actions show the evaluator (auditor for trust) the validity of the base for trust through signals and signs. (Blomqvist & Ståhle 2000.) By doing business with a firm having in firm networks a reputation of treating its counterparts fairly, the focal firm can expect to be treated in a similar manner (Andersson *et al* 2007: 35).

An important factor is the pre-conditions for inter-organisational knowledge transfer – how the learning process may affect and be affected by the relationship management efforts (Nieminen 2005b: 7–10). Cultural values and norms matter (Andersen & Christensen 2000: 110). The role of shared identity increases with the specificity of the aim of the relationship because simultaneously the difference of the people involved increases. The shared identity helps in developing mutual trust that helps develop transparency in the partnership and makes learning mutual. Trust helps firms to understand each other better than agreements and contracts. Howver, if the shared identity or the mutual trust grows too strong, creativity in the development of new knowledge is no longer supported and the learning curve forms a bell-shape. (Nieminen 2005b: 9–11.)

As the knowledge transfer process concerns resources that are difficult to imitate, intangible, and valuable, the receiving firm is very dependent on the transferring one in the beginning. As the knowledge is increasingly absorbed by the receiver, the transferor becomes dependent on the receiver's willingness not to behave opportunistically. The inter-dependence between firms changes during the knowledge transfer process. (Nieminen 2005b: 4–5.) On the other hand, the transferred knowledge becomes more implicit making it easier for the transferring firm to transfer the knowledge to third parties. This decreases the mutual dependency of core and supplied skills. (Andersen & Christensen 2000: 108.)

Fig. 16 illustrates the trust and power dependencies in the relationship and the learning process, and implies dependencies between inter-organisational learning and relationship management. (Nieminen 2005b: 7.)

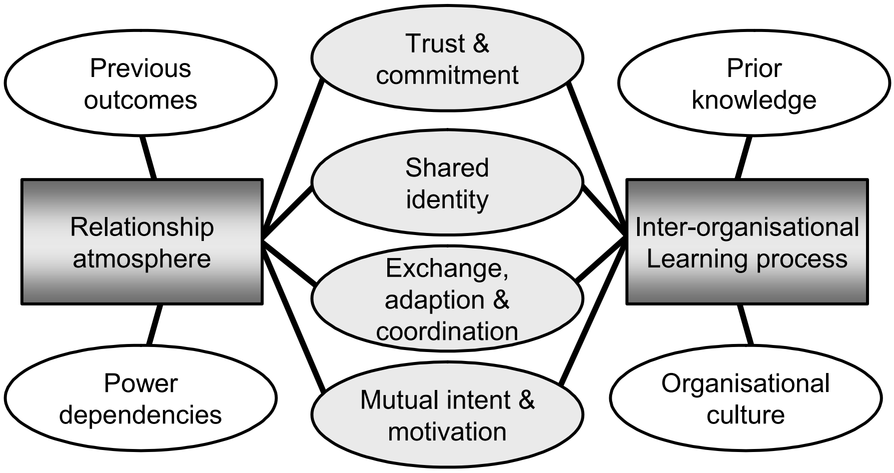


Fig. 16. The inter-dependent factors between relationship atmosphere and the inter-organisational learning process (Nieminen 2005b: 7).

According to Nieminen, knowledge transfer and development of core competences are the sum of knowledge characteristics, organisational characteristics and receptivity, and propensity to share knowledge. The latter one is formed of three components: interaction processes (exchange, adaptation and coordination); support structure (rewarding systems, operational structure and infrastructure); and relationship atmosphere discussed earlier. The relationship atmosphere is composed of mutual trust and commitment, power dependencies, mutual intent, shared identity and previous outcomes. Fig. 17 illustrates the function. (Nieminen 2005b: 7–9.) Andersen and Christensen have built a knowledge transfer model they call a system-based model of shared skill development (Fig. 18). In the model the outcome is the development of shared skills. The organisational, strategic, and cultural differences are the basic initial condition affecting the shared skill development. The process aspect involves both partners' ability to absorb and communicate knowledge across organisational boundaries. (Andersen & Christensen 2000: 106–107.)

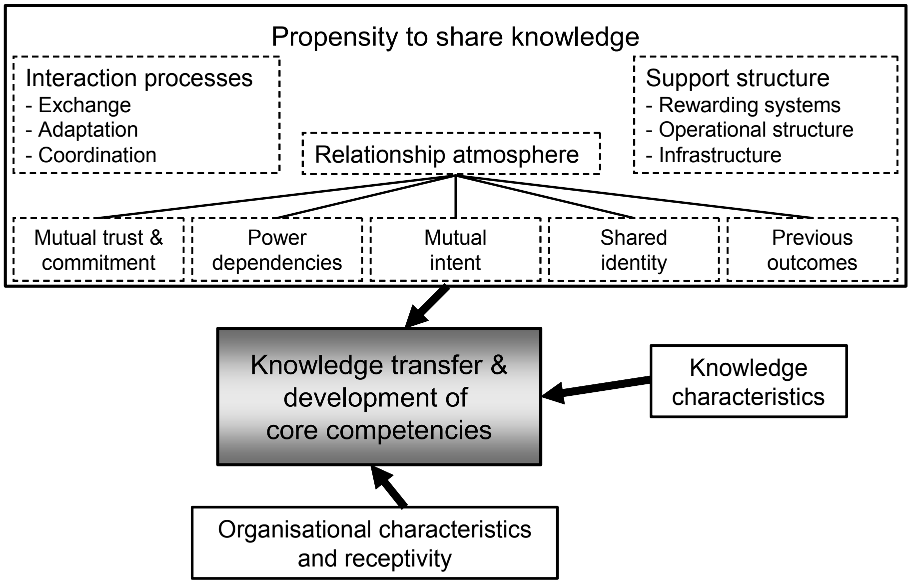


Fig. 17. The factors affecting inter-organisational knowledge transfer (Nieminen 2005b: 9).

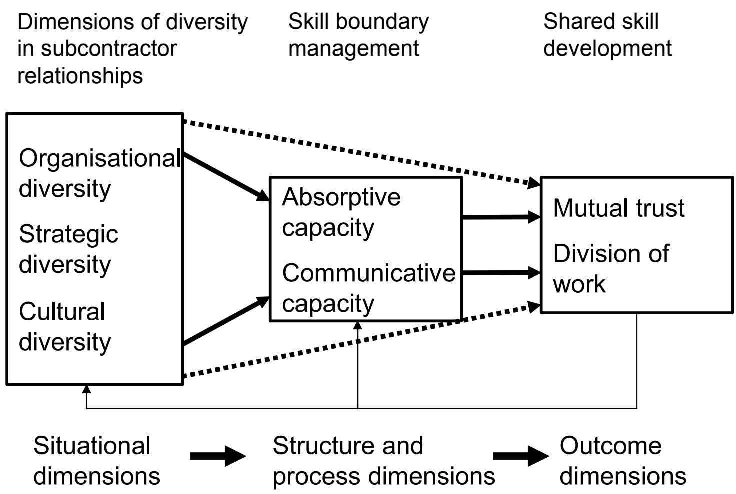


Fig. 18. A system-based model of shared skill development and influencing factors in supply chain relationship (Andersen & Christensen 2000: 107).

Portfolio relationship with several organisations

The previous studies discussed knowledge transfer and learning between two organisations. Firms – also the ones studied in this research – operate in any case in networks with long term relationships where the knowledge is transferred among a group of actors. It has been suggested that the relational embeddedness and the network structure, closed or open system, have a formative effect on knowledge flows and problem solving processes. In an open system there are structural holes, i.e. some of the members are connected to each other only through other members situated in the structural holes. The actors in the structural holes can control the knowledge flows among the other actors and thus are in a very powerful position. Relationships are typically built between two actors. In a closed system actors have connections to all other actors. The knowledge can be obtained in several ways. This gives the actor a possibility to check the quality of the received knowledge, and the knowledge is shared among several actors. (Andersson *et al* 2007: 33–34.)

An open system favours the capture of novel explicit knowledge. If the firm is situated in a structural hole in a totally open system, the knowledge it has collected and combined is truly unique. An open system facilitates knowledge transfer but not so much creating it. The timing is of importance because any firm can absorb the same knowledge. More creation and moving occurs in a closed system where all the actors are linked to one another, but the knowledge often results from problem solving by adapting products and processes from each other rather than from outside the system. This phenomenon supports incremental development and innovation. (Andersson *et al* 2007: 36–39.)

Connected relations with other organisations

A typical example of connected relations is a supply chain that can be described by the supply chain management model (SCM) even though the goal of this study is not to study the supply SCM itself. The Global Supply Chain Forum defines the term as follows (Lambert 2006: 2): *'Supply chain management is the integration of key business processes from end user through original suppliers that provide products, services, and information that add value for customers and other stakeholders.'* There are numerous definitions available with mainly minor differences in the role of information flows and purchasing. Fig. 19 illustrates the SCM both intra and inter-firm business processes that become supply chain processes managing the links (Lambert *et al* 1998: 2). A supply chain network (Fig. 20) is complex (Lambert 2006: 5).

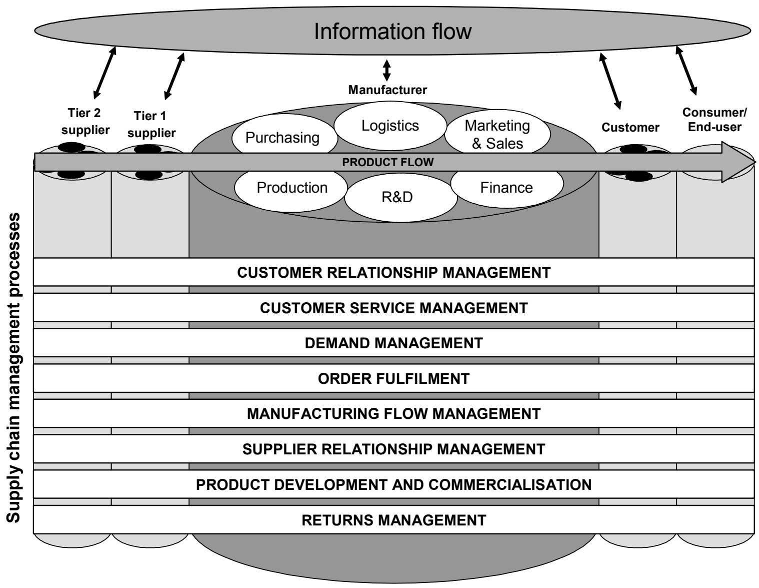


Fig. 19. Supply chain management: integrating and managing business processes across the supply chain (Lambert *et al* 1998).

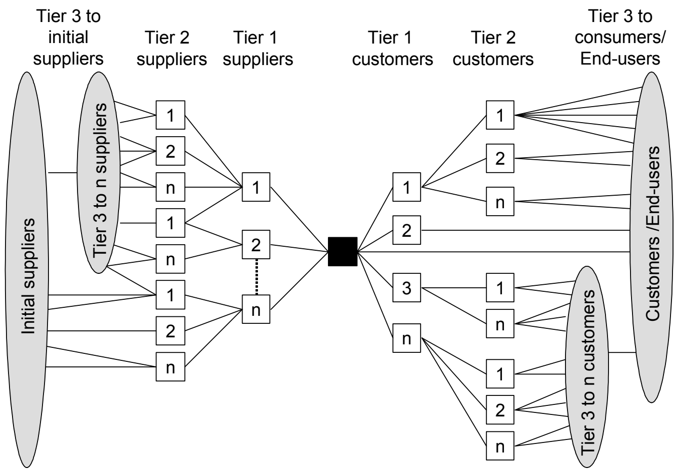


Fig. 20. Supply chain networks' structure (Lambert *et al* 1998: 5).

Business processes can be defined as structured sets of work activity that lead to specified business outcomes for customers (Davenport & Beers 1995). According to Lambert firms want, in increasing amounts, to implement business processes, and integrate them with other members of the supply chain. The reason to do so is said to be the need to make transactions efficient and effective, or to build inter-firm relationships in the supply chain. The value achieved by using standard business processes is that the firms in a supply chain can use a common language, and the firms' processes can be linked. (Lambert 2006: 5–8.)

The SCM framework has three closely related elements: the supply chain network structure, the supply chain business processes, and the supply chain management components. The supply chain network structure consists of the firms involved, and the links between them. Business processes are the activities that produce specific outputs having value to the customer, and the management components are the managerial methods to integrate the processes and manage them across the supply chain. (Lambert 2006: 8–21.)

A supply chain network includes all the firms that participate in it starting from the source of raw materials and ending in their consumption. The need for management of the network depends on several factors, e.g. on the complexity of the product, and the number of available suppliers. When determining which links in the supply chain should not be closely coordinated and integrated, they must be weighed against the firm's capabilities and the importance of the link to the firm. Explicit knowledge of the configuration of a network structure is needed. The three primary aspects are the members of the supply chain, the structural dimensions of the network, and the different types of links across the supply chain. (Lambert 2006: 8–13.)

Three structural dimensions of the network are important for describing, analysing, and managing the supply chain: the horizontal structure; the vertical structure; and the focal firm's horizontal position within the end points of the supply chain. The horizontal structure refers to the number of tiers in the supply chain. If the number of tier one customers and suppliers is high, managing these processes restricts the number of tiers the firm is available to manage. (Lambert 2006: 8–13.)

According to Lambert the supply chain consists of eight business processes illustrated in Fig. 19. The customer relationship management process's goal is to identify key customers and customer groups to be targeted, to segment the customers, and to increase loyalty. In other words it provides the structure for how the relationships will be developed and maintained. The customer service management process involves monitoring the customer's product and service agreements, and identifying and solving problems before they affect the customer. Demand management balances the customer's requirements with the capabilities of the supply chain. Order fulfilment includes all activities necessary to define customer requirements, design a network and enable the firm to meet customer requests while minimising the total cost. Manufacturing flow management covers all the internal and external activities needed to move the product through the production stages flexibly. The goal of supplier relationship management is to define and manage product and service agreements with key suppliers while the goal of product development and commercialisation is to develop and bring products to market jointly with customers and suppliers. Returns management takes care of activities associated with returns and reverse logistics as well as with reducing the unwanted returns and controls of reusable assets such as containers. (Lambert 2006: 13–15.)

To make SCM effective four types of business process links are used according to the importance of each actor to the firm: managed process links, monitored process links, non-managed process links, and non-member process links. The most critical process links are managed while the less critical are monitored. A link can be left non-managed if e.g. there are several suppliers each capable of replacing each other. Non-member process links are links between a member of a firm's supply chain and non-members that could influence the focal firm's activities. (Lambert 2006: 15–17.)

A challenge in managing relationships is that when two firms build a relationship, some of their activities will be linked and managed between the firms (Håkansson & Snehota 1995). Referring to Håkansson and Snehota, Lambert and his co-authors write that they have found firms having different names for same processes, the same name for different processes, and a different number of processes. This causes friction in the joint management of supply chains. (Lambert 2006: 17–18.)

When innovation and knowledge transfer are concerned in supply chain research, Hartmann *et al* (2001: 21–23) emphasise the development of methods, and management of the purchasing situation to ensure quality and innovativeness while Lamming *et al* (Lamming *et al* 2001) highlight the value of transparency over traditional negotiating methods. Håkansson and Persson (2004: 24–25) argue for a broader understanding of the supply chain. Instead of just serial interdependences, there are more complex ones – pooled where two activities are related to a third one, and reciprocal having mutual exchange between two parties

– should be taken into consideration. Andersen *et al* (2001) show with case results that in the Norwegian telecom industry knowledge transfer and technology adaptation has been bidirectional. A Finnish study takes an opposite view and studies smaller software firms searching for partners in the US market. They define the supplier's partner selection process as a continuous assessment of relationships with customers rather than merely commencement needed during the early contract negotiation phase. (Warsta *et al* 2001: 5–19.)

A network of connections between organisations

This study focuses on knowledge transfer processes which are typically networked. While studying inter-firm relationships in a network view, the links between third parties affect the focal firm. One known model is the ARA model (Activities – Resources – Actors) introduced by Håkansson and Snehota (1995). They argue that the firms' role, development, and performance can be explained by their ability to develop relationships because: the resource development takes place to a large extent between firms; the efficiency of internal activities is to a large extent dependent on the supplier and customer relationships; and the more successful the counterparts are, the better it is for the firms. The more a firm can help its counterparts develop and become successful, the higher is the chance it will become successful itself.

Business relationships are often characterised by continuity, complexity, symmetry, and informality. The complexity appears as the number, type, and the contact pattern of individuals; and in the scope and use of relationships: the number of products and services exchanged. The informality results from formal contracts that are often ineffective in taking care of the uncertainties, conflicts and crises. In a business relationship adaptation, cooperation and conflict, social interaction, and routinisation are typical. A limited number of relationships has a profound effect on a firm's performance. The networks do not have given centres and they are dynamic over time. (Håkansson & Snehota 1995: 7–12)

Where products development is concerned, the firms operate in a texture of available technologies. Technical development within a firm is dependent on other firms' technologies including the technologies of third parties. Knowledge is essential in the form of human and physical resources that enable certain activities, which are tied into the activities of other firms. Social relations are important to business relations. Administrative routines and systems are needed for the efficiency of information processing. Legal ties in the form of ownerships, or different formal cooperation agreements such as joint ventures and licensing can connect firms but they can also have a negative effect when used in a false way. (Håkansson & Snehota 1995: 13–17.)

Håkansson and Snehota introduce connectedness claiming that the single business relationships affect or are affected by what is going on in certain other relationships although all the relationships are not connected. For example a product developed together with the customer can be of advantage for other customers who have similar requirements, but it can become a disadvantage for customers with different requirements as it absorbs important development resources. (Håkansson & Snehota 1995: 17–18.)

The relationship profile between two firms can be defined in terms of activity links, resource ties, and actor bonds. Activity links are technical, administrative, commercial, and other activities that can be connected in different ways to those of another firm as a relationship develops. The internal activity structures may need to be adapted. Resource ties connect various resource elements (technological, material, knowledge resources and other intangibles) of two firms. Actor bonds connect actors and influence how the two actors perceive each other and form their identities in relation to each other. Bonds become established in interaction and reflect the interaction process. Three different functions are used to define the effects of a relationship. Function for the dyad originates in the conjunction of the two firms. Function for the individual firm is the effect a relationship has on each firm, on what it can do internally and in relationships, depending on how the outcome of the dyad can be connected to other internal elements and its other relationships. Function for third parties describes who the outcome of a relationship affects and is affected by other relationships. (Håkansson & Snehota 1995: 25–28, Ford *et al* 2003: 39–40.)

The interplay of bonds, ties, and resources makes change and development in relationships possible. When actor bonds evolve, resource ties and activity links change and they become mutually adjusted. The interplay is the main driving force in the development and dynamics. In a business relationship two firms establish connections and resources, activities, and actors are blended and melted in a unique way forming something qualitatively different, not just a sum. The relationship is a '*quasi-organisation*'. The two firms can perform activities and utilise resources they could not accomplish alone. On the other hand, too much emphasis on a firm's own functions may become counterproductive because it destroys the dyadic function, while too much emphasis on the dyadic function may be harmful for self-interest. (Håkansson & Snehota 1995: 28–36.)

To a single firm the set of relationships to others determines the competence of the firm as well as its productivity and innovativeness. Coping with relationships can be seen as a learning and developing process. The '*network function*' means that on the network level any change in any relationship may affect other relationships, and thus firms that are not involved in the changing relationship. (Håkansson & Snehota 1995.)

A relationship's effects are important and need to be coped with through marketing and purchasing; capability development; and strategy development. These are illustrated schematically in Fig. 21. Marketing and purchasing is about relationship development; capability development about coping with the relationships' effect on a firm's development potential; and strategy development means positioning of the firm in the network through its relationship development. (Håkansson & Snehota 1995: 46–49.)

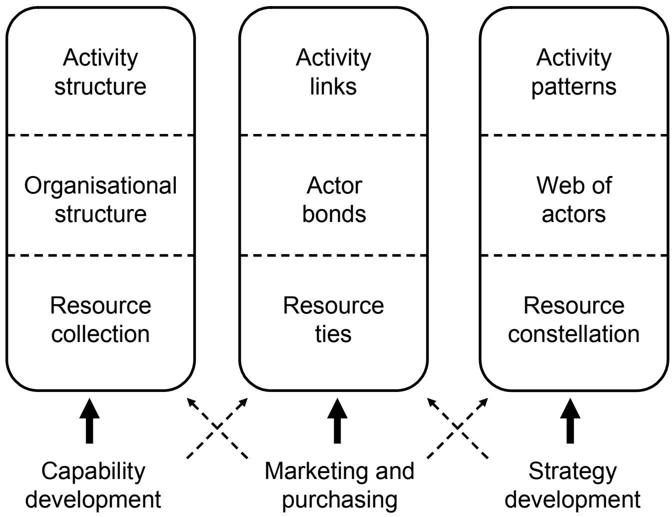


Fig. 21. Critical issues in coping with business relationships in the ARA model (Håkansson & Snehota 1995: 47).

Activity is defined as a sequence of acts directed towards a purpose. Internal activities include e.g. production, research, and product development – as in this study – while purchasing, financing, personnel selection, and sales are external activities. All activities are linked to those of other firms with both the cost and the effectiveness dimensions equally important. In the cost dimension the emphasis is on standardisation and scale, while in the effectiveness dimension it is on differentiation and uniqueness. Activity link synchronisation and matching are essential. They can be productive by bridging the physical and psychological distance between firms, and by affecting the activity structures of the involved firms. A firm's activities are built on others' activities, and enter in those of some others. They are linked in a wider activity chain while the position of a firm is always to some extent unique despite apparent similarities. Activity links are a tool in positioning firm in the network. (Håkansson & Snehota 1995: 28–30, 50–62.)

A relationship between firms ties specific resources of the provider to certain resources of the user – also where product development is concerned as in this study. Handling resource ties in a relationship is critical to securing access and transfer of existing resources, and to develop new resources. The resources' value depends on which other resources they are combined with; and it derives from the scarcity, but also from the creation and development of them. Both the availability and control, and relation of provision and use of resources are critical. When resource ties develop between two firms they become interdependent, and the borderline between the internal and external resources becomes blurred. Resource ties reflect the knowledge and skills in the use and production of resources; and when they arise, the knowledge of how to provide and how to use different resources develops. The same resource element can be involved in several ties; and they affect each other. Connected resource ties form a resource constellation – the resources a firm provides or uses are tied to other firms with which the firm has a direct or indirect relationship. The resource constellation reflects the knowledge or resource use in the business network, and it develops as the knowledge evolves and enables the development of knowledge. Learning of use and provision of resources can occur in three ways: by a single actor through experimentation; by actors using each other's knowledge and experimentation; and by joint learning based on several actors' knowledge and experimentation. All knowledge is seldom transferred because of the difficulty to transfer tacit knowledge, and because counterparts consciously develop knowledge with other actors. Stability in certain relationships is a necessary condition for collective learning. To find something new also weak resource ties are needed but the development of new ties is time consuming. Because of the heterogeneity it is the mix of resources that explains the value of resources to firms, and explains why every firm uses a unique resource collection. The main managerial concerns in resource management are the handling of resource ties in a relationship to make them productive to both parties, the exploitation of the various resource ties to enhance the development capabilities of the firm, and the role of the firm as a direct or indirect resource provider to other firms. (Håkansson & Snehota 1995: 132–146.)

Concerning actor bonds, Håkansson and Snehota emphasise that it is individuals who endow business networks with life – they bring into the relationships their intentions and interpretations but the firms interlock the behaviours. Neither firms nor individuals are independent, isolated, or alone as actors in business networks but the perceptions, knowledge, capabilities, and intentions of others affect them. The relationships firms develop are always firm specific. A firm has to acquire the identity of an actor in the eyes of others in the business networks to be able to attract the interest and resources needed. The bonds between actors are important in shaping the identity. Another important process in the formation of actor bonds is the formation of trust and commitment. The processes are take time, and a business relationship grows over time. Bonds in a two actor relationship can be connected to bonds that either of them has to third parties, or to bond between third parties. The bonds to two different counterparts may affect each other because of the demand of commitment, and thus are compatible. On the other hand, the two bonds can be connected. Personal bonds may affect and connect different relationships of the firm. As a summary, actor bonds in a relationship become an element in a broader web of bonds among actors. Managing actor bonds includes monitoring and possibly redirecting the mutual identities in a relationship, investing and prioritising in the limited number of strong bonds, gaining intelligence about trends and changes in the web of actors, and forming defensive and offensive coalitions and alliances to change the position of the firm within the network. (Håkansson & Snehota 1995: 192–203, Ford *et al* 2003.)

The total pattern of business relationships is relatively stable but new relationships develop and old decline over time. The main change occurs in the existing relationships' content and strength, and the changes affect the whole network. Change can be caused by both exogenous factors – such as economic conditions, and technical development – and endogenous factors caused by actors change their relationships. A network never reaches equilibrium. Changes affect others and cause reactions and counter reactions. (Håkansson & Snehota 1995: 269–283, Ford *et al* 2003: 173–191.)

A Finnish study on critical events and their impact on the development of business networks seeks an answer to the question: what endogenous and exogenous events have influenced this evolution process? In the two longitudinal case studies the evolving business networks are intentionally built and strategically supported. They are partly profit seeking but there are also networks formed for 'capability and knowledge seeking' reasons. The selection of the participants is based on the strategic advantages or threats that can better be anticipated within a network. The cases show that critical incidents can create changes that lead to dissolving relationships or building new relationships. The change mechanisms are either confined with a degree of stability, or connected with more radical change. Stability in networks is typical in long-term relationships where both dynamic change and stability may exist concurrently. The results show that the core actors have a more stable network position while others tend to have a higher degree of change. They often emerge into new independent networks where the connectedness varies. Intentional strategic networks incubate evolutionary networks for example around some product and service innovation. The business and strategic networks live and grow as long as the conditions are favourable. The writers argue that the lead operator may have a very asymmetric power structure when compared to other members. The hub may even be able to create critical endogenous events necessary to influence the goals and strategic intentions of the network while the other members are more dependent. On the other hand, because the other members are able to increase their competitiveness and have access to resources and capabilities that would be otherwise out of reach, they are able to take better advantage of the opportunity structure, face the competitive threats, and influence the development. (Elo & Törmänen 2003.)

Denize *et al* argue that the ARA model is a useful framework for understanding information exchange – a subject close to this research. The exchange comprises of transfer activities and exchange resources, which are described according to the information type, the exchange medium, the resource properties, and the transfer activity properties. The actor dimension includes the type of actors involved, expectations on information exchange, and the motivation of each actor. The information transfer activities constitute the activity links. The exchange resources are characterised by specific information types and the utilised media. This conceptualisation is argued to explain the information exchange impacts on inter-firm relationships. (Denize *et al* 2000.)

Baraldi has studied the use of IT in managing activities and resources in a certain existing business network, and found that the IT systems collide with the complexity of the networks because the systems are based on simplified models and theories (Baraldi 2001).

2.5.2 External actors

The focus of this study is knowledge transfer to firms' product development processes from other actors both from local, regional, national, and international levels. This section is a review of the literature on the role of the external actors in the knowledge transfer processes. The actors have been classified into higher education institutes and research institutes, other firms, intermediaries and facilitators, and municipalities.

Howells (2004: 1) claims that the competitiveness of a firm depends mostly on the effectiveness with which it can gain access to, and utilise, sources of technological knowledge and capabilities beyond its boundaries. According to one German survey on 1800 manufacturing firms, customers and suppliers are the main sources of knowledge for firms. Over 60% cooperates with customers, about 50% with suppliers, over 30% with other firms, and over 30% with publicly funded research institutions including universities. (Fritsch & Lukas 2001: 302–310.) The figures vary between countries and sectors but the order and magnitude are confirmed by other studies (Schibany & Schartinger 2001, Kristensen & Vinding 2001). As a case study, this research will not contribute to these results.

Nieminen and Kaukonen (2001) have studied how significant various partners are for firms' innovation related activities (Table 2). A sample of about 350 firms shows that customers are in their own class with 83% identifying them as fairly or very significant. All firm type of actors are more important than any type of research or higher education institutions. When the European Union's 5th Framework programme projects were studied, universities were found to be the most important external source of information with over 60% of firms valuing them as fairly or very significant, public and private non-profit organisations followed at about 50%, and customers were in third place with 25%. The same research shows that universities and public research institutes are of high importance in producing new knowledge close to the core business and new core business. (Kutinlahti 2005: 129–138.) This difference equals the finding that scientific research seems to have an important role when radical innovations are created but more common incremental or evolutionary innovations are usually made on the basis of available knowledge, whether scientific or product related by origin (Nieminen & Kaukonen 2001: 17–27).

Laursen and Salter (2004: 22–25) found that more "conventional" knowledge sources than universities, such as a firm's internal R&D department, suppliers, and consumers are the knowledge sources for manufacturing innovation activities.

The results suggest that firms who adopt "open" search strategies and invest in R&D are likely to draw from universities. This indicates that the managerial choice matters in shaping the propensity of firms to transfer knowledge from universities

Table 1. The most important partners in firms' innovative activities (Nieminen & Kaukonen 2001:75).

	Of no significance, %	Of little significance, %	Significant, %
Customers	3	14	83
Equipment suppliers	10	37	54
Subcontractors and material suppliers	15	36	49
Public financing an consulting organisations (e.g. Tekes, Kera)	31	26	42
Other places of the firm	49	11	40
Rivals	24	45	31
Research institutes	34	34	31
Private consultancy and development agencies	34	38	28
Technical universities and faculties	41	36	23
Other educational institutions (e.g. universities of applied sciences)	35	44	21
Universities	49	39	12
Industrial associations (MET, Setele etc.)	61	31	8
Technology centres	67	27	6
Schools of business administration	66	31	3

Higher education and research institutes

Although universities are, according to a survey (Nieminen & Kaukonen 2001: 75), not very important for firms' innovative activities, their role in innovation systems and firms' development processes has been emphasised especially in the Triple- Helix literature (e.g. Leydesdorf & Etzkowitz 1998, Etzkowitz & Leydesdorf 1995) and policy makers have considered it necessary to strengthen the linkages (Nieminen & Kaukonen 2001: 98). An OECD study (2002) shows that co-patenting and the number of publications resulting from joint research has grown intensively since the late 1980s. The role of universities has also been studied extensively by university researchers from many points of view. Mowery and Bhaven (2005) write in their chapter in the Oxford Handbook of Innovation

(Fagerberg *et al* 2005) that if a similar handbook had been published 20 years earlier less attention would have been paid to the role of universities. The same can be noticed from scientific journals; browsing the issues from the mid 1990s, there are only a few examples while in the issues from the last few years there is a large number of articles on university and industry co-operation. Kutinlahti (2005) writes that '*the deepening ties between universities and industry as well as the commercialisation of academic research have been the subjects of intense policy and research interest since the mid 1980's. Universities have become more active in trying to commercialise their research and in establishing linkages within industry. Furthermore, different types of policy schemes and programmes have been launched to support university-industry collaboration and commercialisation of results generated by public research institutes.*' (Kutinlahti 2005: 13.)

In the USA the main method for transferring knowledge and technology from HEI was the licensing of intellectual property rights (IPR) to major firms. The classic way is that the university grants the right to use a patented invention to a private firm in return for up-front fees, a minimum royalty, and sales based royalties. This model does not function with start-up firms which are mostly under-funded and do not have the financial resources. Universities have adapted to the problem mainly by reducing initial fees and increasing the royalty fees. A second model is that the licensor receives an equity interest in the firm instead of the initial licensing fees while still collecting sales-based royalties. The third approach is the incubation model where equity is used to obtain the licence, and often the physical, technical and administrative support necessary for a start-up firm to start operation. Universities using this model invest in research parks or incubator facilities. (Lenetsky 2002.) Also in the case of industry sponsored and joint research projects the main discussion topic in the USA are the IPR rights and licensing (Irwin & Dries 2002) even though the licence revenues are mainly small and achieved by only a few universities (Miyata 2000, Feller *et al* 2001).

Licensing and university-industry research centres have been a research topic in the USA where university-industry collaboration is concerned (McAdam *et al* 2005, Florida 1999), while the discussion in Finland is mainly focused on the joint university-industry research programmes and projects as a part of local innovation policy and innovation systems (Tervo 2004). Research centres have been founded to foster collaboration For example in Oulu University the collaboration with CWC, Centre for Wireless Communication where CWC is part of the University of Oulu, and works in close cooperation with firms. (Arokylä

2002: 34–35.) It is claimed that the American model for commercialising research results does not necessarily suit the European universities. In Finland firms have earlier mainly taken care of the commercialisation, but a discussion is ongoing about the increasing role of the universities. (Kutinlahti 2005.) According to Lampola the attention has been mainly on patents even though they are applicable only to a very small number of research results (Lampola 2002: 45–46).

Research knowledge transfer is one of the processes that is studied in this thesis. Lampola classifies the research into two main classes: free research; and contract research. Both have several subclasses mainly based on different financing sources (Lampola 2002: 66). Nieminen and Kaukonen define two main and several subforms of relationships between universities and firms. The first one, collaborative research mechanisms include university-based institutes serving societal and industrial needs, jointly owned or operated laboratories, research consortia, contracted university research, and government-funded co-operative research programs. The other main form of cooperation is the knowledge transfer mechanisms including innovation centres, patenting and licensing, continuing education, Science/Technology Parks, consulting, personnel exchange, seminars, and publication exchange. The main categories are research, consulting and services, and education and training. (Nieminen & Kaukonen 2001: 24.)

The survey results of Nieminen and Kautonen show that the most usual form of cooperation that firms have with universities, are Master's theses on firms' needs. This form had been used by 46% of the firms. The equivalent numbers were 42% for contract research, 37% for product development, 31% for exchange of knowledge, 26% for personnel training, 19% for R&D programmes, 7% for market research and 6% for organisational or process development. (Nieminen & Kautonen 2001: 83.)

The Finnish universities of Applied Sciences (UAS) – one existing also in Kemi – cooperate mainly with small and medium sized firms in their own regions (Lyytinen *et al* 2003: 74–75). For the firms cooperating with UAS, the local UAS is the most important partner. The cooperation consists of R&D cooperation, working life connection in education, services, and some other joint activities. The firms expect mainly possibilities to recruit capable staff, commercialise created knowledge, develop their own personnel, and capture new knowledge. Firms were found to be satisfied with the cooperation and willing to continue, and develop the operations more diversified in the future. According to the results the main reason for not cooperating with an UAS is that at the moment there is no need for that. (Marttila *et al* 2004: 103–106.) The Finnish Ministry of Education has emphasised the regional role of the Universities of Applied Sciences (Valtioneuvosto 2005).

Balconi and Laboranti argue that public funding allows academics to set their research agenda to perform explorative, uncertain research. Even if the ultimate goal of research is to provide the foundations for the creation of new artefacts that function successfully, and can be produced and sold, academics also need direction from industry. The cooperation is needed also because interaction with industrial researchers with a more technical culture, facilitates problem solving. (Balconi & Laboranti 2006: 1628–1629.) A study conducted simultaneously in the UK and USA showed that the main interest for universities to cooperate with industries is to obtain financing for research, royalties, and good publicity (Decter *et al* 2007: 153). In cooperation with academia, firms receive new innovative ideas, enhance the problem-solving capabilities of their researchers and can effectively recruit new graduates (Balconi & Laboranti 2006: 1617–1629). Also the trend to slim down organisations – including R&D functions – has enhanced university cooperation (Decter *et al* 2007: 153–154), but still cooperation with universities and public laboratories is more likely when firms have in-house research capability and apply for international patents (Busom & Fernández-Ribas 2004). Large firms are more likely to cooperate with universities than SMEs that actively observe and monitor outside knowledge especially through screening scientific publications. However, the level of interaction depends on their willingness to signal their competences by patenting and on the relative weight of network interactions in their knowledge production (Fontana *et al* 2006: 321–322). All in all, the research agenda of science is inspired by industry to search for new knowledge that industry finds most promising. An empirical study showed that the proficiency of science is associated with intense collaboration with industry. This collaboration is based on face-to-face knowledge exchange with researchers. Links with universities allow firms to recruit highly productive individuals. The recruitment of former students also constitutes the professors' preferential links with firms because of the cognitive proximity and personal acquaintances. (Balconi & Laboranti 2006.) This implies the important role of trust and social connectedness as major factors in cooperation, as verified by several studies (e.g. Gopalakrishnan & Santoro 2004: 65–68, Carayannis *et al* 2000: 486–487, Santoro & Bierly 2006: 486–506, Cutler 1989: 21–23). Santoro's and Bierly's study shows that trust, social connectedness, technological capability, and technological relatedness foster a transfer of tacit knowledge while a university's highly developed intellectual property policies seem to advance explicit knowledge transfer but have a negative effect on tacit knowledge transfer. The reason may be found in mistrust and fear of bureaucracy (Santoro & Bierly 2006: 496–506).

A study based on surveys and interviews, conducted in the Austrian and Swiss machine tool and plastics industry, discusses different types of developers in the industries and various types of institutions involved in research and development (Balthasar *et al* 2000). It was found that developers with a higher educational level are clearly more oriented towards institutions than their colleagues without higher education. People who do not have a higher education tend to be internally-oriented and do not have contacts outside of their own firm. The authors define four different types of institutions participating in firms' innovation processes:

- science type institutions rely on considerable research funds independent of industry. It essentially finances itself by basic funding for the benefit of universities as well as fundamental and applied research funds and programmes;
- practical research type institutions largely cover their expenses with funds from government R&D programs and from project cooperation with industries;
- problem solving type institutions are decisively maintained by the industry (fees for events, equipment, projects);
- rapid-response type institutions are mainly financed by basic funding to fulfil teaching activities and they receive no substantial funding for research of transfer purposes. (Balthasar *et al* 2000: 530)

Schibany and Schartinger (2001) argue that firms are not typically looking for the results of academic research but a capacity for problem solving.

Developers turn to scientific institutions when they are explicitly searching for a connection to the scientific development. They are mainly medium-sized and large firms and have earlier experience in cooperation with institutions. Science type institutions are said to rely on an expensive infrastructure and considerable research funds that are independent from the industry. The practical research type institutions focus on the market needs of R&D with developers – having practical problems demanding long-term research – as customers. The institutions have academic staff working on projects together with industrial representatives. Typical examples of these institutions are university institutions that have considerably grown. The problem solving institutions are independent of existing schools. They are utilised when the developers want to educate themselves further or they want to have material or examinations performed. The institutions are typically founded on the industry's initiative. The rapid-response institutions are typically universities of applied sciences or engineering colleges, where professors speaking developers' language help to solve 'small' everyday problems. Science and rapid-response institutions are mainly funded on a yearly basis, while the practical research and problem-solving institutions often manage with small or no such funding. (Balthasar *et al* 2000: 239–247.)

Based on a study of 120 technology transfer cases at the Pennsylvania State University, Daghfous (2004: 947–951) argues that different learning activities play different roles under different conditions. These conditions mainly relate to the degree and the type of uncertainty perceived by the firm in the beginning of the project. He suggests that in projects with high technical uncertainty, experimentation should be emphasised, as well as use of cross-functional teams to acquire new skills and knowledge and discover additional improvement opportunities. When there is a high organisational uncertainty, firms should establish training programmes and cross-functional teams but also identify counter-productive lessons and unlearn them. When the technical uncertainty is low, firms should increase the operational benefit from the project by having a systematic procedure for learning from past experiences.

A study on Newcastle University's technology transfer activities in the North East of England focuses on the innovation support services aiming to foster regional development. The research questions are, '*how do universities work with partner firms in developing innovative support services for innovating firms?; does this innovation and institutional development process correspond to a densification of the region's techno-economic network?; and what are the implications of this for the management of universities so their relationships with local businesses have the greatest territorial impact?*' (Benneworth & Dawley 2005: 79.) The authors explore how firms and universities had co-developed three innovation support services that were used also by other firms to support them in their own innovation processes. The firms – that were best in innovating – involved themselves strategically with the university, through the university's formal governance structure, to enrol the university to support their own activities, but also to get the university to develop activities to support their needs. They also encouraged the university to strategically engage with the centres of excellence. After such flagship activities had been identified, the university developed the service or concept, and worked with the firms to produce the service. The university learned that it was best to develop new services with firms that were capable of giving constructive feedback. (Benneworth & Dawley 2005: 82–84.)

Most of the barriers in the development of a new service were external: highly specific funding streams making service integration difficult; administrative decisions changing the ground in the middle of the project; and risk that service could be abandoned because of short-term funding. Benneworth and Dawley argue that the success of a university in the regional development with the help of innovative services is dependent on the university managers' commitment and strong strategies for regional development, which are widely implemented within the institution. (Benneworth & Dawley 2005: 84–85.)

The Business - Higher Education Forum (2001: 71–74) in the USA defines several types of offices as best practices in its initiative for university-industry research collaboration. The key offices and functions of effective collaboration are claimed to be Office of Sponsored Programs or Office of Research Administration to establish and manage collaborations, Office of Technology Transfer or Office of Technology Licensing to decide when to seek patents and when to negotiate patent licensing agreements, Office of Development to coordinate university fund raising, and Office of Corporate Relations to oversee management of the university's relations with industry. On the other hand, it declares that university researchers operate as independent contractors in the selection and accomplishment of their research efforts. As a result, establishing university-industry research collaborations requires attracting the interest and involvement of individual faculty members. Neither partner can sustain a collaboration without this foundation.

In this study the knowledge transfer from universities is of the type that could be transferred with the help of a technology transfer office. Several academics have, anyhow, found centralised technology transfer offices and innovation centres ineffective. In a UK study Chapple *et al* (2005: 379) criticise the revenues from licensing especially versus start-up activities, and the skills of the office personnel. Debackere and Veugelers (2005) argue in a more detailed way after careful attention of an adequate structure and processes. Transparent and unambiguous regulations with respect to ownership titles and property rights are an important element as well as the optimisation of the various transfer mechanisms and monitoring processes through experimentation. Creation of a mix of incentive mechanisms, targeted to the research groups and the individual researchers, is a critical success factor. Academic authorities should accept that success is achieved only with a decentralised management style that implies sufficient freedom to engage and to operate for the researchers and their groups whenever transfer opportunities occur. It also implies that the research groups are pivotal in deciding how the proceeds from their exploitation activities will be used, and stimulates the research groups to compete with their findings and results in the market for exploitation and innovation. These structural arrangements should be complemented with the necessary processes at the level of the interface or liaison unit. Firstly, a well-balanced process to manage and to monitor contract research in the area of industrial innovation is needed. Secondly, there should be an active knowledge management policy that includes a patent funding mechanism and professional intellectual property management. Finally, the liaison unit may provide the necessary opportunities for networking amongst its entrepreneurs and academics alike by creating a network fora and opportunities to meet.

Feller *et al* (2002) argue that a technology transfer office's effectiveness depends on its ability to coordinate its activities with other work units described above, its ability to process information within and without the university, and an effective alignment of incentives between and among the transfer office, personnel and administrative units. According to the writers the changes imply a mix of dissatisfaction with existing arrangements (underperformance) and a perception of unrealistic opportunities (underachievement).

In Kemi the higher education and research sector is mainly represented by the local UAS. Different types of centralised models of R&D have been typical in the Finnish UASs in the starting phase. The level of centralisation varies. In some cases the projects may be conducted in a separate R&D unit from the start to the end. The strength of the model is that the R&D unit is a clear contact point, the unit can form a special profile, sharp knowledge edges are possible, and the unit can take the role of an intermediate. The obvious weaknesses are weak links to education, personnel and students, and teachers' links to industry do not develop. In the opposite distributed model the link between education and R&D is strong, R&D can be a larger part of education, and the knowledge accumulates in the educational units – even very sharp knowledge edges can be used. The model enables the formation of a lean organisation. The weaknesses in the distributed model are that project and financing skills may be weaker, there are several contact points, and some projects might demand collaboration over the organisation's internal borders. The third possibility is the integrated model with the matrix organisation. The strengths are the possibility to integrate education and R&D on the organisational level, coordination, a better possibility to build multidisciplinary projects and the existence of a larger number of ‘living’ interfaces. The weaknesses are a larger number of external contact points, project management demands clear models, management and responsibility questions may be complicated, balance between the emphasising project and the substance knowledge and a possibility to spread various types of information to the environment. (Marttila *et al* 2005: 30–38.)

The educational aim of a university is to educate people to various positions in the society. In some countries the legislation provides that the courses and programmes must be adjusted to labour market needs (Öresund University 2005: 45). Learning projects are becoming more common – also those based on firms’ needs (Marttila *et al* 2005: 13–14). Aalborg University in Denmark has applied project oriented and problem-based learning since the year 1974. The training of personal skills is included in the curriculum: abilities to learn how to learn, collaboration skills, the perception of context, academic behaviours, and conflict solving capabilities. In the nine semester programme the personal skills are there throughout but the focus on them is stronger in the first semesters, declining towards the 6th semester. In the first semester they constitute over ¾ of the studies. The problems used as tools of learning are real life problems from the industries. Every student team carries out one project each semester and many firms take advantage of this possibility. The outcome from such team-work can be a prototype for a new product, ideas for new products, ideas for new projects, contacts for future networking, and contacts for future jobs for the students or a job offer for students in their spare time.

The model has been adapted also to adult students working in the industries. In addition to the use of distance learning technologies, also other adaptations have been done. The university based projects are substituted with firm based projects, and the student teams with firm based teams. The curriculum is re-arranged into fewer courses and work based learning is included. Support and commitment in the industry for the students’ learning process in teams is needed as well as cooperation between the firm and the university about the projects that guarantee the learning context for the students and benefiting both the student, the firm and the university. The learning process, goals, form, and timing are planned to optimise the situation for the participant and for his team. The content, form, or timing can be revised based on the context, and transformation of knowledge into the organisation can be an integral part of the study. (Fink 2001, 2003, Moesby

2005.) Lucic and Rohrer (1995) describe a successful case where undergraduate students were involved in a technology transfer project dealing with electronics design automation software. In addition to the learning achieved, they report the success of using people instead of telephone calls, letters, e-mails, unread user manuals or an unloaded computer tapes in software implementation.

Takala and Tossavainen (2004) have analysed a post-graduate student group at Nokia Corporation studying at the Helsinki School of Economics. The authors describe the interactive individual – firm – university process. In the preparation phase the study process begins, and the required proposals and applications are submitted. After official acceptance the student gets a firm mentor, and becomes a member of a community of practice. In the second phase focusing on subjects, that are strategically important for the firm, mutually interesting and value-adding topics are enabled. Next a study agreement is made, which enables starting and implementing the study project. The research results are shared internally within the corporation but also in the academic community. Takala and Tossavainen summarise the products and services in the model to be study projects related to business interests, structured competence development activities, leading edge professional in-house service, new knowledge for internal use, PhD dissertations, journal articles and other publications, and patents and related results.

One effect that the university knowledge transfer has, is the foundation of university research based spin-off firms. The number of them has been used also as one component to measure the university output (Wallmark *et al* 1988). Based on his research in Germany, Sternberg (2005: 7–23) argues that innovative start-ups, with the person who has previously created the knowledge as founder, is the most effective way to translate knowledge into marketable products. He also reports that these types of start-ups are regionally more embedded than other firms. According to Debackere and Veugelers (2005: 331–332) the number of new academic spin-offs has been rising in the last years. A study on spin-offs in the Georgia Institute of Technology incubator, based on a resource-based view of the firm and the absorptive capacity construct, it supported the existence of knowledge flows, and that the flow is dependent on the absorptive capacity of the spin-off firm (Rothaermel & Thursby 2005: 318). The results of a study among Spanish university spin-off firms showed that in the founding year the firms were very active in consulting, product development, and training with the universities but later the role of university knowledge flows diminished, while at the same time the relationships with customers increased (Pérez & Sánchez 2003: 826–830). O'Shea *et al* (2005: 1005–1007) argue that there are several necessities to make the spin-off process effective: the need to develop a commercially supportive culture to emerge within universities to enable academic entrepreneurship to flourish; the need for active partnership and financial support with industry and government funding agencies; the recruitment and development of science and engineering academic stars; and the development of a commercial infrastructure to enable the valorisation of academic research to occur. According to Mueller (2006: 1505–1507) regional entrepreneurship and university-industry relations are in key positions to make knowledge flow.

According to Arundel and Geuna (2003: 25–29) firms prefer knowledge transfer methods that provide opportunity to access tacit knowledge. This emphasises the role of social capital in university-industry relations. Chakrabarti and Santoro (2004: 27–31) have defined three dimensions of social capital in this context: networking, problem solving, and trust. The base for forming the networking dimension are: students hired by the firm as a direct result of the relationship, recent university graduates hired by the firm, level of participation in research centre sponsored consortia, participation in trade associations, number of personnel exchanges with the research centre, and level of participation in jointly owned or operated facilities specifically for advancing new technologies. The problem solving dimension can be described by time spent interacting with centre personnel specifically for advancing new technologies, the level of joint decision making in technological consulting arrangements, level of participation in research centre sponsored research seminars, and level of participation in co-authoring research papers. Finally, the trust component consists of the extent the firm is willing to share ideas, feelings, and specific goals with the university centre; the extent that firm doubts the university research centre's competence as well its motives and the fairness in sharing its abilities; and extent the firm perceives that the university research centre adheres to a set of principles that the firm finds acceptable.

The university-industry cooperation has also its problems. Where new spin-off firms are concerned there is always the risk of the perfect technology syndrome; the ambition to make the technology too perfect and forget the business economics threatening start-ups founded by researchers (Hänninen 2004). In some cases the firms may try to diffuse from public research topics that might threaten the existence of their own existing products (Agrawal & Garlappi 2005: 18). This implies a potential competitive or conflictive situation in commercialising results. A competition between the parties can occur also with regard to financial and human resources. On the other hand, close cooperation between researchers and firms cause a risk that the researchers will be deflected in ways that conflict with their institutional responsibilities. (Garret-Jones *et al* 2005: 537–544.)

Other firms

Technology Parks exist to form a milieu for firms to develop and collaborate, and thus studies on the role other firms have in a firm's product development process is of great interest. According to several studies, other firms are the most important partners in firms' product development processes (e.g. von Hippel 1998b, 1986, Nieminen & Kautonen 2001). Von Hippel (1998b) uses the term 'functional sources of innovation' to describe that the partner involved in a firm's product development process is expecting to get some benefit: e.g. suppliers by selling goods, customer by using the product, etc.

In the year 2003 half of the SMEs in 19 European Union countries cooperated with other firms: 25% non-formally, 13% both formally and non-formally, and 12% only formally. Almost 70% of Finnish and 45% of Swedish SMEs had non-formal cooperation, while over 40% of Finnish and about 25% of Swedish SMEs cooperated formally. The Finnish SMEs ranked highest in the European Union for cooperation. The same survey also reports that smaller firms cooperate non-formally to a greater extent, while the larger ones prefer formal collaboration. On the EU level more than one third of SMEs cooperate formally only with one or two partners, while two thirds of the firms have up to seven partners. Cooperation with foreign partners is around 10% depending on firm size. In about 90% of the SME cases the cooperation lasts for over 3 years, and in over 60% for more than 5 years. For all sizes of SMEs, the wish to maintain independence is the main barrier to co-operation. The main motives for cooperation are access to new and larger markets, a wider supply of products, access to know-how and technology, additional production capacity, and reduced costs. The smallest firms typically seek new and larger markets, while the largest SMEs prioritise cost reduction. (European Comission 2004a: 23–41, 56.) From 1978 to 1999 the number of new R&D partnerships has risen with 400% (Roijakkers & Hagedoorn 2006: 432–435), and strategic alliances by 800% from 1988 to 1999 (Verspagen & Duysters 2004: 564) when all sizes of firms are considered. A Spanish study shows that the cooperation with firms other than customers, suppliers or competitors is related to in-house research capacity and having applied for international patents (Busom & Fernández-Ribas 2004: 25–26).

Another mode to acquire knowledge is to use informal contacts, which can be expected to happen also in the case Technology Parks. A Danish study among engineers in a regional cluster of wireless communication firms in Northern Denmark shows that 76% of engineers had informal contacts with at least one employee in another firm in the cluster, and 41% of those having contacts used them to acquire knowledge that they took advantage of in their jobs. In total, over 30% of all the engineers acquired knowledge this way, and 12% more specific knowledge on new products. In two thirds of the cases the source was a former colleague, in half of the cases a classmate, and likewise in half of the cases a private friend. The study also shows that engineers with 3 years or more experience in the cluster or in the industry acquire knowledge through informal contacts 1.4 times more often than engineers with 2 years or less experience. (Dahl & Pedersen 2004: 1679–1684.)

When strategic technology alliances are concerned, there are two basic ways to build the networks: social capital strategy, and structural hole strategy. Firms dominated by the social capital view seek a limited number of partners with whom they build strong and repeated ties. When the strategy of bridging structural holes is used, the firm chooses partnerships based on the strategic position of the potential partners in the network. (Verspagen & Duysters 2004: 570–571.)

An interesting question is how firms choose the technology or knowledge acquisitions mode in R&D. A study on Korean telecommunication industry shows that firms prefer in-house R&D in the case of low developing costs, a high technical position, high R&D experience, strong history of in-house R&D, low experience in R&D cooperation, low need of standardisation, low research manpower, or high extent of competition. R&D cooperation is chosen in each of the following cases: high research manpower, high need for standardisation, technical position is high, much R&D experience, level of competition is low, not much experience of in-house R&D, or there is a history of R&D cooperation. Technology is purchased when the developing cost is high, research manpower is low, technical position is low, there is not much experience in R&D, the need for standardisation is low, or there is not much experience in in-house R&D. The history of in-house R&D, history of R&D cooperation, extent of competition, and developing costs determine the choice between in-house R&D and other modes. R&D experience, the technical position, need for standardisation, and research manpower discriminate between R&D cooperation and technology purchasing. (Cho & Yu 2000: 699–702.)

The class of other firms includes customers, material and equipment suppliers, subcontractors, R&D partners and rivals (Nieminen & Kaukonen 2001: 75). The customer group includes several types of actors. Both individual persons and firms may be customers or end-users depending on the products.

The willingness of firms to participate in cooperation depends on the importance of formal means to protect their knowledge in the industry. Firms in industries associated with a substantial amount of patenting are more concerned with information leakages to their competitors than those in less patent intensive sectors. On the other hand the use of strategic protection methods by other firms reduces the level of knowledge freely available to any single firm, and increases the willingness to cooperate to access external, typically complementary knowledge. (Schmidt 2005: 16–22).

An anchor tenant is a large, locally present firm that is heavily engaged in R&D in and has at least minor absorptive capacity in a particular technology area. By participating in the local market for technology and specialised inputs, it may have a significant effect on smaller innovative firms as a customer and partner, and also increases vertical knowledge flows. A subsidiary of a large firm attracts high-quality suppliers, skilled workers etc. more than an SME of the same size. (Agrawal & Cockburn 2003: 1236–1239, 1247–1251.) Thus the cooperation with a branch office of a large firm offers SMEs a possibility to develop products and services.

Eric von Hippel emphasises the customers' and users' role in product development. He even claims that users are most often the innovators. In one of his studies examining over 100 innovations he found out that 77% of all the innovations were primarily developed by the users. (von Hippel 1988b: 44.) These users have the 'lead user' characteristics that he defines in the following way: '*Lead users are defined as members of a user population having two distinguished characteristics: They are at the leading edge of an important market trend, and so currently experiencing need that will later be experienced by many users in that market; and they anticipate relatively high benefits from obtaining a solution to their needs and so may innovate.*'(von Hippel 2005: 22.) Even if lead users are involved in product development, many users have custom needs for products and services, which lead to a need of diversification or customisation. (von Hippel 2005.)

Olson and Bakke (2001: 393) have conducted a study on a software firm that implemented the lead user method in product development for gathering new product ideas from leading edge customers. The problems found were that managers in high technology areas had difficulty in translating technical characteristics into product features and benefits, and that high technology customers had difficulties in translating their desired benefits into technological solutions. While the firm was doing well already, the method was seen more as a 'nice to have' factor than a 'need to have' factor which led to abandoning the lead user method and to return to earlier routines.

According to Geoffrey A. Moore (2002: 9–15) the first customers of high technology products are technology enthusiasts. In the time scale they are followed by visionaries, then pragmatists, and lastly conservatives. This is why a firm must be aware that the customers for a product change over time.

Rivalry is one of the phenomena that is expected to exist in Technology Parks such as in Kemi and Kalix. Sourcing knowledge from rivals can be done voluntarily, not only by using reverse engineering. Often the transfer occurs between individuals who are willing to give another person in a rival firm some help in expectation of future counter help from a knowledgeable expert. This can happen on various organisational levels. Before transferring the knowledge the individuals evaluate the consequences to the firm. (von Hippel 1986: 27–30.) Dutch researchers studied two learning alliances. They discovered that the formal commitment of the organisations was crucial: without commitment the learning never reached the organisation but stayed on an individual level. An alliance without formal regulations appeared to be effective while – according to the participating individuals – an alliance with too many regulations was doomed to fail. The system was based on personal goodwill. Trust, e.g., could only be based on the person, not on his organisation. If someone betrayed the trust he was ignored later and no further knowledge was shared with that person. The spirit of such alliance is 'us against others' or 'together for another party'. The conditions needed involve inter-personal trust and group cohesion, active interaction or learning by doing, comparable knowledge levels, and diversity in skills and expertise. The shared knowledge includes experiences on processes, expertise and finished projects, insights to other organisations (e.g. knowledge management products), and information on publications about a certain knowledge domain. The information not shared included plans and market developments, proposals for research, new projects, knowledge of strategically important clients, as well as models, methods and instruments. (Soekijad & Andriessen 2003: 585–586.)

Narula (2004: 153–160) writes that globalisation has affected the way both SMEs and large firms undertake innovation. First, the use of non-internal technology development both by outsourcing and by joining strategic alliances has been growing. Second, at the same time products are increasingly multi-technological. SMEs have earlier taken advantage of networks but this development has led all firms to a growing use of them. Outsourcing is agreements where joint innovative activity does not take place but they are more clear customer-supplier relationships. In an alliance there is a clear, significant, and systematic interdependence between firms in innovative activities. Both alliances and outsourcing require complementary resources. In-house capacity is needed to absorb the externally acquired knowledge. According to Narula's study SMEs use twice as much of their R&D expenditure for R&D collaboration than large firms. A problem especially for SMEs is that – according to the study – the success rate in R&D alliances is low: a failure rate of 50% is judged to be 'very good indeed'. Obviously the higher risks and higher managing costs are the reasons why SMEs prefer outsourcing. When they use an alliance they are more careful about picking partners because they have limited opportunities to fail. There is a strategic reason for being careful because in partnering with a larger firm it can lead to a loss of technological competence.

There are large process industries both in Kemi and Kalix. In some large industries outsourcing has a major role. For example, in the aerospace industry suppliers provide around 70% of an OEM product. Suppliers have different roles and different scales of responsibilities. In partnership formation the commercial issues are the most important ones but previous experience and capability are considered, too. The simplest way is to subcontract a complete design. The involvement of suppliers' guest engineers in design teams is a common practice. It has been argued that the more effective use of the supplier knowledge and capability could be the next differentiator between product development projects. (Fan *et al* 2000: 14–17.) A Finnish case study on a failed IT outsourcing in a production firm shows an example of the factors that should be eliminated in the process: unclear agreement, discontinuation from negotiation to transformation, and insufficient preparation of personnel. The study gives three pieces of advice: prepare people for the change, create the basic understanding, vision and goals, and build relationships and a way to work. (Vianello 2004: 94.)

Firms in Technology Parks are expected to collaborate, and thus this line of research is of interest to this study. A study from 1995 analyses collaborative product development among UK information and communication technology producers to find the risks and benefits as well as key success factors. The three most important reasons for collaboration were satisfying customer requirements, taking advantage of market opportunities for which the firm lacks necessary skills and expertise, and responding to changes in technology. The experiences were quite the opposite: the three most frequently mentioned effects were more costly product development, more complicated product development, and difficulty to control and manage the product development process. The three major risks were leakage of information, loss of control or ownership, and longer development time. Firms with experience in collaborative product development were also asked about specific factors affecting the outcomes of the collaboration. According to the answers on the choice of partners the important factors are culture, mutual understanding, and complementary expertise. The process should have clear mutually accepted ground rules on objectives and responsibilities. During the process frequent communication and mutual trust are the most important factors followed by regular progress review. The collaboration succeeds only if there are mutual benefits to all partners. Commitment at all levels – including the top management – is necessary. Additionally there must naturally be a market need for the product. (Littler *et al* 1995: 21–31.)

Bourgeois and Eisenhardt call an environment a high-velocity environment when demand, competition, technology and regulation are changing rapidly and continuously (Bourgeois & Eisenhardt 1988). Vilkamo and Kiel have studied technology partnering in such an environment. They argue that strategic technology partnership in high-velocity environment differs from partnering in less dynamic environments. Both the product development time and product life-cycles are shorter. The pace of a component provider's new product introduction often differs from the tempo at the technology integrator due to different levels of complexity. Also a partnering relationship between firms has its own life-cycles that are separate from but interconnected with technical life-cycles. These differences in various life-cycles present a new challenge for management of technology partnering relationships. On a practical level, a technology strategy should integrate technology partnerships into the strategy formation instead of being seen only as an implementation tool, and technology partnering needs to be managed for flexibility instead of pure efficiency. (Vilkamo & Kiel 2000: 6–8.)

Davis *et al* have studied collaborative product development from the supply chain management point of view, with one major organisation – NASA – and its partners as the case. They analysed how the organisation handles supply chain issues such as changes in technology, motivations for collaborative activities; how the organisation works with its partners; what are the selection criteria, formality of the relationship, trust between the partners, and whether the organisation is experienced at working across organisational boundaries. The result of a parametric analysis implies that the organisation engaged the others as members of supply chains with appropriate policies and understanding of the types of relationships. In order to gain success in the relationships, formal mechanisms – including a proper documentation of desired outputs - are needed. When selecting partners, managers mentioned leveraging resources, acquiring new competencies, and the track record of the partner as some of the criteria. Synergy is sought. Geographical proximity was not seen as important. The development of trust is a prevalent issue in supply chain management literature. Trust must be developed on a personal level before it exists on an organisational level. Proper documentation, including a good plan with common goals and objectives, is central for the relationships to develop well. Most of the organisations can have the role of a customer, supplier, competitor, or collaborator depending on the activity. (Davis *et al* 2004: 6–7.)

Intermediaries

In an innovation system the role of intermediaries is to mediate knowledge and information, and to influence the structures and dynamics. There are not many organisations that focus only on mediating or developing the structures, but many organisations or parts of them may have the role even unconsciously. Smedlund *et al* argue that intermediaries should be studied as a concept used as a framework to analyse the organisations' and actors' roles in an innovation system. (Smedlund *et al* 2005: 28.) Howells defines an innovation intermediary as: '*an organisation or body that acts as an agent or broker in any aspects of the innovation process between two or more parties. Such intermediary activities include: helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between, bodies or organisations that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaboration.*' (Howells 2006: 720.)

The innovation systems, and e.g. the Technology Parks' role – have been reviewed earlier. In this chapter the focus is on local and regional level activities in mediating knowledge to firms. The mediated knowledge includes both substance related knowledge, such as technological, needed in e.g. product development and know-who, know-who, and know-where type of information.

The literature on intermediaries deals with several different types of phenomena. These include literature on technology transfer and diffusion, on the role and management of such activities, on the innovation systems, and on service organisations and knowledge intensive business services (Howells 2006). Without an intermediary the knowledge transfer between firms forms a distributed network, while with an intermediary it has the role of a hub activating and coordinating the work (Coombs *et al* 2003: 1128–1129). Popp (2000: 160–161) argues that, at least in supply chains, intermediation can lower costs.

One line of research argues that the role of an intermediary is to build bridging ties and linkages in personal level networks. Regional institutions and locally oriented organisations provide a host of collective support services to firms in the region. (McEvily & Zaheer 1999: 1147–1151.) The variety of organisations taking the role includes e.g. regional technology centres, local research institutes, university liaison departments, innovation agencies, professional societies, trade associations and various types of industry consortia, and university-industry relationships (McEvily & Zaheer 1999, Lynn *et al* 1996, Bessant & Rush 1995). As consultants these organisations have several types of intermediary roles in the knowledge and technology transfer processes as described in Table 3 (Bessant & Rush 1995).

Concerning all types of needs, the intermediaries are said to have four basic types of roles. First, they transfer specialised expert knowledge they have already assimilated. Second, they share experience either implicitly or explicitly transferring knowledge among firms. Third, they have a broker role providing firms a single contact point through which to access a wide range of specialists. Fourth, the intermediaries have a diagnostic role helping users to articulate and define their particular needs in innovation. The intermediaries' potential contribution is in capability building, institution building, failure avoiding, cost lowering, support targeting, and decentralisation of operations (Bessant & Rush 1995: 101–102.)

One type of an intermediary is a firm acting as a knowledge broker between other firms. This type of firm works with clients in several different industries gaining knowledge of existing technological solutions they have applied, and introducing these solutions where they are not known. It creates new products that are original combinations of existing knowledge from disparate industries. A knowledge broker typically has a broader range of ideas than firms working in one or few industries. The process consists of accessing knowledge in various industries, learning the knowledge and solutions used in the industries, linking developers in other industries with knowledge and solutions in different industries as well as combining ideas from one industry to ideas from other industries, and implementing innovative concepts from other industries to real products and processes in another. (Hardagon & Sutton 1997, Hardagon 1998.)

Table 2. Intermediary roles in knowledge and technology transfer (Bessant & Rush 1995: 101).

User needs	Bridging activity	Supply side
Technology	Articulation of specific needs Selection of appropriate options	Sources of technology
Skills and human resources	Identification of needs Selection Training and development	Labour market Training resources
Financial support	Investment appraisal Making business case	Sources of finance – venture capital, banks, government, etc.
Business and innovation strategy	Identification and development Communication and implementation	Environmental signals –threats, opportunities, etc.
Knowledge about new technology	Education information and communication Locating key sources of new knowledge Building linkages with the external knowledge system	Examples of best practice Emerging knowledge base
Implementation	Project management Managing external resources Training and skill development Organisational development	Specialist resources

Knowledge intensive business services (KIBS) are services produced mainly for firms, with a high intellectual value. A study in Germany and France supports the idea that SMEs interacting with KIBS are more innovation oriented other firms. The reason is that KIBS fulfil the innovation circle - knowledge generation, processing and diffusion - function within the innovation system. The study shows that there are regional and national differences based on differences in innovation capacity and performance, and on differences in national innovation systems. Like knowledge brokers also KIBS process the knowledge and enhance the innovation capacities of their client firms. (Muller & Zenket 2001). In addition Czarnitzki and Spielkamp show that the use of KIBS also reduces costs and other obstacles for innovation in other firms, and they have links to scientific institutions to access knowledge they use for the advantage of their clients. (Czarnitzki & Spielkamp 2000: 19–20.)

All types of intermediaries – thus probably also those in the case Technology Parks – are assumed to take a proactive, central, and pivotal role in innovation systems instead of just passively reacting to the needs coming from the firms (Howells 1999: 124). Their importance is also in the fact that utilising intermediaries is recommended as a part of the business process of acquiring external knowledge and technology (Chatterji 1996: 51–56).

A start-up firm needs several types of knowledge. Some of it may be transferred directly e.g. from higher education institutions in the form of training or research results. Business incubators – usual in Technology Parks – have a major role in advising and guiding entrepreneurs to access the knowledge they need. Saurio argues that focusing and expanding competence, partnerships, and networks are important success factors for small knowledge based businesses. To achieve this, several kinds of expertise are needed. Both the firms and their developers must cooperate regionally, nationally and internationally. (Saurio 2004:28.) Case descriptions of several incubators operated by the Finnish UASs show that the incubators have roles as intermediaries both on university, local, regional, and wider levels (Kuvaja & Saurio 2004). Surveys conducted on the incubators' success among the start-up firms show that the university – start-up firm networking has usually succeeded well (Rothschild & Darr 2005, Chan & Lau 2005, Abduh *et al* 2007). The university-firm relationship has even been described to be more useful than the science park connection (Chan & Lau 2005). Some studies suggest that in networking the start-up firms do not get any or very little advantage (Chan & Lau 2005, Abduh *et al* 2007).

Howells has conducted a study on various intermediaries in the UK. Using an inductive method he found that the intermediary organisations' activities covered ten functions (adapted from Howells 2006: 721–722):

1. Foresight and diagnostics
    a) Technology foresight, forecasting and roadmapping
    b) Articulation of needs and requirements
2. Scanning and information processing
    a) Scanning and technology intelligence
    b) Scoping and filtering in partner selection

3. Knowledge processing, generation and combination

    a) Combinatorial; helping to combine knowledge of two or more partners
    b) Generation and combination including also generating in-house research and technical knowledge to combine with partner knowledge

4. Gate-keeping and brokering

    a) Matchmaking and brokering including negotiation and making deals
    b) Contractual advice in finalising the contract

5. Testing, validation and training

    a) Testing, diagnostics, analysis and inspection
    b) Prototyping and pilot facilities
    c) Scale-up
    d) Validation
    e) Training

6. Accreditation and standards

    a) Setting specifications or providing standard advice
    b) Formal standards setting and verification
    c) Voluntary and de facto standards setting

7. Regulation and arbitration

    a) Regulation
    b) Self-regulation
    c) Informal regulation and arbitration

8. Intellectual property protection

    a) Intellectual property (IP) rights advice
    b) IP management for clients

9. Commercialisation of the outcomes

    a) Marketing research and planning, business planning
    b) Help to establish and run sales networks
    c) Finding potential early stage capital and organising funding or offerings
    d) Venture capital funding
    e) Initial public offering

10. Assessment and evaluation
   a) assessment of performance and technology (see 1)
   b) Technology evaluation of products and technologies once in the market (see 1)

Howells (2006: 723–725) contends that the functions of an innovation intermediary are more numerous and diverse than other studies have implied. Secondly, there are usually more than two parties they are mediating between. New findings indicate that customers are increasingly active users of the service, the collaboration lasts for years, and the intermediaries typically offer also other functions such as contract research, testing, and training without the brokerage function.

2.6 Knowledge transfer and management

The main aim of this thesis is to study the knowledge transfer in the case Technology Parks and the local innovation systems. In this Section knowledge transfer processes are reviewed on a common level with some linkage to Technology Parks and innovation system theories that were reviewed earlier. The next Section looks at tknowledge: its types; character; and value to the firms. Section 2.6.2 is a literature review of the knowledge transfer itself. Section 2.6.3 examines knowledge management and organisational learning to a certain degree – the basic theory needed to analyse the transfer is taken into consideration. Section 2.6.4 reviews knowledge management models, and the 2.6.5 discusses knowledge transfer and management.

2.6.1 Knowledge

The importance of knowledge to firms and other organisations has risen globally as well as in small Technology Parks. According to Miles *et al* (1998: 281) globalisation and technological change have set the stage for a new era of economic development, where the driving force is knowledge, the speed of its development, and the effectiveness of its utilisation. Some authors argue that knowledge and its applications are at the roots of modern economic growth and prosperity (Teece 1998: 55), knowledge is thought to be the only meaningful resource today (Chen et al 2006: 6), and after being a resource among others it is becoming the primary resource (Stenmark 2001: 9). In the 20th Century the developed economies have undergone a transformation from raw material processing and manufacturing activities to processing of information and the development, application, and transfer of new knowledge (Teece 1998).

The importance of the competitive advantages derives from the nature of strategic knowledge itself (Bou-Llusar *et al* 2006: 100). Knowledge assets are often difficult to copy, intellectual property laws protect them in forms of patents, trademarks, and copyrights (Teece 1998: 57).

Managing intellectual capital in the information age is a new challenge for advanced industrial economics. Many business sectors are characterised by new economics, where the importance of managing knowledge has dramatically grown, because of new information technology, and the changing role of intellectual property. Moreover, the context in which knowledge is created and exploited is truly global. (Teece 1998: 55.)

When product and other development activities are concerned, innovation – the source of sustained advantage for most firms – depends upon the individual and collective expertise of employees (Leonard & Sensiper 1998: 112). This is emphasised by Teece (1998: 61) when he argues that new products are more often components of broader systems or architectures. Another, even broader view, is introduced by Geoffrey A Moore (2002: 107–113) in his whole product concept that enlarges the view of what is a product. Both of the latter authors reflect the need of partners and allies because the complexity of products makes it difficult for one firm to master all the knowledge. According to some authors, firms often treat information as a by-product (Wang *et al* 1998: 95).

To be able to recognise and analyse knowledge transfer to the firms' product development processes, the knowledge itself has first to be defined and classified. The literature shows that some authors start their discussion from Greek philosophers (Nonaka & Takeuchi 1995: 21, Mertins *et al* 2003: 1). Several authors have been studying and theorising on the characteristics and content of the knowledge. A popular classification is the division into data, information, and knowledge. According to Mertins *et al* this classification could lead to unproductive discussion of the 'right' distinction between the categories, if it is not properly understood. According to the authors having the knowledge management point of view, the distinction into data, information, and knowledge is relevant and easy to understand. Data and information answer the questions: who – what – where – when while typical questions for knowledge are: how? and why?. (Mertins *et al* 2003.)When data and information are compared, data has no content or meaning, while information is the result of a process that interprets and modifies data to a certain defined form (Pierce *et al* 2006 in Melkas & Uotila 2008: 29–30).

The most usual distinction of knowledge is the division into tacit and explicit knowledge, originally published by Polanyi. Nonaka and Konno define it as follows: '*explicit knowledge can be expressed in words and numbers and shared in the form of data, scientific formulae, specifications, manuals, and the like. This kind of knowledge can be readily transmitted between individuals formally and systematically*.' Also products are one form of explicit knowledge (Nonaka *et al* 1998). On the contrary '*tacit knowledge is highly personal and hard to formalise making it difficult to communicate or share with others*.' Tacit knowledge has two dimensions. The first is the technical one meaning informal skills that are often called know-how. The second dimension is cognitive: beliefs, ideas, schemata, and mental models. (Nonaka & Konno 1998: 5.)

Scharmer (2001) introduces a third form of knowledge: self-transient knowledge. It is a sub-group of tacit knowledge, that is divided into tacit-embodied knowledge, and not-yet-embodied knowledge. Scharmer describes the model with an iceberg, where explicit knowledge is visible, tacit knowledge is under the surface, and self-transcending knowledge deepest under the surface. (Scharmer 2001: 137–139.) The model has been applied also to research on innovation systems (Melkas & Uotila 2008).

When the two main groups of knowledge – tacit and explicit – are compared, tacit knowledge is personal while explicit is public (Kane *et al* 2006: 142). This comes from the fact that tacit knowledge is difficult to formalise and communicate (Nonaka & Takeuchi 1995).

2.6.2 Knowledge transfer

'*Firms are social communities that specialise in the creation and internal transfer of knowledge*', Kogut and Zander show in their study (Kogut & Zander 1993: 625). On the other hand, external knowledge sources are often critical to the innovation processes, regardless of the organisational level on which the innovating unit is located (Cohen & Lewinthal 1990: 128).

The organisational absorptive capacity – the ability of a an organisation to recognise the value of new external information, assimilate it, and apply it to commercial use – is critical for the innovative capabilities of an organisation. The absorptive capacity depends on the absorptive capacities of individuals but it is not just the sum of them, and it includes both external knowledge transfer, and internal knowledge transfer between subunits. A communication system may rely on specialised information transfer between actors, or being more informal. The absorptive capacity of a firm depends on the individuals who are at the interface of either the firm, or the external environment, or at the interface between subunits. When the gatekeeper roles are set to a few persons, others are released from monitoring the environment. However, the centralisation may cause difficulties under a rapid uncertain technical change. The absorptive capacity is not dependent only on gatekeepers but also on the expertise of those individuals to whom they are transmitting the information. There can also be a trade-off between the absorptive capacity and the internal communication. If all the actors inside an organisation share the same specialised language, they may be effective in communication with one another, but they may not be able to acquire diverse external knowledge sources, and even a 'not-invented-here' syndrome may result and further lead to lockout e.g. in a technology. Some overlap of knowledge between individuals is necessary for the internal communication but there are benefits in diversifying knowledge across individuals. (Cohen & Levinthal 1990: 131–142.)

Nieminen (2005: 108) summarises the determinants of the absorptive capacity as mutual trust and power dependencies within a relationship, support structures (e.g. governance mode, infrastructure), mutual intent, dominant logic representing the receiver's ability to capitalise on the transferred knowledge, and the organisational receptivity. This model is an enhancement to the model introduced by Lane and Lubatkin (1998: 473–474) where they argue that the ability to learn from another firm to depends on the similarity of the knowledge bases of both firms, organisational structures, and compensation policies as well as of dominant logics.

Developing a broad and active network with internal and external relationships, the individuals' awareness of others' capabilities and knowledge grows. Thus the individuals' growing absorptive capacity strengthens the absorptive capacity of an organisation. (Cohen & Levintahl 1990: 131)

Most of the explored firms in this study are SMEs. A UK study implies that there are significant age, educational, and size effects that influence an SME's acquisition and assimilation of knowledge. Primarily, it is the small firms of 15+ employees that have the capacity to absorb and use new knowledge – especially those with higher educational levels and clear growth objectives. These firms are not start-ups but they do tend to be young firms with young founders. (Gray 2006: 352–354.)

Eric von Hippel has studied the sources of innovation and emphasises the role of customers and suppliers (von Hippel 1988a: 14–18). The information is often costly to acquire, transfer, and use in a new location, and this is why he calls it the 'sticky' information (von Hippel 1994: 430). He has also identified a problem in practice in his case studies. For example, ASIC customization was found to require access to application specific "sticky" information in each case. The same was found in the computer telephony integration systems (CTI). In both cases, he found that users, rather than suppliers, are the actual designers of the application-specific portion of the products. (von Hippel 1994: 442–444.) The term 'sticky' has since then been widely used in the literature.

Organisational learning is often described by the organisational learning curve showing the cumulative output as a function of labour hours per unit (Argote 1999: 1–28) or the production time as a function of the cumulative production (Fioretti 2007: 3). Organisational learning curves compound the following factors (Fioretti 2007: 2):

- the individual learning of single workers who learn to use a machine or perform a task that does not require coordination with other workers. Individual learning curves have roughly the same shape as organisational learning curves and surely concur to the overall effect;
- the collective coordination of workers on given tools and machines. Workers have a wide scope for finding better ways of scheduling their operations and exploiting the potentialities of the machines that they are using, particularly if these machines have some flexibility;
- the incremental innovation of the machines and tools employed in a plant. Initiatives by supervisors, technicians and engineers change the environment where workers coordinate their operations, offering new possibilities of improvement;
- increasing returns to scale. Some empirical cases where the production time decreased with the cumulative output might have been influenced by the introduction of faster machinery once the output increased sufficiently.

A study in chemical industries resulted in the conclusion that variations in the slope of the learning curve are related to research and development expenditure and capital intensity (Lieberman 1987).

An organisation can also forget. One major factor influencing this is the extent of the labourforce turnover. The knowledge embedded in individuals is one of the organisational memory modes, which also implies that transferring personnel is a very effective way to transfer especially tacit knowledge. This form of organisational memory has also its pitfalls. Studies have shown that the knowledge embedded in groups is more stable than the knowledge embedded in individuals. Other downsides are that individuals may not be motivated to share their knowledge, or they just can leave the organisation. The other forms of embedded knowledge are the knowledge embedded in technology, and the knowledge embedded in structures and routines. (Argote 1999.)

Knowledge transfer mechanisms between organisations and units of organisations are of interest in this study. Several of them have been described and studied in the literature. The transfer may occur both on the individual, the group, and the organisational level. The mechanisms include training members of the recipient organisation, observing the performance of experts, and providing opportunities to communication. Documents, blue prints, and transfer of experienced personnel are additional mechanisms. Since some of the knowledge is embedded in the hardware, software, and products, providing those to a recipient organisation facilitates the knowledge transfer. In summary, knowledge can be transferred by moving people, technology, or structure to the organisation, or by modifying people (e.g. training), technology, and the structure of the recipient organisation. (Argote 1999.)

Many authors have written on the difficulty of transferring tacit knowledge. Lubit (2001) lists solutions to accomplish it without transforming the knowledge to explicit form:

- working together with experts making observations and learning from coaching;
- working in groups and networks including brainstorming etc.;
- recording learning histories by writing narratives of critical events in a firm such as a change initiative, a product launch, or an innovation including also mistakes;
- developing routines for dealing with various situations and spreading the routines throughout the organization.

All in all, there are two basic types of knowledge to be transferred: tacit; and explicit. The knowledge transfer can be internal or external and it may occur on the individual, the group, or the organisational level. The two main models are modification and moving. Modifying people means training, using observation, and arranging opportunities to communication. Moving people can happen within an organisation from one unit to another or between organisations. Technology can also be developed either by moving it in from external sources or by modifying it in the organisation. The routines, the structures, and the standard operating procedures can be either modified in the organisation or be moved into the organisation.

2.6.3 Knowledge management models

Knowledge transfer is one function of knowledge management. It can be defined for example as follows (Dalkir 2005: 3): '*Knowledge management is deliberate and systematic coordination of an organisation's people, technology, processes, and organisational structure in order to add value through reuse and innovation. This coordination is achieved through creating, sharing, and applying knowledge as well as through feeding the valuable lessons learned and best practices into corporate memory in order to foster continued organisational learning*.'

Another definition based on another model is presented by a researcher at the Fraunhofer Institute (Mertins et al 2003: 11): 'Knowledge management includes all methods, instruments and tools that contribute to the promotion of an integrated core knowledge process – with the following four core activities as a minimum, to generate knowledge, to store knowledge, to distribute knowledge and to apply knowledge – in all areas and levels of the organisation in order to enhance organisational performance by focusing on the value creating business processes.'

According to the definitions all knowledge transfer processes in the studied Technology Parks and firms belong under the headline knowledge management.

A well known theory of knowledge transfer and management is the SECI model developed by Nonaka and Takeuchi. The model is grounded on the two basic types of knowledge: tacit and explicit. The knowledge creation is a spiralling process between the two knowledge types (Fig. 22). In the socialisation tacit knowledge is exchanged through joint activities in physical proximity. The externalisation requires the expression of tacit knowledge, and translation of it to understandable terms. Commitment to work in group and integration to its mental world is needed. The combination involves the conversion of explicit knowledge into a more complex set of explicit knowledge – the systematisation of knowledge. In practice this means capturing and integrating new explicit knowledge, dissemination of this knowledge among organisational members using presentations and meetings, and editing it to a more usable form. The last step, the internalisation, of the created knowledge is the conversion of explicit knowledge into the organisations' tacit knowledge. First, the explicit knowledge has to be embodied in action and actualising practice e.g. innovation or improvement. Second, the learning by doing processes are triggered by using simulations and experiments. (Nonaka & Konno 1998: 42–45.)

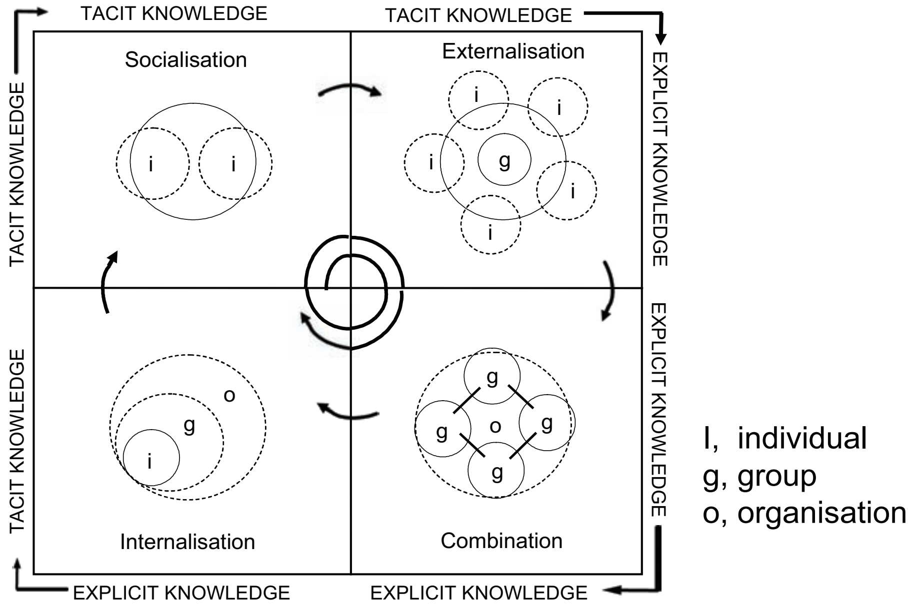


Fig. 22. Spiral evolution of knowledge conversion and the self-transcending process (adapted from Nonaka & Konno 1998: 43).

Bas are the social institutions for dynamic knowledge conversion. There are four types of them (Fig 23). Within the originating ba – where the knowledge creation process begins – individuals share feelings, emotions, experiences and mental models. Face-to-face experiences are the key to the conversion and the transfer of tacit knowledge. The interacting ba is more consciously constructed, and selection of people having the right mix of knowledge and capabilities for a team is critical. In the interacting ba the tacit knowledge is made explicit with the help of initiators leading a dialogue. The cyber ba is a virtual interaction place presenting the combination phase. New explicit knowledge is combined with the existing information and knowledge to generate and systemise explicit knowledge throughout the organisation. The most efficient way is to use the information technology. The exercising ba supports the internationalisation phase by facilitating the conversion of explicit knowledge to tacit knowledge. Focused training with senior mentors and colleagues consists primarily of continued exercises stressing certain patterns or working out such patterns. Learning is based on active participation instead of teaching. (Nonaka & Konno 1998: 45–47.)

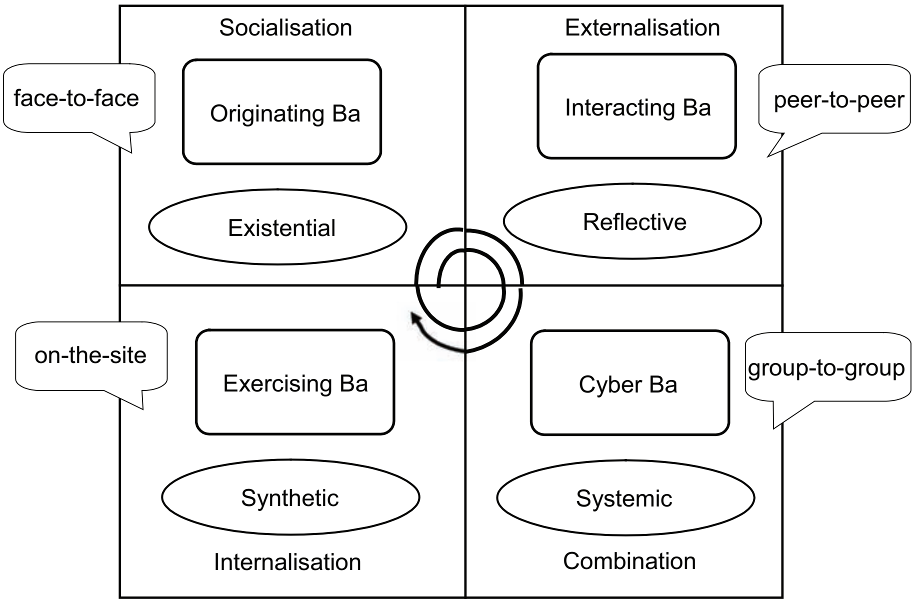


Fig. 23. The four characteristics of Ba (adapted from Nonaka & Konno 1998: 46).

The SECI model has been applied also to the product development process. There the socialisation includes the sharing of tacit knowledge from users, collaborating organisations, and the organisation itself. The externalisation consists of creating a concept, the internalisation justifying the concept, and the combination building an archetype finally followed by cross-levelling the knowledge. Explicit knowledge produced in the process may include e.g. advertisements, patents, products and services. (Nonaka *et al* 1996: 213–215.)

The SECI model has been utilised in a large number of studies since it was introduced. Ray *et al* (2001: 14–15) have studied knowledge management in Japanese firms. Their finding is that most of the ba activities occur automatically but self-organising ventures with outsiders are problematic. Bolisani and Scarso (1999) have used the model to study knowledge management in interorganisational collaboration, and the possibility to use ICT applications for the purpose. Feller (2004) studied interorganisational process learning in interorganisational product development projects. His findings support the model, and verify that it can be applied to inter-organisational process learning.

Some studies analyse knowledge management in SMEs with the help of the SECI model. Desouza and Awazu (2006) were surprised at its scope in their study in 25 firms in the USA. The model typically emphasises the socialisation, and the centrality of people with technology in the background. To be able to acquire external knowledge, the SMEs had typically good local connections. Aramburu *et al* (2006) conducted a study on firms in the Spanish Basque region. They found that there were changes towards knowledge management in the firms, but those could not be seen in the adaptation of the organisational structures. The change had been made quite well in the small firms but in large and medium sized firms only to a very small extent.

Knowledge management is typically described in cycles. After an earlier study of some major approaches to knowledge management cycles Dalkir presents an integrated cycle with three major steps (Fig 24) (Dalkir 2005: 43):

- Knowledge capture and/or creation.
- Knowledge sharing and dissemination.
- Knowledge acquisition and application.

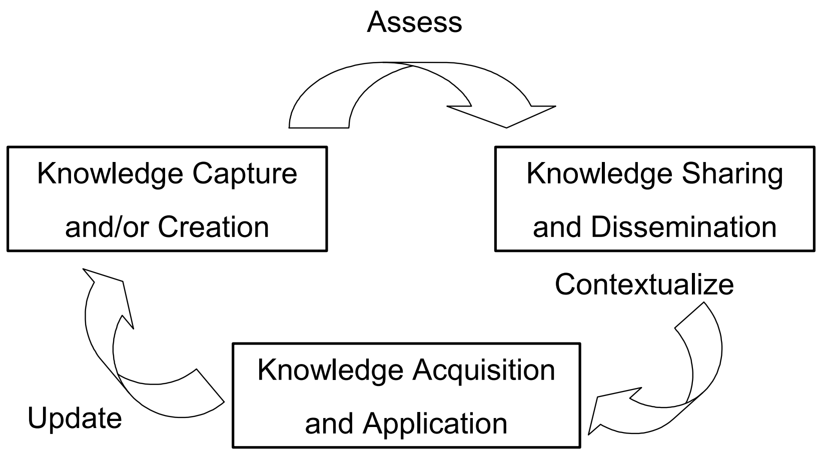


Fig. 24. An integrated knowledge management cycle (Dalkir 2005: 43).

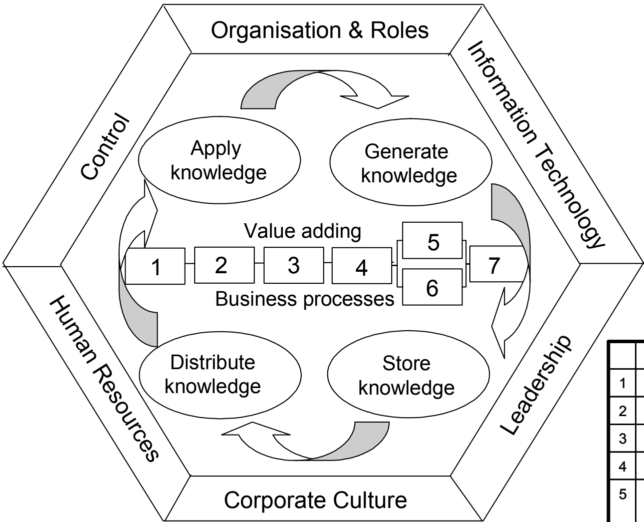
In the model the knowledge capture refers to the identification and the codification of existing internal knowledge and know-how, as well as external knowledge from the environment. The knowledge capture includes the development of new knowledge and innovations that did not exist within the firm earlier. After deciding that the new content has a sufficient value the content will be contextualised. This involves maintaining a link between the knowledge and those knowing the content, and it implies the identification of the key attributes of the content in order to better match the variety of users. The contextualisation will usually succeed when the new content is embedded in the business processes. The cycle is then reiterated when the users understand and decide to make use of the content. The users will validate the usefulness of the knowledge and they will signal when it becomes out of date or it is not applicable. (Dalkir 2005: 43–44.)

When tacit knowledge capture is concerned, Dalkir lists interviewing experts, structured interviews, stories, learning by being told, and learning by observation as knowledge transfer methods. Other possible techniques are e.g. *ad hoc* sessions, road maps, learning histories, action learning, e-learning, learning from others through business guest speakers, and benchmarking against best practices. The key knowledge acquisition phases are the identification of the knowledge, the conceptualisation and the codification. (Dalkir 2005: 80–96.)

The next steps are the sharing and the dissemination of the knowledge through the organisation. Learning is a social event. In addition to the traditional social interaction, technology offers a new medium to share knowledge. E-mail groups, discussion groups, and other virtual workspaces typically in organisation's intranet are utilised. These groups are called communities of practice, and they are characterised by common goals, commitment, and a virtual workspace. In the final step, the knowledge application, the knowledge is put in an actual use. The use and the reuse of the captured knowledge is the reason why knowledge management is needed. (Dalkir 2005: 109–140.)

Fraunhofer IPK has designed an own reference model for knowledge management by combining the results of a state-of-art study in the industries and the results of academic research, and using requirements from the industries as a reference (Fig. 25). The model has three layers: the value adding business processes; the knowledge management core process; and the so called design fields of knowledge management. The design fields are corporate culture, leadership, human resources, information technology, organisation and roles, and control. (Mertins *et al* 2003: 1–11.)

Kalpic and Bernus (2006) discuss the role of business process modelling through the perspective of knowledge management. The authors suggest that the business process modelling is an important tool for knowledge management: it allows the transformation of informal knowledge into formal knowledge, and facilitates its externalisation in the form of knowledge artefacts, sharing, and subsequent internalisation. Beside the business process model they use SECI model to present the knowledge. Also several other types of knowledge transfer models have been studied. E.g. Kane *et al* (2006) introduce ethnography as a framework for understanding better the more personal elements of knowledge.



	Operating Processes
1	Understanding market & customer
2	Development vision & Strategy
3	Design products & services
4	Marketing & sell
5	Produce & deliver for manufacturing organisation
6	Produce & deliver for service organisation
7	Invoice & service customer

Fig. 25. Core process and design fields of knowledge management (Mertins *et al* 2003: 11, Heisig 2003, copyright Fraunhofer IPK 2003).

2.6.4 Studies on knowledge transfer and management

Several studies on knowledge transfer and management in and between organisations have been done. The following is a review of ones relevant to this study.

Gunnar Hedlund (1994) approaches tacit and articulated knowledge, on individual, small group, organisation, and interorganisational levels, as carriers having interaction between them. The transfer processes are: reflection between tacit and articulated levels (articulation: tacit to articulated; internalisation: articulated to tacit); dialogue (extension from lower to higher level; appropriation for transfer of tacit knowledge); and import and export of knowledge (assimilation, dissemination). Hedlund calls the new type of organisation the N-form as an opposite phenomenon to the M-form meaning an organisation divided to multiple divisions. Table 4 lists the main differences between these organisation types.

Table 3. Differences between N-form and M-form organisations (Adapted from Hedlund 1994).

	N-Form	M-form
Technological interdependence	Combination	Division
People interdependence	Temporary constellations, given pool of people	Permanent structures, changing pool of people
Critical organisation level	Middle	Top
Communication network	Lateral	Vertical
Top management role	Catalyst, architect, protector	Monitor, allocator
Competitive scope	Focus, economics of depth, combinable parts	Diversification, economics of scale and scope, semi-independent parts
Basic organisational form	Heterarchy	Hierarchy

Hedlund (1994) favours a combination over a division of human resources, temporary constellations of people over permanent structures, lateral communication over vertical, and the top management role as catalytic rather than monitoring. In summary, this means decentralised knowledge management and creation. Tsoukas (1996) indicates that a firm is a distributed and decentred knowledge system that does not know what it needs to know. According to him the resources a firm uses are neither given nor discovered but created. The organisational problem is the utilisation of knowledge which is not known in its totality by just one person. Miles *et al* (1998) add that the knowledge utilisation is a collaborative process – whether between the employees in a firm, or in the transfer and utilisation between firms – where individual efforts are voluntarily combined to produce results that could not be achieved alone. Newer organisational forms – networks, alliances, federations, and the cellular design – demand a collaborative behaviour. Additionally, ideas are time-bound assets that are lost if unexploited.

Desouza and Awazu (2003: 345–348) suggest that there is a common ground between the technological and the sociological imperatives of knowledge management development in an organisation: the internal knowledge market. As a conclusion from ‘mini-cases’ in firms, and the economics literature on market-based systems they define the components of internal knowledge markets: players (the buyers and the sellers); rules (the governance of interaction); and space (area where the buyers and the sellers collect). In an internal knowledge market both the buyers and the sellers are in the same organisation, and their roles can interchange at any point of time or with any transaction. Also a machine can be an agent: e.g. an information system. A market sets the rules on how the buyers and the sellers will interact. These are defined *a priori* and they determine the exchange and pricing mechanisms. Two questions should be asked: “what goods will be bought and sold?” and “how will the goods be paid for?”. To a large extent only codified knowledge can be bought and sold, while it is difficult but not impossible for uncodified knowledge to be bought or sold.

Knowledge has a price, and the market dictates the medium of payment. In a barter market the exchange governs. In common marketplaces a product is exchanged for a common medium (currency). Many firms use proxies to represent real monetary value for the knowledge objects. There are three mechanisms to set the prices. Private negotiations are the most common. Even if in many cases no explicit price is fixed, implicitly the price is paid with the exchange of knowledge. Knowledge is thus a social product. A pricing system may base on time used to produce the knowledge. This is said to prevent the ‘free-riding problem’. The third mechanism is auction based pricing. The authors say that an electronic internal knowledge market is a logical space for the internal knowledge market. The market should be organised into departments, navigation should be available, and the environment should attract. (Desouza & Awazu 2003: 347–349.)

Trust is necessary to ensure that users participate. In the starting phase the ’chicken-and-egg’ predicament must be avoided as well as the black market which can occur both on the buyer side in the form of delivering the bought knowledge further without permission, and on the seller side in the form of selling the knowledge outside the system. (Desouza & Awazu 2003: 350–351.)

Hellström *et al* (2002) have conducted a case study on the decentralised human-based knowledge management system that has replaced the knowledge database solution at Ericsson Software Technology. In the study it was found that the database solution neither covered the interpersonal context of the knowledge exchange, nor the situational nature of the exchange itself. There was a preunderstanding that knowledge was most effectively exchanged in an actual problem solving situation. Two primary ways were found: flashes and learning situations. Two forms of the less than 10 minute person-to-person flashes were identified: broker flashes where the knowledge of who knows was exchanged; and knowledge flashes where know-why, know-how and know-what knowledge was transferred. Broker flashes took place when people walked around, at reviews, at inspections, when employees participated in project risk analyses, and when employees participated in various types of cross-sectional teams and networks. Learning situations occurred when one of the employees had formally learned but lacked experience in the relevant problem solving area. A typical arrangement is to have an experienced knowledgeable colleague moderating a workshop, participating in developing a project plan with one or more others, or guiding a quality coordinator in using the firm software quality assurance processes. The brokerage system has been formalised and the organisational role is defined as a 'knowledge broker', a catalyst whose responsibility is to connect persons with knowledge and experience with persons who need the knowledge for particular purposes. The role was set to facilitate knowledge flashes and learning situations and to identify the knowledgeable persons, their respective competence areas and list them; to facilitate contacts between knowledge need and expertise; to strive to connect people across organisational boundaries; to be perceived to be available by potential 'users'; and to follow up flashes and learning situations. The broker moves around the organisation, talks to as many people as possible, listens, and establishes knowledge needs and corresponding expertise so that these can be connected.

Brown and Duguid (1998) emphasise the role of a knowledge broker and the role of a knowledge translator, who frames the interest of one community in terms of the perspective of another community. The challenge is that the translator must be knowledgeable about the work of both communities to be able to translate. Often external mediators and consultants are called in to provide the task.

2.7 Implications from the theory

Research question 1: What kind of elements affect knowledge transfer from and through a local innovation system with incomplete services to firms' product development processes?

The main goal of this study is to clarify the functionality of small Technology Parks as innovation systems, or as a part of a local innovation system. In the previous text theories and previous studies were reviewed. This Section consists of a discussion based on the literature review, and it describes the identified *factors*, and defines how they are used to analyse the empirical cases. The first two factors – *innovation system, and social capital* – are *enablers* that form the foundation for knowledge transfer. The next two factors are *processes* built on the enablers, and make knowledge transfer happen. The *product development process* defines the need for knowledge, and the *organisational networking* builds the structure to transfer knowledge. Finally the fifth factor – the *knowledge transfer* itself – is a *consequence* and summation of the enablers and processes. It is expected that the role of the factors may vary between Technology Parks. A cross-park analysis is conducted to explore these differences. Fig. 3 in the Introduction Section 2.2 illustrates the structure.

Social capital, organisational networking, product development process, and knowledge transfer could be included in the innovation system framework. In this study it was seen as useful to divide one large system into smaller subsystems to facilitate the analysis.

Neither of the five components of the framework is meant to cover the whole theory. The theories are too large to be included in one thesis project. On the other hand, the study focuses on knowledge transfer and related topics. The limitations will be discussed and described in the sub-sections.

2.7.1 Innovation systems

Sub-question 1: What is the role of an innovation system in enabling knowledge transfer to firms' product development processes in small Technology Parks?

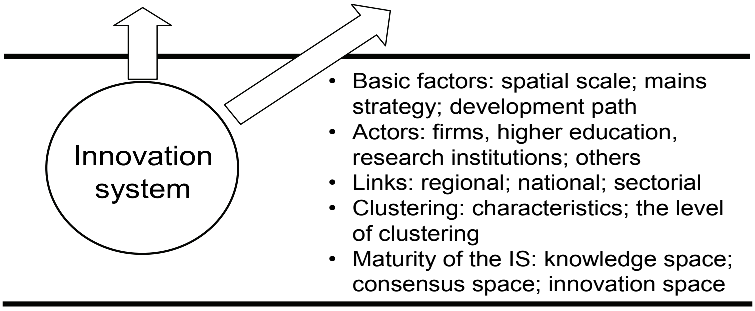


Fig. 26. The main features of the analysis of the innovation system.

The innovation system – in which a firm operates – is an enabler for its innovative processes. Because of this the Technology Park, and the innovation system have to be explored and analysed to understand the enabling factors.

In the Technology Park literature the geographic area of a Technology Park was identified as problematic: the area can cover e.g. a few buildings, a whole town, or even a county. In most of the Technology Parks all the local actors may not participate in the firms' innovation processes nor all the local firms involved are located in the Technology Park. (Phillips & Yeung 2003.) Even though Technology Parks are often presented as independent systems (e.g. IASP 2002), they may be a part of larger innovation system. The conclusion is that the *spatial scale of the focal Technology Park*, *or the local innovation system* has to be explored when a Technology Park is analysed as an innovation system. If the local innovation system is found to differ from the science park, it has to be the study object.

According to Ylinenpää's (2001) study, the chosen *main strategy of the focal Technology Park* has a major effect on the operations. Ylinenpää defines two main strategy options: the incubation strategy aiming for favourable conditions to create new start-up firms; and the attraction strategy trying to attract established and larger firms to locate knowledge-intensive divisions or units. The latter strategy may lead to a vertically oriented 'firm constellation' instead of a horizontal 'network' structure, and thus the strategy choice may influence the product development and knowledge transfer processes. Because of its influence the main strategy is an important feature to be analysed.

To understand the functionality of a Technology Park, its earlier history and development has to be known: every park has been founded in its own time and shares some features in its development path with the others even though not simultaneously (Breshanan *et al* 2001). According to literature, the earlier development affects the functionality today. The third part of the Technology Parks literature based study is a short analysis of *the park history and the development path.*

The innovation system literature verifies that other actors – external to a focal firm – have an important role in the focal firm's innovation processes. In a Technology Park there are some specific actors to operate some special activities. In many cases the Technology Park firm itself takes care of several tasks: building and maintaining the premises, operating business hotel services, running the incubating services, etc. There is a large variation between science parks. (Jauhiainen *et al* 2004.) A*ctivities and actors* will be studied in detail but limited to knowledge related topics.

Other firms were found to be the most important partners in firms' innovation processes in all the studies where measured, which makes the result reliable (e.g von Hippel 1986, von Hippel 1986, Nieminen & Kautonen 2001, Laursen & Salter 2004). The other firms include several different groups having different characteristics from the focal firm point of view. Customers are of the highest importance according to surveys of firms (Fritsch & Lukas 2001, Nieminen & Kautonen 2001, Schibany & Schartinger 2001, Kristensen & Vinding 2001, Laursen & Salter 2004, Moore 2002). Local customers inside the 'local innovation system' are of the highest importance (Porter 1991, Lai & Shyu 2005) followed by equipment, material, component, and subsystem suppliers (Nieminen & Kautonen 2001, Fritsch & Lukas 2001, Schibany & Schartinger 2001, Kristensen & Vinding 2001, von Hippel 1998b). The existence of local rivals enables both mutual knowledge transfer, joint knowledge transfer from third parties, and knowledge creation through joint participation in research programmes (von Hippel 1986, von Hippel 1986, Soekijad & Andriessen 2003). An anchor tenant with heavy investment in R&D may have a major effect on local smaller firms (Agrawal & Cockburn 2003). Both other firms and *inter-firm relations* will be analysed to understand the knowledge flows among firms.

Strategic and tactical alliances, and subcontracting in product development processes have become more and more usual in the globalising market with multi-technological products (Narula 2004). Alliances, partnerships, and outsourcing of individual tasks or projects are of high importance (Narula 2004, McKenzie 2005, Moore 2002, Vilkamo & Keil 2000, Howells 2004, Fan *et al* 2000, Bourgeois & Eisenhardt 1988, Eisenhardt & Bourgeois 1988, Vilkamo & Kiel 2000). In practice, they are forms of inter-firm relations, and will be analysed.

Knowledge intensive business services (KIBS) is argued to have a significant role in knowledge processing and transfer (Muller & Zenket 2001, Czarnitzki & Spielkamp 2000). The role of KIBS and other intermediaries in an innovation system is to intermediate knowledge and information as well as to influence the structures and dynamics of the system (Smedlund *et al* 2005, Howells 2006, Coombs *et al* 2003). Many organisations or parts of them may have the intermediate role even unconsciously (Smedlund *et al* 2005. Incubators' role is to assist start-up firms, and transfer or intermediate them the knowledge they need (Saurio 2004a, Saurio 2004b, Rothschild & Darr 2005, Chan & Lau 2005, Abduh *et al* 2007, Chan & Lau 2005). To identify the intermediaries and their roles, *the intermediate activities* are analysed.

The type and existence of *higher education and research institutes* varies between Technology Parks and local innovation systems. While most of the personnel is presumed to have high educational level, higher education institutes (HEIs) form the central source of qualified personnel. The knowledge base can be focused to fit better the needs of local firms with the help of project-based learning, and thesis focused on the firms' needs (Fink 2001, Fink 2003, Moesby 2005, Nieminen & Kautonen 2001). The local degree and other education programmes are analysed to find out their roles. Local research has a significant value to the firms. (e.g. Nieminen & Kautonen 2001, Leydesdorf & Etzkowitz 1998, Etzkowitz & Leydesdorf 1995, Mowery & Bhaven 2005). The different models the institutions utilise for contract research, publicly funded research, study projects, licensing etc. are of importance to understand their enabling roles.

An innovation system consists of actors and their operations that are conducted in collaboration between organisations. Competition, transaction and networking between various types of actors described above are central for the functionality of a local innovation system (OECD 2000, Lundvall 2005, Edquist 2005). *The links between actors* are explored when analysing the local innovation systems on a general level, while detailed analyses of the empirical innovation project cases are conducted later.

A local innovation system does not function without *links to a broader geographical context: the regional, and national innovation systems.* When defining the spatial boundaries of a regional innovation system the main criterion is the high 'coherence' or 'inward orientation' with regard to the innovation processes instead of e.g. administrative boundaries (Edquist 2005). In practice this can be interpreted so that a science park or a local innovation system can be part of a larger regional system, or have links to one or several regional systems

(Cooke 2004). These links are explored and analysed in each of the two case Technology Parks. The national innovation system forms the boundary conditions in which the local actors operate. The national system should not be seen as a question of resource allocation but the dynamic features including learning, knowledge flows and relationships (Lundvall 1998, OECD 1997). When exploring the links to national level, actors on a larger than regional level are taken into consideration.

The sectoral innovation system approach focuses on knowledge and technology domain, actors and networks, and institutions (Malerba 2001, 2005) – the same types of elements as the spatially defined innovation systems but focusing on one sector only. The sectoral system can be local, national, or global, or it can have all these dimensions combined (Malerba 2005). In this study the actors' local, regional, national, and international *sectoral links* are explored.

The maturity and functionality of the 'local innovation system' are analysed by applying the Triple Helix model (Leydesdorff & Etzkowitz 1996). The two layers – institutional relations and functional relations – are essential (Leydesdorff 2006). The evaluation of the science-based regional economic development is done by studying the intensity of interaction among organisations within institutional spheres, openness to interaction across institutional spheres, linkage mechanisms, the public venture capital, and local authorities. The result will describe the maturity level of the knowledge space (creation of a regional innovation environment), the consensus space (a 'triple helix' of linkages generate ideas and strategies), and the innovation space (realising goals, experiments, public venture capital). (Etzkowitz 2002.) Based on the results of the previous analyses, a Triple Helix analysis, and a *cluster analysis* of the 'local innovation system' will be conducted applying existing analysis models (Breschi & Malerba 2005, Paija 2001, den Hertog *et al* 2001).

Both the triple-helix and cluster analysis can be conducted to different intensities. Either of them could make a basis for a doctoral thesis. Because in this study the results are needed to understand the maturity of the local innovation system, both of the analyses are partial, and they cover only the knowledge related topics.

As a summary, the Technology Parks are analysed as local innovation systems by studying the basic factors (i.e. spatial scale, main strategy, development path); actors (i.e. firms, HEI, research institutions, others); links (i.e. regional, national, sectorial); clustering (i.e. characteristics, the level of clustering); and the maturity of the innovation system (i.e. knowledge space, consensus space, innovation space).

2.7.2 Social capital

Sub-question 2: What is the role of social capital in enabling knowledge transfer to firms' product development processes in small Technology Parks?

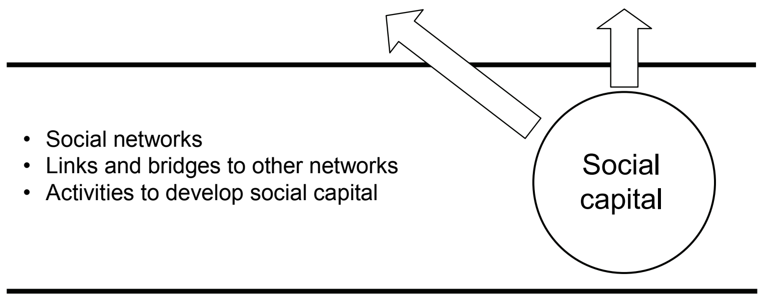


Fig. 27. The main features of the analysis of the social capital.

The aim is not to cover all social capital related topics in this study but some limitations will be done while defining the framework.

Connections and links between people form the basis for networking among firms and between firms and other organisations. Even if the cooperation between firms is built on precise contracts, the negotiations and connections are dependent on the interaction between persons working in those firms. Strong ties are important for social support. A weak tie is the opposite – a friend of a friend type of interaction – that is valuable as a source of novel information. (Granowetter 1973, Powell *et al* 2004.) Structural holes are potential connections that can be used to broker gaps in the network (Powell *et al* 2004, Burt 2004). Brokerage across the structural holes provides a vision of options otherwise unseen (Burt 2004). Direct ties serve as sources of resources and information, indirect ties as sources of information, and structural holes between partners expand the diversity of information. Direct and indirect ties influence the innovation output positively, but increasing number of structural holes decreases innovation output. (Ahuja 2000.)

Social capital consists of social networks, norms, and sanctions that govern their characteristics. It has three basic components: a network, a cluster of norms, values and expectations shared by group members, and sanctions that help to maintain the norms and network. The sub-types of social capital are defined as bonding, bridging and linking. Bonding can be referred to strong ties and bridging to weak ties while linking is an even weaker connection including e.g. norms like mutual respect. (Halpern 2005.)

Strong ties, a high level of social capital, and proximity are argued to foster innovation and learning processes as total (e.g. Landry *et al* 2001, Scarbrough 2003, Chakrabati & Santoro 2004, Hellström & Malmquist 2000, Hellström *et al* 2002, Sobrero 2000, Owen-Smith & Powell 2004, Arndt & Sternberg 2000) while weak ties foster radical innovations (Elfring & Huisink 2003). Key persons are important to make networks efficient (Müller-Prothmann *et al* 2005, Chakrabarti & Santoro 2004). On the other hand, Florida (2002) argues that a high level of bonding local social capital prevents innovativeness, and Castells (2000) emphasises the role of virtual communities. The research community does not agree on the topic.

Where innovation system research is concerned, social networks are often found to be an advantage for the functionality even though they are not expected to be based on as strong ties as in a family. E.g. the Triple-Helix model emphasises the intensity of interaction, openness, linkage mechanisms, and the consensus space (Etzkowitz 2002).

The majority of researchers find that local social – or at least interpersonal – networks support interorganisational networking and knowledge transfer to product development processes. The results of the study are utilised to analyse the influence of the social capital on innovation and knowledge transfer.

In this study the local social capital is explored with the focus on interpersonal networks. Links and bridges to other networks form the other main focus. Additionally activities conducted to develop social networking are studied. Norms and sanctions are excluded.

2.7.3 Product development process

Sub- question 3: What kind of knowledge is needed in various phases of product development processes in firms in small Technology Parks?

The main focus of this study is on knowledge transfer to the product development processes of the firms in small Technology Parks. The process itself is not a primary object of the study because the type and sources of knowledge needed in the different parts of the product development process varies (Knudsen 2007). However, it is necessary to analyse the process to some degree.

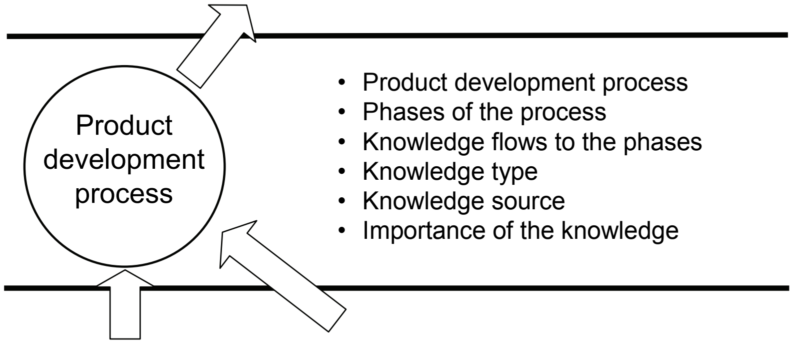


Fig. 28. The main features of the analysis of the product development processes.

Several models to describe the innovation process exist. The number and definition of stages vary to some degree. The fuzzy front end consists of identification of the opportunity, idea generation and refinement, and idea evaluation (Apilo & Taskinen 2006). Some writers involve the concept of development in it (Koen *et al* 2001), while some others involve even the idea of evaluation in the main product development process (Cooper 2006). The concept development is followed by the technical design stages. The technical development is then followed by functional testing, validation and refinement as well as production ramp-up and launch. (Cooper 2006, Ulrich & Eppinger 2003, Apilo & Taskinen 2006.) Moore adds the development of a 'whole product' after the product is already in the market, and additional features and services are needed to find new customer groups (Moore 2002).

Firms rarely innovate alone (Schibany & Polt 2001) but seek collaboration to share risks (Littler *et al* 1995), and find complementary resources (Littler *et al* 1995, Becker & Dietz 2004, Emden *et al* 2006, Ebersberger & Lehtoranta 2005). Users are a major source of knowledge (von Hippel 2005, Zamboni 2005, Lettl *et al* 2004, Olson & Bakke 2001, Knudsen 2007) as well as suppliers (Wynstra & ten Pierick 2000, Hartley *et al* 1997, Petersen *et al* 2003). In addition to the mediating role, intermediaries may also have a role in tailoring new technologies (Tomes *et al* 2000). The role of higher education and research institutes is emphasised (Etzkowitz & Leydesdorf 1995, Etzkowitz & Leydesdorf 2000, Simonen 2007, Nobelius 2004) although in surveys they are not on the top of the list (Fritsch & Lukas 2001, Schibany & Schartinger 2001, Kristensen & Vinding 2001, Nieminen & Kaukonen 2001). The role of outsourcing, alliances, and partnerships is rising (e.g. Hoecht & Trott 2006, Kumar & Snavely 2006, Veflen Olsen 2006, Perrons & Platts 2005, Perrons & Platts 2005) especially when incremental innovations are concerned (Beneito 2006).

In this study the Ulrich-Eppinger model is utilised for analysing the case projects and the processes. The reason is that the model has enough phases between the front and back ends, and thus enables a detailed analysis of the knowledge transfer processes.

In this study attention is paid to analysing the product development process and its phases followed by analysing the knowledge flows to the various product development phases according to the knowledge type, source, and importance.

2.7.4 Interorganisational networking

Sub-question 4: How does interorganisational networking function in knowledge transfer to firms' product development processes in small Technology Parks?

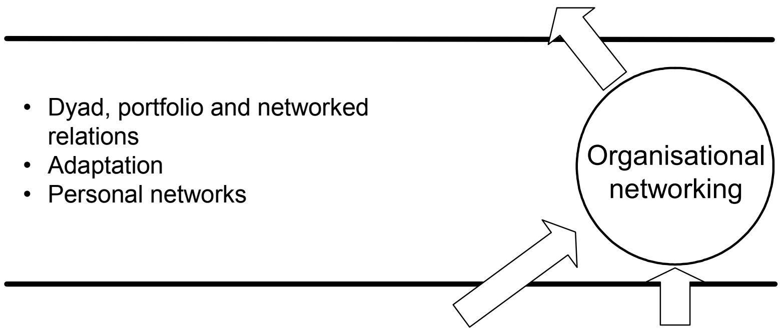


Fig. 29. The main features of the analysis of the organisational networking.

The basic level of an interorganisational relationship is a *dyad one-to-one relation*, where personal contacts and social capital are argued to be an essential role (Halinen & Salmi 2001). Personal contacts may either promote or inhibit the exchange of information, assessment, negotiations and adaptation, and service production and transfer. Because of various factors, firms use managerial practices and processes to foster trust building. The trust itself has three dimensions: competence, goodwill, and behaviour. (Blomquist & Ståhle 2000.)

The reputation of treating counterparts fairly (Andersson *et al* 2007), cultural values, and norms are of importance (Andersen & Christensen 2000). A shared identity helps in developing mutual trust that helps develop transparency, intent to mutual learning, and understanding each other better than formal agreements. On the other hand, too strong trust is claimed to destroy creativity. (Nieminen 2005b.) This is in line with Florida's (2002) arguments on the negative role of bonding social capital on innovativeness. Mutual trust and commitment, power dependencies, mutual intent, shared identity, and previous outcomes define the relationship atmosphere. Processes needed in for interaction are exchange, adaptation, and coordination. The support structure should cover the rewarding system, operational structure, and infrastructure. (Nieminen 2005b.)

In practice most firms operate simultaneously with several other firms and organisations. This is called *the portfolio of relationships* (Ritter *et al* 2004). If the system is open, the members are connected to each other through other members in structural holes controlling knowledge flows among actors. In a closed system all actors have connections to all others. An open system favours the capture of new knowledge but not so much its creation. A closed system supports more both moving and creating of knowledge, and supports incremental development and innovation. (Andersson *et al* 2007.) If the market is turbulent the actors are forced to constant strategising, partnerships are decided fast, many of them are short, and the networks are constantly changing (Blomqvist & Ståhle 2000). The whole network can be managed by using e.g. methods used e.g. in supply chain management including business process integration etc. (Lambert 2006, Lambert *et al* 1998).

Lambert (2006) defines four types of business process links according to the importance of each actor to the firm: managed links; monitored links; non-managed links; and non-member links. In some cases connected relations are managed (Ritter *et al* 2004), which in practice means that the specified part of the relationship chain is closed (see Andersson *et al* 2007).

To understand the knowledge transfer to firms' product development processes, interorganisational networking for knowledge is analysed as dyad one-to-one relations, and one-to-many portfolio relations. Adaptation and personal networks are also analysed.

2.7.5 Knowledge transfer and management

Research question 2: How is knowledge transferred in and through the local innovation system to firms' product development processes in small Technology Parks?

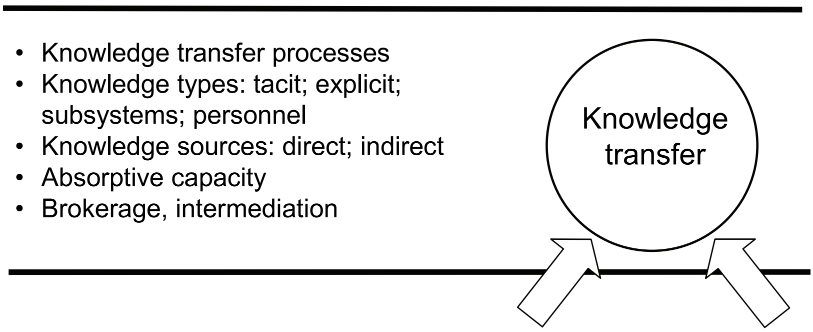


Fig. 30. The main features of the analysis of the knowledge transfer.

The focus of this study is on *the knowledge transfer processes* in small Technology Parks, including the transfer inside the local innovation system, and the knowledge transfer through the local innovation system to the innovation processes of the firms. The amount to which a firm is capable of capturing knowledge is dependent on its absorptive capacity which is not just the sum of the absorptive capacities of the individual persons but includes also the knowledge transfer functions. Difficulties may be caused e.g. by centralised gatekeeper roles, the expertise of the individuals receiving the knowledge, the narrowness of expertise, or even by the 'not-invented-here' syndrome. (Cohen & Levintahl 1990.) The absorptive capacity is determined by mutual trust and power dependencies within the relationship, the mutual intent, receiver's ability to capitalise on the transferred knowledge, the organisational receptivity (Nieminen 2005), the similarity of the knowledge bases of the firms, the organisational support structures, and the compensation policies (Lane & Lubatkin 1998).

The knowledge needed to enhance the absorptive capacity does not include just the substantive knowledge itself but also awareness of where the useful complementary knowledge resides within and outside the organisation: knowledge of who knows what, who can help with what problem, or who can exploit new information Cohen & Levintahl 1990). It has been found that age as well as education and size effects influence the SME acquisition and assimilation of knowledge (Gray 2006).

Knowledge transfer into a firm leads to organisational learning processes – that can be described with learning curves (Argote 1999, Fioretti 2007) – including the individual learning of the employees, coordination of work, incremental innovation of the process, and the effect of new tools (Fioretti 2007). Research and development expenditure influence the slope of the learning curve (Lieberman 1987). Knowledge can be transferred by *moving people, technology, or a structure to an organisation, or by modifying people (e.g. training), technology, and the structure of the recipient organisation*. If the knowledge is embedded in individuals the extent of labourforce turnover may cause organisational amnesia (Argote 1999).

There are two basic types of knowledge: tacit and explicit. The tacit knowledge is the most difficult to transfer, but succeeds with the help of various types of collaboration forms (Lubit 2001, Nonaka & Konno 1998, Nonaka *et al* 1996). Lubit (2001) lists solutions to accomplish it without transforming the knowledge into explicit form: working together with experts making observations and learning from coaching, working in groups and networks including brainstorming etc., recording learning histories by writing narratives of critical events such as a change initiative, a product launch, or an innovation including also mistakes, and developing routines for dealing with various situations and spreading the routines throughout the organisation. The explicit knowledge e.g. in the form of data, specifications, manuals, scientific formulae, or product can readily be transmitted formally and systematically (Nonaka & Konno 1998, Nonaka *et al* 1996).

Several knowledge transfer and management theories are available in the literature. They deal mainly with knowledge management on the organisational level (Nonaka & Konno 1998, Mertins *et al* 2003).

In this study the main interest is in the processes that transfer external knowledge to the firms' product development processes. The analysis focuses on knowledge types (tacit, explicit, subsystems, personnel), knowledge sources (either direct or indirect from the product development process point of view), absorptive capacity, and brokerage and intermediation.

3 Conducting the study

3.1 The case study method

Conducting a case study is a research strategy that can be used for at least five different purposes: to explain causal links in real-life phenomena that are too complex for the survey or experimental strategies, to describe an intervention and real-life context in which it occurred, to illustrate topics within an evaluation, to explore a situation with no clear set of outcomes, and to conduct a meta-evaluation. In a case study research design, five components are especially important: the study questions, study propositions, a unit or units of analysis, the logic linking the data to the propositions, and the criteria for interpreting the findings. A research design benefits from the development of a theoretical framework. The use of theory helps in defining the research design and data collection, and generalising the results. (Yin 2003). The generalisation is often seen as a major weakness mainly because of the small number of cases (Bryman 1989).

There are four types of case study designs. The simplest one is a holistic single-case study having one case in one context. In an embedded single-case study the design involves several cases in one context. In multiple case designs there are several contexts with one case in each in a holistic study, and several embedded units of analysis – cases – in each context. Fig. 31 illustrates the various designs (Yin 2003). Bryman (1989) comments that a high number of cases makes the distinctiveness of the case study questionable.

The structure of the study closely follows the process of building theories from case study research introduced by Eisenhardt, and summarised in Table 5. The specific features of the process are: the research question may change during the process, the case selection is theoretical – not sampling, multiple sources are used, analysis is made parallel to data collection, hypotheses are shaped parallel to collection, and the process from data collection to reaching closure is repeated until saturation is reached. (Eisenhardt 1989).

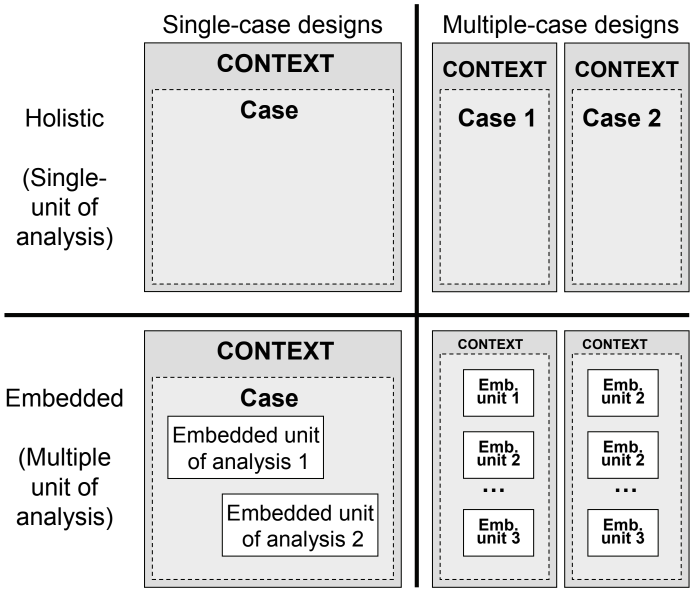


Fig. 31. Case study designs (adapted from Yin 2003: 40).

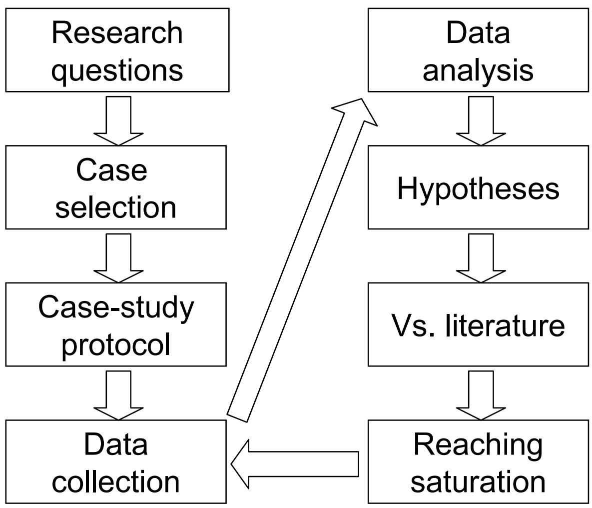


Fig. 32. The process of building theory from case study research (Eisenhardt 1989).

Table 4. The process of building theory from case study research (Eisenhardt 1989).

Step	Activity	Reason
Getting started	Definition of research question Possibly *a priori* constructs	Focuses efforts Provides better grounding of construct measures
Selecting cases	Neither theory nor hypotheses Specified population	Retains theoretical flexibility Constrains extraneous variation and sharpens external validity
Crafting instruments and protocols	Multiple data collection methods Qualitative and quantitative data combined Multiple investigators	Strengthens grounding of theory by triangulation of evidence Synergistic view of evidence Fosters divergent perspectives and strengthens grounding
Entering the field	Overlap data collection and analysis, including field notes Flexible and opportunistic data collection methods	Speeds analyses and reveals helpful adjustments to data collection Allows investigators to take advantage of emergent themes and unique case features
Analysing data	Within-case analysis Cross-case pattern search using divergent techniques	Gains familiarity with data and preliminary theory generation Forces investigators to look beyond initial impressions and see evidence thru multiple lenses
Shaping hypotheses	Iterative tabulation of evidence for each construct Replication, not sampling, logic across cases Search evidence for "why" behind relationships	Sharpens construct definition, validity, and measurability Confirms, extends, and sharpens theory Builds internal validity
Enfolding literature	Comparison with conflicting literature Comparison with similar literature	Build internal validity, raises theoretical level, and sharpens construct definition Sharpens generalisability, improves construct definition, and raises theoretical level
Reaching closure	Theoretical saturation when possible	End process when marginal improvement becomes small

Fig. 32 illustrates Eisenhardt's process as a flow chart. The research question, case selection and case-study protocol are first defined. After that comes the data collection and analysis, shaping of hypotheses, and comparison to literature is repeated until saturation is reached. This means that the process is repeated until only marginal improvement is found in the last cases. (Eisenhardt 1989.)

The methods and processes are bases on theories that have been applied widely. The description of the application used in this study is described in the Section 3.2. below entitled Conducting the study.

3.2 Conducting the study

3.2.1 The case study design

The two case Technology Parks – Digipolis in Kemi, and Electropolis in Kalix – are studied as a holistic two case design to identify the similarities and differences in the local innovation systems. These similarities and differences are later utilised in the firm level analysis to find the influence of the local innovation system on the knowledge transfer processes. Secondly, a design with embedded units of analyses in two contexts – Kemi and Kalix – is used to study the knowledge transfer to firms' innovation processes. Fig. 34 illustrates the setting of the study.

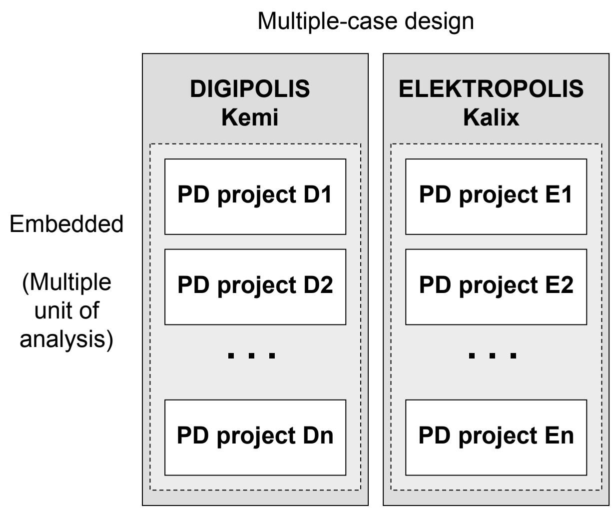


Fig. 33. The case study design used in the study (adapted from Yin 2003).

The analysis consists of several steps (Fig. 35). First, data on the two Technology Parks was collected, and case reports were written in parallel. When the case reports were finished, single case analysis was carried out on each of the parks with the help of the framework described earlier in the chapter ‘Implications from the theory’. Finally, the cases were compared with the help of cross case analysis between the two Technology Parks.

The product development case data was collected in firms in both of the Technology Parks. Each case was reported after the interview. The analyses consist of a single case analysis of each case, cross case analysis between the cases in each of the Technology Parks, and cross case analysis between the cases in the two Technology Parks. Additional cross case analyses were conducted within several subgroups both between cases in each Technology Park, and between cases in the two Technology Parks.

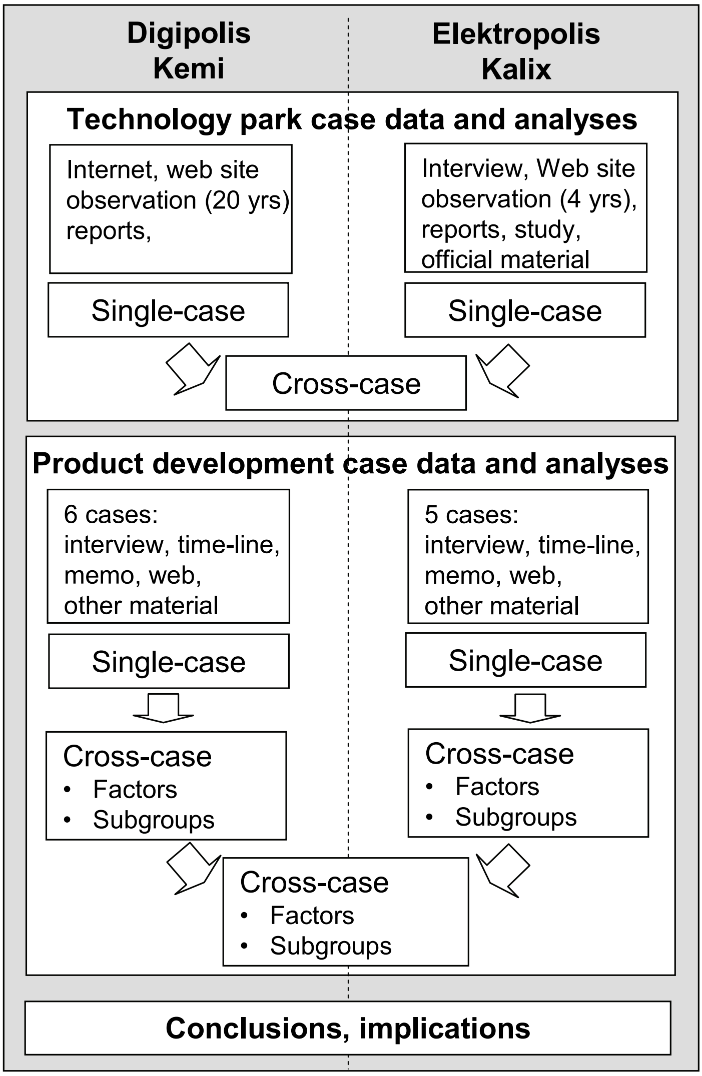


Fig. 34. Case study analyses of the study.

3.2.2 Case selection

Yin (2003) defines several rationales for choosing a case or cases. In single case studies a critical case may be chosen to test a well defined theory; a unique or extreme case may be so rare that it is worth documenting and analysing; a representative or typical case may be chosen; a revelatory case may give the possibility of observing a phenomenon previously inaccessible; or a longitudinal case is chosen to study the same case at two or more points of time. In a multiple case study the reasons to choose the cases are the same.

A multiple case study can be compared to a study having multiple experiments. This implies following a replication logic, not a sampling one. Each case should be selected so that either similar or contrasting results are predicted. Each individual case is conducted independently as a whole study. (Yin 2003).

This study searches for the answer to the question how knowledge is transferred in small Technology Parks with limitations in knowledge related actors and services. The first part of the study explores Technology Parks. Digipolis in Kemi in the North of Finland and Electropolis in Kalix in the North of Sweden were chosen for several reasons. The researcher's main duty outside of this study is to manage applied research in collaboration with and on the needs of firms in the Kemi region, with some firms in Kalix participating. This background has formed a pre-understanding of the two Technology Parks and the firms in them, gives access to the firms, makes firms and other actors comfortable about giving confidential data, and knowing the context reduces the risk of misinterpretation. The risk is that if the pre-understanding is wrong inpart, which may then cause misinterpretation. However, as long as the risk is recognised it can be avoided with multiple sources of data, and being alert in the interviews.

There are some 30 firms in Digipolis and over 10 in Electropolis. Each of the firms have conducted or are conducting several product development projects that are used as cases in the research. 40 firms with e.g. 5 projects each would make a total of 200 cases which is too large for a case study (see e.g. Bryman 1989, Yin 2003). The interviews were started with pilot interviews in two firms both in Kemi and Kalix, and additionally in Oulu in the North of Finland and Luleå in the North of Sweden. In each location one small young firm, and one – at least a little – larger and older firm were chosen. The interviewees were in a central position in the focal firms, and have closely participated in product development projects. From each of the firms two product development projects were chosen with the interviewees: one successful; and one less successful. The main other factor influencing the choice was the possibility to obtain exact reliable data. This means e.g. that the interviewee participated in the project.

In the main study the number of interviews was not decided beforehand. The tactic was to conduct case interviews about the firms' product development projects in each park until the final interviews do not produce any new significant data (Eisenhardt 1989). According to Eisenhardt the number of cases should be from 4 to 10: less than 4 makes it difficult to generate theory, and with more than 10 it becomes difficult because of the complexity and volume of data (Eisenhardt 1989). The final number of cases was 6 in Digipolis, and 5 in Electropolis.

The firms were chosen so that differences between sectoral innovation systems were not so big and that they would reflect the influence of the local innovation systems: they all belong to some extent to the ICT sector. The other selection criterion for the interviews was to choose firms that were known to conduct product development in some way: generic, platform based, customising, etc. The selection of the interviewee depended on the case. The main criterion was to choose a person who has been in a central position in the projects.

3.2.3 Plans for the field study

According to Yin (2003) a case study protocol consists of the following sections: an overview of the case study project (project objectives and auspices; case study issues; and relevant reading about the topic being investigated); field procedures (presentation of credentials; access to the case study "sites"; sources of information; and procedural reminders); case study questions (the specific questions that the investigator must keep in mind in collecting data; table shells for specific arrays of data; and the potential sources of information for answering each question); and a guide for the case report (outline; format for the data; use and presentation of other documentation; and bibliographic information). (Yin 2003). Eisenhardt (1989) pays more attention to the interviews: having multiple data collection methods, collecting several types of data, and preferring to have several investigators.

As described earlier, the interviews and data collection in this study were conducted on two levels: one examining the two Technology Parks, and the other the product development projects in firms in the two Technology Parks. Because of this, the plans were prepared separately for each of the two levels.

In both types of interviews the study and its goals were introduced to the interviewees through the help of some pictures. The main research questions were also introduced. In Kalix the manager of the local Technology Park firm informed the firms beforehand about the study and recommended them to participate. In Kemi, and partly also in Kalix, the interviewees also knew the researcher beforehand which helped gain access to confidential data. The firms' official materials were used to identify the basic information about the firms.

The Technology Park interview structure is presented in Appendix 1. A prepared form was not used because the Technology Parks differ in the kind of actors, history, ownership etc. The interview covered several topics: the park history, the Technology Park firm data and activities, the other firms in the park in addition to the basic information available on the web sites, inter-firm co-operation, intermediary organisations and their roles, education and training organisations and their roles, and the projects that have been run in different fields, such as education, training, research, development and business environment development.

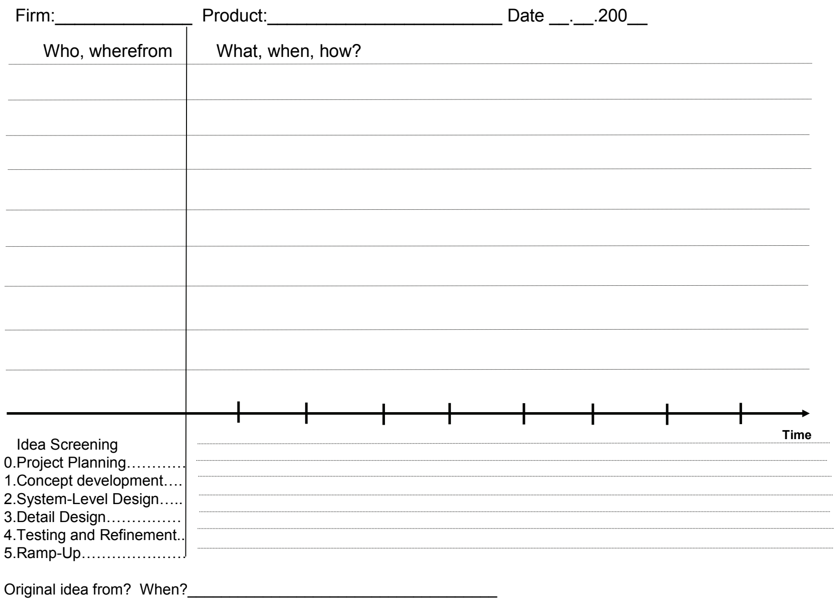


Fig. 35. Time-line for description of the product development cases.

The basic data on the focal firm and the person interviewed were collected using the structure in Appendix 2 and a standardised form (Appendix 3). Time-line descriptions were used as the backbone of the interviews to illustrate the product development cases in a concrete way (Fig. 36). For each actor, with a role in the project, an actor form (Appendix 4) was filled in with the basic data about the actor, actor's role in the project, and changes in the role over the project time.

In addition to the formal documents, field notes were taken. Additionally the firms' website information, and brochures, were used as a data source.

3.2.4 Collecting data and reporting the cases

Several authors have written textbooks and articles dealing with field research both in qualitative and quantitative research (e.g. Bryman 1989, Eisenhardt 1989, Yin 2003, Esterberg 2002, Patton 1980). Where interviews are concerned, they all emphasise the role of preparation both in the form of planning interview questions and by preparing personally to conduct the interviews and making observations.

Documentation has several strengths as a source of evidence. It is stable, unobtrusive, exact, and has a broad coverage. The possible weaknesses are retrievability, biased selectivity, reporting bias, and access. Archival records have the same characteristics. Additionally they are precise and quantitative but they may be difficult to access. The strength of interviews is that they are focused on the study topic and give the possibility to gain more insight into the topic. The weaknesses include the possible bias due to poorly constructed questions, response bias, inaccuracies due to poor recall, and reflexivity as an interviewee may give the answers he or she thinks the interviewer wants to hear. Direct observation covers the events in real time and the context of the event, but is time-consuming, selective, reflective and costly. Participant observation adds an insight view into interpersonal behaviour and motives, but may lead to bias due to interviewer's manipulation of events. Also physical artefacts may serve as evidence. They give a view of cultural features and technical operations but are selective and not always available. (Yin 2003).

Conducting interviews

After proper preparation, the interviews in the field succeeded well. Before the interviews some basic material about the firms was collected to gain a better pre-understanding. The interviews lasted from 2–2.5 hours. The interviewees appreciated the study and understood that it may be useful for further development of the Technology Park activities,as all except one agreed to participate in the study immediately, even though many of them had heard from other interviewees the time it took.

The interviews were conducted between August 2006 and April 2007.

The material from the firms' product development cases include a total of 11 basic data sheets, 11 field memos, 11 time-lines of the case project, 75 actor sheets, and various types of brochures, product leaflets etc.

Reporting cases

Each case was reported individually using a standard structure to enable effective use of the material (Appendix 5). The first section, the basic information, includes the time of the interview, name of the firm, the Technology Park it is located in, and name and position of the interviewee as well as the turnover, the number of employees, firm ownership and history, and the main products of the firm. The second section in the case report consists of the interviewee's personal background (place of birth, education, professional history, and history in the firm). The third section includes the history of the firm with all its important milestones. In the fourth section the main interest is on the product development case including written details of the process that could not be clearly described in a time-line form.

A time-line model was developed to describe the product development processes. Fig. 36 includes the process stages, and the actors on various geographical levels with significance in the knowledge transfer process.

To facilitate the easier identification of the various innovation system levels, the same links are described as a time independent network model illustrated in Fig. 37. It illustrates the knowledge flows in a product development project from various actors on different innovation system levels. The knowledge types and the experienced importance of the knowledge are reported in Fig. 37.

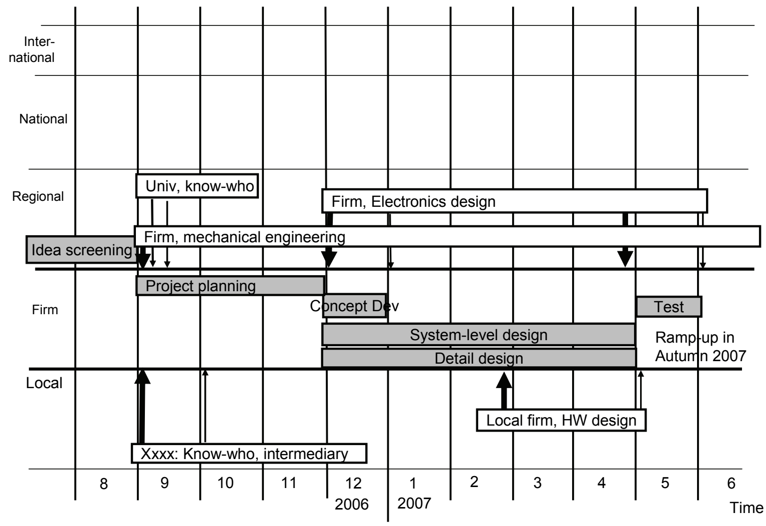


Fig. 36. Time-line / knowledge flow description of a product development process.

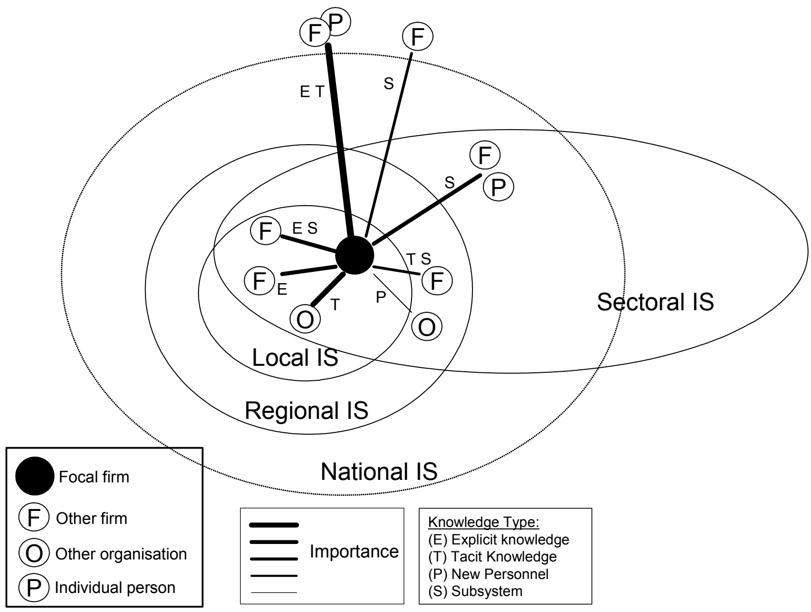


Fig. 37. Knowledge transfer from various innovation system levels.

4 The empirical cases

The case reports on the Technology Parks – Digipolis in Kemi; and Electropolis in Kalix – are presented in Section 4.1. Section 4.2 includes descriptions of the firms and the product development cases. They are anonymous to respect confidentiality.

4.1 Technology Parks

4.1.1 Digipolis – Kemi

The description of Digipolis – the Technology Park in Kemi – is based on the researcher's 22 years of observations while working in various positions in the park, Ahola's (2007) study, Kemin Digipolis Oy's official information material, and documents such as the annual reports of Kemin Digipolis Oy and Digipolis Research, articles and conference papers, and the Digipolis Magazine.

Park history

The Technology Park activities started in Kemi in 1986 when Fincitec Oy and Kemin TT-Keskus Oy were founded by a venture capital firm, Lakespo Oy, and financed by the regional government of Lapland. In the beginning, both firms were located in classrooms rented from the Kemi Institute of Technology. The first firm premises (in Lumikontie 2) for Fincitec Oy were built in 1988, and the next one (in Lumikontie 1) for Kemin TT-Keskus Oy in spring 1991. The first office block premises (Tietokatu 6) was built in 1991 enabling more firms to start in the park. Afterwards several other buildings were built, and in 2007 the total area of firm premises is 11500 square meters in 5 separate buildings.

Kemin Digipolis Oy

In the early years until 1990, the development was conducted mainly by Lakespo Oy. The first plan for the Technology Park was drawn up by the municipality of Kemi in the Kemi project during 1989 to 1990. In the beginning of the 1990s, the development task was assigned to Kemin teollisuuskylä Oy (Kemi Industrial Premises Ltd.), and later to Meri-Lapin Studiokylä Oy jointly founded by the municipalities of Kemi and Tornio, and the University of Oulu in the year 1995. In 2002 the name of the firm was changed to Kemin Digipolis Oy, after Digipolis was chosen as the park name in the year 1999.

Fig. 38. Digipolis Technology Park in Kemi (source: www.digipolis.fi).

Originally both the municipalities of Kemi and Tornio jointly owned 47.6% of the firm, and occasionally there were activities in Tornio, too. The rest was owned by the support foundation of the University of Oulu. Later, the ownership changed so that in the year 2007 Kemi owns 62.5%, Tornio 31.25% and the University of Oulu 6.25%.

The development activities the firm conducts, participates, or partially finances, are financed by the municipality of Kemi, with additional financing from various sources – especially the EU structural funds. Kemi and Kemin Digipolis Oy have a three year long framework agreement, and yearly agreements with targeted results and the lines of activities. According to the agreement for the year 2007 (writer's translation): *Kemin Digipolis Oy operates on the interface between IT and process industries. The firm's main product is an operational environment for technology firms: Digipolis. The main goal of the operation is to increase businesses and the number of jobs.*

The agreement sets the goals for each line of action, which are defined as the development of a knowledge environment, the development of existing firms, promoting the setting up of new firms, communication, collaboration networks, internationalisation, and new openings. In the development of knowledge environments the lines are connections and packaging techniques, microelectronics and testing techniques, optical measurement techniques, knowledge intensive industry services, and environmental techniques. The lines are defined to support existing firms and businesses with high level research, training, and education and the help of local higher education institutions.

Kemin Digipolis Oy operates mainly in the Technology Park but also with other firms in the town and the region. Where research is concerned, firms from other parts of Finland and the North of Sweden participate.

The overall goal for the year 2007 is to set up three new firms providing 10 to 20 jobs, and 20 to 40 new jobs in the existing firms. The municipality of Kemi paid 600 000 € for the development service in the year 2007. Kemin Digipolis Oy conducts or participates projects with a turnover of 2.5 million €.

Firms

The number of technology firms has risen from the original 2, in the year 1986, to 30 in spring 2007 (See Table 6). Simultaneously the number of jobs in the firms has risen to 400. When classified according to their customers and business sectors, 15 firms belong to the ICT sector including electronics, 14 firms to process industry services, and 7 firms to other sectors. Between ICT and process industry services there is an overlap of 6 firms.

12 of the firms are independent and locally owned, while 18 are led from other locations of which: 9 are national; 6 international, and 3 regional. Locally owned firms are mainly micro firms. The ownership of some locally owned firms has passed to larger firms especially since the end of the 1990s.

9 of the firms conduct product development in its various forms: 5 develop their own new products, 2 create products for their customers, 1 unit customises a corporation's products, and 1 develops customised applications. Of the other firms 17 sell projects, and the other 4 are regional customer support units.

Table 5. Technology related firms in Digipolis in Spring 2008.

Firm	Business sector
Botnia Mill Service Oy AB	Industrial maintenance services
Covair Oy	Projects, air filters, and remote monitoring
Dacad Oy	Services; cad databases and archiving projects
Embio Oy	R&D, wireless technologies, ASIC, FPGA, system level testing
Eltel Networks Oy	Projects and maintenance in electricity and communication networks
Eltel Networks Pohjoinen Oy	
Fromlog Oy	Design, development and project consulting, mechanical wood processing
Fujitsu Services Oy	IT services
Futumon Oy	Wood protection chemicals
Gigafly Oy	Mobile software products
Insinööritoimisto 3D Hacklin	Engineering design
Insinööritoimisto Rouvinen Ky	Electrical and automation design
Isoworks Oy	IT services, projects
Ixonox Oyj	Lotus Notes / Domino application development
Kalix Tele24 Ab	Telephone exchange in distance
Metso Automation Oy	Process automation systems
Metso Endress+Hauser Oy	Valve maintenance
Mionix Oy	Vision systems
National Semiconductor Finland Oy	Semiconductor development
Prosensor Oy	Environmental measurements
Scandimet Oy	Engineering design
Selmic Oy	Microelectronics, LTCC, HTCC; design, production and assembly
Suomen Erillisverkot Oy	Network service operator, authority networks
TeliaSonera Finland Oyj	Tele operator
TI-automaatio Tmi Tuomo Iisakka	Automation
TietoEnator Oyj	IT services
UpNet Engineering Oy	Engineering services for industries
YIT Kiinteistötekniikka Oy	Building systems: design, installation, maintenance
YIT Rakennus Oy	Construction
YIT Teollisuus- ja verkkopalvelut Oy	Data and electricity networks; maintenance and prepare

Inter-firm cooperation

According to the agreement between Kemi and Kemin Digipolis Oy, one of the goals in the activities of Kemin Digipolis Oy is: *' to develop a functional regional, national and international cooperation network that supports firms' operations.*

The network is formed of universities, higher education institutions, colleges, research centres, and technology centres that are useful for the development of firms' products and operations.'

The agreement does not mention the development of cooperation between the firms in the Technology Park, but it does mention cooperation between the local process industries and ICT firms. Many of the business service firms serve local, regional, and national process industries. Most of the ICT firms have their customers and even headquarters elsewhere. The interviews revealed two cases in which a firm serving process industries collaborates with an ICT firm: in one case the firms had a joint product development project; while in the other a service firm purchased a tailor-made software for its in-house use. About 85% of the firms have customers in Kemi-Tornio region, 70% elsewhere in the North of Finland, 10% abroad, and 7% in the Technology Park. The cooperation among the firms in Digipolis is minimal.

With regard to research, applied research, and testing services, 33% of the firms co-operate with Kemi-Tornio University of Applied Sciences, and the technology research unit of the University of Oulu. These two work in close collaboration in the framework of the Digipolis Research agreement between the two organisations and VTT, the national technical research centre of Finland. 10% of the firms collaborate with other research centres or universities – mainly with the University of Oulu and VTT in Oulu.

Social networks have been activated by Kemin Digipolis Oy by arranging monthly business breakfasts. In each of them one firm or organisation tells about its activities. In the Studio house (Tietokatu 6) there is a joint coffee room where employees meet each other on a daily basis.

Intermediary organisations

Kemin Digipolis Oy has several activities and projects as an intermediary and broker between firms, Technology Parks, universities, and research centres locally, regionally, in the North of Finland, and in the North of Sweden. In the years 2003 to 2006 there was a programme manager in micro and nano technologies with the task of developing collaboration between firms, and between firms, universities and other research organisations regionally, nationally, and internationally. From 2007 there is a programme manager developing collaboration and activities in knowledge intensive business services in process industries.

Another type of collaboration is the Multipolis Network, where Technology Parks in the North of Finland cooperate to coordinate activities, conduct joint projects etc.

Kemin Digipolis Oy leads networking projects in cooperation with other Technology Parks in the North of Finland, Sweden, and Norway. The projects map the firms' needs by interviewing firms, arranging matchmaking opportunities, business breakfasts, and business meetings, and helping to plan joint research and development projects.

Kemi-Tornio University of Applied Sciences runs a business incubator in the region, including Digipolis. In addition to assisting start-up firms, the incubator has a major role in 'opening doors' to them, and helping them to start cooperation with other firms.

Researchers have also an intermediary role. For example, a number of firms in the region and Digipolis participated in the Compus Maintenance project which studied the maintenance sector in the region, and seeks new operation models for future cooperation.

Education, training, and research

The main local source of educated people is the Technology School of the Kemi-Tornio University of Applied Sciences (K-TUAS), which confers bachelor degrees in mechanical engineering, electrical engineering (electric power engineering and automation engineering), information technology, and industrial management, and master degrees in technology management. The unit is in the middle of the Technology Park which has in fact grown around it. Specialised training for new and existing personnel has been arranged by K-TUAS with the help of part financing from the Employment Office – either with national or European Union social funds. Also the technology unit of Lappia Vocational College is located in the middle of the Technology Park, and provides firms with employees, and possibilities for apprenticeship.

The closest science university conferring Master and Doctoral degrees is the University of Oulu, 100 km south from the park. Most of the M.Sc. graduates in the firms have graduated from there.

As described earlier in this chapter, the main research partner for the firms are K-TUAS and the locally-based unit of the University of Oulu. The units had in the autumn 2007 over 30 graduate employees, and additionally students preparing their doctoral theses, and in practical training. The activities are closely linked to education. The research lines are: electronics connection and packaging technologies, electronics testing and reliability, industrial maintenance, optical measurements (vision systems, machine vision), and environmental technologies (esp. measurement technologies).

Projects

Some projects have been described earlier in this chapter. Additionally there are projects in research, development, and training. The projects are typically financed by the European Union structural funds (e.g. ERDF, ESF, Interreg) or TEKES (The Finnish Funding Agency for Technology and Innovations). The total yearly turnover of the projects run by various actors was in the region of 2.5 million € in 2006.

4.1.2 Electropolis – Kalix

The case report on Electropolis – the Technology Park in Kalix – is based on the researcher's 4 year observations while working in close cooperation with the Technology Park firm and firms in the park, interview with Mr. Anders Högström, the Managing Director of Kalix Electropolis Ab, and key persons in local firms, the Technology Parks and firms' information material, and other documents including project reports, brochures, plans etc. Some of the firms are located in the Electropolis Technology Park area, but many of them are in other parts of the town.

Park history

The activities in electronics started in Kalix in 1973 when Jan-Erik Larsson returned to Kalix after studying and working in the south of Sweden. Jan-Erik and Karl-Göran Larsson founded their first electronics businesses in Kalix in the 1970s. In the 1990s there were three ICT firms, of which Hans Fält Elektronik Ab was the largest. It went bankrupt in autumn 2001. Kalix Electropolis Ab was set up to manage the empty premises to form a new Technology Park.

After the bankruptcy, several of Fält Elektronik's departments were incorporated: BL Elektronik Ab is the former logistics and service department, Electrotech Ab is the research and development department, and OrbitOne Ab's

Kalix unit is the former production department. Additionally Microbit 2.0 Ab base on incorporated Antenna Ab's product development department.

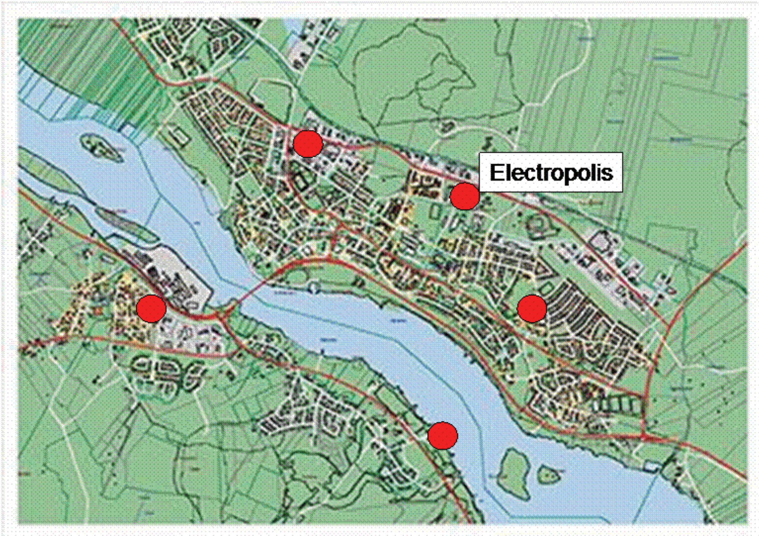


Fig. 39. The firms' locations in Kalix.

Kalix Electropolis Ab

Kalix Electropolis Ab was first fully owned by the municipality of Kalix. In 2006 IUC Norrbotten Ab purchased 50% of the shares, and is willing to raise its ownership to 60%. At the same time the local electronics firms became partial owners of IUC Norrbotten Ab, which is one of the regional IUC firms (Industriell utvecklingscentra) in Sweden that are owned by SMEs in the respective region.

In 2003 it was decided that the role of Kalix Electropolis Ab should be more than a real estate developer. The premises were moved to a municipal owned real estate firm. A project was started to serve the development of the firms in the small local cluster better, by developing local cooperation and competence development, and developing external cooperation network. The board was rebuilt so that the local firms have the majority. From the beginning of 2006, the geographic operating area was enlarged to cover electronic firms in other regions such as Pajala, Luleå, and Övertorneå.

Even after the geographic enlargement the activities themselves are mainly the same as earlier. The firm's mission is: "Electropolis – cooperation in the electronics sector in Norrbotten". According to a brochure (author's translation) the aim is as follows:

Electropolis's goal is to develop close cooperation between electronics firms, and implement activities that support growth in the sector. Some important aims are e.g. to:

- *be open to firms' business ideas and to be a broker when competence, mentoring, and financing are concerned;*
- *support the establishment of well-defined business clusters utilising firms' unique competences, and support firms together to offer total function or system solutions to a bigger market;*
- *support application oriented R&D measures in close cooperation between the firms and universities. The measures must be based on the firms' development needs, and they be conducted close to the firms;*
- *market the cluster of firms in the province (Län) in Sweden, and internationally – e.g. by joint participation in fairs and seminars that make the electronics industries in Norrbotten better known;*
- *stimulate cooperation with service and product owner firms in the region, in Sweden and internationally.*

The activities will be built on electronics firms' growth plans, and real needs. A needs inventory, analyses, and action plan will be drawn up regularly in cooperation with the firms

Firms

As mentioned earlier, in the 1990s there were three ICT firms in Kalix: Antenna Ab, Fält Elektronik Ab, and CareTech Ab. At the end of the decade, the firms had over 150 employees, but at the beginning of the 21st century the number went down during the bankruptcy. Afterwards four firms have been founded on the basis of earlier departments, and one firm has been incorporated from the earlier Antenna Ab. The number of jobs has in 2007 risen above the earlier amount, and is now over 150. All the recent 12 firms belong to the ICT sector.

8 of the firms are owned locally, in two the majority of the ownership is elsewhere (1 national, 1 international), and 2 are departments of larger national firms. Originally all firms, except one, were locally owned.

11 of the firms conduct – or participate in – product development in its various forms: 7 develop their own new products, and 6 products for their customers. One firm manufactures products to their customers.

Table 6. Technology related firms in Electropolis.

Firm	Business sector
BL Elektronik Ab	Services: Preparation, inspection and upgrading of electronic products; short series productions; logistics
Caretech Ab	Security telephones and related products
Cuptronic Ab	Circuit board technology
Electrotech Ab	Product design, test development, assembly and product management for customer products; focus on measurement nad communication.
Kalix Fiberoptik Ab	Products and systems based on fiberoptics for telecommunication.
OrbitOne Ab	Production of esp. medical electronics; subcontractor
Microbit 2.0 Ab	R&D to customers; OEM and own products
Samhall Ab	Production; subcontractor
KEDAB	PCB and mechanics design; prototype manufacturing
Satmission Ab	Total solutions for satellite communication
TeleAlarm Nordic Ab	Security telephones
Vaza Elektronik Ab	Design and test services in electronics; own product

Since Kalix Electropolis Ab's activities were geographically extended to other sites in Norrbotten, several firms have joined the cooperation network. *Rubico Ab* in Luleå focuses on DSP based systems and digital signal processing including both product development and consultancy. *Abelco Ab,* founded in 1970, sells its own solutions in form of total concepts and designs and produces OEM products. The business areas are automation, energy technology, medical technology and machine-to-machine applications. *CeitaTech* in Pajala is an association combining together the activities of small firms and private persons. It offers e.g. HW and SW development. *Propac Ab* in Luleå, founded in 1979, designs and produces computers and screens for industrial, military and vehicle use. *TS Signalteknik Ab* is a Pajala based firm specialised in detector systems for railways. *Mikromakarna Ab* in Pajala offers system production from prototypes to serial production in electronics and mechanics. It cooperates with a Russian firm in Murmansk.

Inter-firm cooperation

Kalix Electropolis Ab promotes and seeks cooperation among firms, and new customer based product development cases that can be conducted in cooperation among the firms. Cooperation between the firms inlcudes the exchange of experience and expertise, marketing activities, production, electronics and mechanics design, prototyping, joint use of testing equipment, and joint products.

The firms sell their products mainly elsewhere than in Kalix but there is a lot of cooperation in development. 58% of the firms have customers in Kalix, 25% in the region, 92% on the national level, and 75% abroad. Every firm has customers at least on a national level.

When research institutes and universities are concerned, 33% of the firms cooperate with them on a regional level, and 8% on a national level. 25% cooperate with universities in the north of Finland, and 8% with other international partners.

Local social networking has been activated by Kalix Electropolis Ab. Its board consists of key persons in the local firms, a university professor, and local politicians or decision makers. The meetings are held mainly in Kalix but also in other places such as Digipolis. After persons have learned to know and trust each other, the discussions have become open. This has led to joint projects and cooperation between firms. Another method used to develop social networking is the arrangement of an annual Christmas dinner for all the personnel of the firms. In 2006 the participation covered 2/3 of the total number of employees. Additionally, several firms are located in the Electropolis building with a communal coffee room where employees can become acquainted.

Intermediary organisations

Kalix Electropolis Ab and its Managing Director have a central intermediary role between the local firms, between the local firms, regional firms, and national firms, and between the local firms and research organisations.

Process IT Innovations research and development network, led by LTU, has a growing role in planning and conducting projects that bring together the industry as an end-user, universities as a research partner, and the technology firms both in delivering subsystems to the projects and as receivers of the new knowledge created in the projects.

Internet Bay organisation has been useful for identifyin needs, and for networking.

Education, training, and research

There are no local higher education or research institutions in Kalix. Luleå Technical University (LTU) conducted one three year programme locally between 1999 and 2002. When the project started, some firms opened offices in Kalix to get skilled people. The IT crash in the early 2000s changed the situation somewhat although every student from the programme found a job. Many engineers working in Kalix live in Luleå. ICT firms are growing again and need new experts. There are cases where firms in Luleå have succeeded to attract people already living in Luleå to join them. This is seen as problematic from Kalix firms' point of view.

The municipal education and training organisation, Kalix UniverCity, started a two year long qualified vocational training (Kvalifiserad yrkesutbildning) in autumn 2007. The curriculum covers electronics and software design, and electronics manufacturing. The main partner is Umeå University. LTU and K-TUAS participate by teaching in their expertise areas.

Another source of skilled people is the persons who were born in the north and have studied and worked in the south of Sweden. Kalix municipality has mapped them and arranges in Stockholm "Home Returning" (Hem återvänding) occasions to tell them about the opportunities in Kalix. Some people have returned to Kalix.

Kalix UniverCity has mapped needs for shorter trainings. The mapping covered all sectors. The organisation also organises the training. Kalix Electropolis Ab has organised some training, too, although its main role has been to stimulate the firms to organise self paid courses. Also some component producers have arranged events where they informed about their new products in detail. The recent courses have covered lead-free technologies, lean production, and new components. The joint courses serve also as social capital development.

Projects

Some of the recent projects are described briefly in this section to explain what the basic project types are.

The main activities of Kalix Electropolis have been conducted in latter years as an ERDF/EU financed project. In the early years, the project covered activities with the firms in Kalix. From the beginning of 2006 the activities have been extended to electronics firms in the whole Norrbotten region. Inside the main project there have been smaller subprojects e.g. for participating in fairs.

On the firm level there have been several projects in which the firms have participated. The projects have covered regional, national, and cross-border product joint product development, research in regional, national, and international cooperation to build the base for new features to existing products and new products to existing product families.

4.2 Firms and product development cases

Research material includes product development projects. The Electropolis cases are coded as E1 to E5, and the Digipolis cases as D1 to D6. In the three cases where the interviewed firms have units both in Digipolis and regionally, the roles of each unit and the knowledge transfer issues are separate from each other. The case descriptions present the firms and the cases as they were at the time of the interviews.

4.2.1 Digipolis – Kemi

Case D1

The unit is a specialised development unit of a larger regional publicly owned firm. The unit develops subsystems for own use and for customers' radio telecommunication products. The number of personnel is over 20. Product development is conducted mainly with the help of customers' process models. 75% of the personnel graduated from K-TUAS. The firm cooperates with K-TUAS using some testing services, participating in research projects, and to find new personnel. On a regional level, the unit cooperates with other units of the same firm. The local unit has no direct links to the regional HEIS. LTU has been used as a source of EMC knowledge. Other important sources are an EMC consultant and tool providers. Their customers are in the same sector as the unit.

The case product is a piece of test equipment, and the development incremental based on an earlier product. The idea came from a customer and the decision to start producing was made by the management and the customer together. The concept was developed with the customer. Specifications were made in cooperation with other units of the firm. Detailed design, test planning and tests were made by the unit and the process was controlled by customer reviews. In the end the customer had – after training – tested the product in practice. Refinements were done according to that. The duration of the project was about 15 months.

Case D2

The unit is an office of a large international corporation. The unit in Digipolis focuses mainly on test development and testing, but also on design to some degree. The number of personnel is over 20. The product development process is highly developed and computerised. The design personnel is sourced from the University of Oulu (UO) and the local pool of designers, while test developers come from UO and K-TUAS. The firm cooperates with K-TUAS using testing services, participating in research projects to transfer knowledge into the unit, and to recruit new personnel. On a regional level the unit operates in the same projects with another unit of the same firm. UO serves as a source of knowledge of new methods and technologies. The firm's own corporate support unit, corporate sales, and corporate technical marketing are the main sources of knowledge. The corporate support unit runs an online support system. The customers are in the same sector as the unit.

The product is always a microelectronics design: in most cases a new one, but sometimes a modification of some earlier design. The product ideas come from the corporation, and are based on market analyses, or directly on one customer's need. The idea screening and decisions are made on a corporation level. Concept development and system level design are corporate owned stages in which the Finnish units participate. The detail-design stage is mainly done in another unit in the region, and partly in Kemi, while testing and test development is done in Kemi. Each project ends with evaluation in collaboration with the corporate level. A typical project lasts for 12 months.

Case D3

The unit is a private micro firm. The main products are mobile software and games. The firm employs 2 persons and one part-timer. The product development process is in practice a small software development project model. The personnel graduated from K-TUAS. The firm started with the support of K-TUAS incubator services. There is no other local cooperation. The firm collaborates with other SMEs in the same sector on a national level to source knowledge. Application specific knowledge is sourced from customers and various types of specialised organisations. The customers belong to different business sectors than the firm.

The product is a specific mobile software. The idea was developed by the firm. It was tested by a national organisation knowing the sector, and the national business sector association, that participated also in the concept development, reviews, functional testing, and in the system level design in its non-technical content level. The member firms are the paying customers. The duration was 15 months from the start of the planning to the market launch.

Case D4

The unit is an office of a national corporation. It focuses on customer specific software development on a chosen platform: a software development and database tool. The unit is responsible for a product line within the corporation. It has 18 employees in Digipolis and 14 on other sites. Customers' development processes are used in most of the cases, but the firm has its own, too. The personnel is mainly educated by K-TUAS and M-LI. The firm cooperates with K-TUAS and M-LI in some of the training of its personnel. On a regional level, the firm's own experts are used as a knowledge source. On a national level, the firm's own resources are used: i.e. internet learning, joint courses, and team members. Some personnel training is provided in cooperation with competitors and customers, as well as subcontractors and tool providers. Personal contacts are used to source knowledge. The customers belong partly to the same business sector, and partly to other ones.

The product development case is a tailored modification of an existing product. The need came from the customer, and the planning was made by a consultant, but the idea originates from the firm's earlier product. System-level design was made by the firm with the help definitions and knowledge from the customer and the consultant. In the detail-design stage prototyping and reviews were used extensively. The internal nationwide network was used for knowledge sourcing. After installation, customer test-used the product that was then accepted. The development project lasted for 4 months, although some refinements were made 3 months later.

Case D5

The unit is a production unit of a regional firm. It concentrates on customer specific production of subsystems for customers' products. At the time of the interview the number of employees in Digipolis was over 40. The firm uses customers' product development processes. The product development stage is mainly done by a regional unit, and the production ramp-up in Digipolis. The personnel in the unit is mainly either trained or educated by K-TUAS. Most of the personnel with degrees have done their thesis in the K-TUAS research laboratories. On a regional level, VTT and UO are used as sources of knowledge and personnel. The firm cooperates in research with UO, VTT, and K-TUAS. The customer, a design firm, and a pool of designers are used as knowledge sources on a regional level on the site of the other unit of the firm. The national level is not used for sources. On the international level, material suppliers function as knowledge sources. Personal contacts are also used to source knowledge. Some of the customers belong to the same business sector, and some to other ones.

The idea for the product came from the firm. The task was to apply a new concurring technology to an existing subsystem. The concept and specification came from the customer. System-level design was done by the firm and the customer together using knowledge from research organisations. In detail-design two firms were used as well as knowledge from VTT and UO. Several prototype rounds were made in close cooperation with the customer. The production ramp-up demanded several rounds before the percentage of acceptable products was high enough. This stage was made in the unit in Digipolis. The duration of the project was about 38 months.

Case D6

The unit belongs to a large national corporation. It develops customised modifications on a product platform. The number of personnel is about 20. The development process is defined in the quality system. In latter years, all new employees are recent graduates from the K-TUAS. On a local level, the unit cooperates with consulting and installation firms. Regionally there is cooperation with the firm's regional unit and local authorities. On a national level, there are links to the main office of the firm, to some consultants used as subcontractors, and national authorities. The customers are on all levels, with the local customer a very important one. They are all in the same sector.

The case product is a modification of a product platform. The need and the idea came from the customer and the specification was done in negotiation with the customer. A consultant and authorities were used as knowledge sources. The specifications are done by the consultant. The detail-design is made by the unit using internal experts in other units and national level experts. All testing is conducted in cooperation with the customer, consultant, and authorities. Ramp-up is done with the help of baby-sitting. The duration of the project was about 10 months.

4.2.2 Electropolis – Kalix

Case E1

The firm is an independent SME specialised in communication and measurement techniques, and develops products both for its customers and itself. In the customer owned products the customer pays all the costs, owns the product, and the firm develops it, coordinates manufacturing, assembles it, delivers it to end-users, and manages the product throughout its life cycle. The number of personnel is over 10. The development process is defined in the quality system. Many of the persons have graduated from LTU. The closest partner firm is a regional software firm. Locally the most important partner is Kalix Electropolis Ab, but there is also a local customer. Links to other firms in Electropolis are strong. On a regional level, LTU and an industrial firm – involved in a new platform development project – are recent important partners. Customers are on regional, national and international levels. Customers are in another business sector.

The case product is a platform used in customer products. The idea is its own, and is based on the needs in the customer projects. The idea was screened by testing it with customers. The concept has mainly been developed by the firm, except the software concept which has been developed by the regional partner. The concept and the use of it in customer projects have been tested with the customers. The system-level as well as the detail-design was done by the firm except the software development. Tests were mainly made by the firm, but some testing was sourced regionally. Subsystem production is outsourced, but assembly is done by the firm. The duration of the project from the idea screening to the first utilisation of the platform was 2.5 years. The platform development continues according to the needs of the products based on it.

Case E2

The firm is an SME owned mainly by venture capital firms. It is specialised in one application area, and develops its own products. The number of employees is over 20. Product development projects differ from each other, and are conducted as projects. Collaboration on local level has increased in close contacts with Kalix Electropolis Ab. Several local firms are used as experts and subcontractors. On a regional level, LTU is seen as a source of new personnel. A regional manufacturer is used as the subcontractor and source of DFM (design for manufacturing) knowledge. On a national level one person in a component provider firm has been of considerable value as a knowledge source. The international level is important. The product development started with the help of a foreign firm and especially one person in it. The manufacturing and some other subcontracting is also outsourced internationally. The customers are on national and international levels. They represent other sectors than electronics and ICT.

The case is an end-user product that is used mainly at home but purchased by the public sector. The idea is the firm's own: what happens in the market and in enabling technologies is observed; a picture formed; and then a decision made. The idea was tested with customers, from which one international customer committed to the development. The concept was developed and the system-level design conducted by the firm in collaboration the the international customer. In detail design the main sources of knowledge are a national supplier, a regional subcontractor, a international firm delivering subsystems, and new skilled personnel graduated from LTU. Subsequently, the local network has risen to high importance. Technical testing is done by the firm itself, and functional testing with the key customer. The duration of the project was over 4 years, of which the concept took 2 years. Incremental improvements are developed continuously.

Case E3

The firm is an SME owned by private persons. It is specialised in research and development for other firms, it has one house product, and a number of OEM products. The number of employees is about 10. The projects are conducted with standardised processes. On a local level there is a lot of cooperation with other firms. Kalix Electropolis Ab is central in promoting cooperation. On a regional level, the firm collaborates with a software firm and an electronics manufacturer. LTU is seen as a source of recruitment. Also some student projects have been done. Component providers are an important source of knowledge on the national level. There are no international links.

The product is a subsystem adding new features to another local firm's product. The other firm owns the product. The idea came about in interaction and discussions with the firm owning the product. The idea was tested against the maturity of the market. The idea-screening was made with the help of a prestudy: alternative solutions, price evaluation, technical alternatives, and the choice of components. The pre-study served also as a part of the concept-development. Knowledge was sourced from the customer, and component and processor suppliers. The firm did the system-level design in cooperation with the customer who made some parts of the design. In detail-design the customer transferred tacit and explicit knowledge, as well as subsystems to the project. In the testing stage, the customer is used as an external knowledge source. The duration of the project is 12 months without production ramp-up.

Case E4

The unit is a specialised production unit of a national level private firm. It is specialised in a narrow product segment, and it takes overall responsibility of subsystems. It has also coordinated product development projects. On local level Kalix Electropolis Ab is seen as an important network builder that also seeks new customers and needs. The personnel is mostly recruited locally and trained in the firm. There is regional cooperation in product development. Mechanics are sourced at national level. The customers are mostly national.

The product is a subsystem of a regional firm's product. The idea or need came from the customer. Kalix Electropolis Ab arranged some financing and sought partners. A person from LTU did the concept-development. A regional firm designed the hardware concept, and a local firm did the detail-design of the hardware. The regional firm that designed the hardware concept participated in the testing, while the customer tested the product by using prototypes. The duration was 11 months.

Case E5

The firm is an SME owned by a private person. It is specialised in services including preparing, updating the logistics of subsystems which its customers have supplied to end-users; and small scale production. On a local level the firm cooperates with Kalix Electropolis Ab and a product development firm. Many of the employees have earlier worked in another firm that was declared bankrupt, while the others have been trained in the firm. On a regional level the focal firm cooperates with a SW and a production firm. In idea sourcing LTU is used. On a national level the firm cooperates with expert firms when needed. The customers are mainly international. In the case product the customers are national.

The case product is an electronic device used by a special group of individual people. The idea came from LTU via Kalix Electropolis Ab, and screened by the firm with a national special organisation. The concept was developed in cooperation with a local electronics design firm, a national organisation, and a regional SW firm that was founded by the persons who headed the research project from where the idea came. A national component provider brought in some knowledge. The same group of firms designed the system-level design, with a housing firm transferring knowledge to the process. In detail-design a local firm designed the hardware, a regional firm the software, and a national firm the housing. A regional production firm provided DFM knowledge, and a national organisation and a national association supplied information about end-user needs. Functional testing was conducted by 100 end-users. The electronics was produced by the regional production firm, and assembled by the focal firm. The duration of the project was about 4 years starting from the idea screening, or 3 years from the concept development.

5 Analyses and results

5.1 The Technology Park analyses

The Technology Park analyses are divided into two Sections: Innovation system; and social capital. They follow the outline of the equivalent Sections 2.7.1. and 2.7.2.

5.1.1 Kemi – Digipolis

Innovation system

In Digipolis there are 30 firms (August 2007), the technology unit of K-TUAS (education, training, and applied research), and a research unit of the university of Oulu. The total number of jobs is 450 to 500, in the firms it is about 400. All of this is located in a small geographical area. The firms serve mainly two business sectors: ICT; and process industries. According to the interviews many of the ICT firms have their customers elsewhere, but some of them serve also the local process industries. The firms in the process industry sector have mainly local customers. In conclusion, the local innovation system is larger than the Technology Park, and covers the Kemi-Tornio region.

The business incubator has existed in Digipolis since 1992. 12 of the 30 firms in the Technology Park (31st August 2007) were founded with the help of the incubator. They employ in Digipolis in August 2007 about 40 persons, and some have employees also elsewhere. One firm was set up with incubator-like activities some years before the incubator started. With it the total number of jobs in firms founded with the help of incubating services is 60. Some incubator start-ups were later merged with larger firms, and some have moved to other locations in the Kemi-Tornio region, and even elsewhere.

The availability of graduates has been the main reason to locate in Digipolis for one firm that does not have local customers. According to the interviews the most usual reason to locate in the Technology Park are the services.

As a summary, there are both firms, founded in Digipolis, and subsidiaries located there. The strategy has followed both the incubation and attraction strategies (Ylinenpää 2001).

The history of Digipolis starts from the year 1986 when the first ICT firms started. They had most of their customers elsewhere. Applied research activities started in 1988, the first office premises were built in 1991, and the business incubator was founded in 1992. There is no local venture capital available but national and regional investors partially own some of the firms. The growth rate has been slow, but neither has there been any major declines. Refering to the study of Breshanan *et al* (2001) the park is still in a very early stage of development, and the history does not indicate whether it is going to succeed or not.

The ICT firms do not trade with each other, nor are they rivals, except when physical telecommunication network construction is concerned (there were two rival firms). In the other main sector, the process industry, there is little trade or rivalry between the firms in Digipolis either, but the firms have local customers in the Kemi-Tornio region. In two cases, ICT sector firms have local process industries as customers.

K-TUAS confers bachelors of science. It has also conducted projects to train new personnel both for existing firms, and for new firms. In the interviews it became evident that in all of the six firms most of the personnel and recent recruitments were either graduates from K-TUAS, or otherwise trained by K-TUAS. Where research and related services are concerned, 10 of the firms (33%) in Digipolis cooperate with the K-TUAS or M-LI.

The other actors include the development firm Kemin Digipolis Oy, the real estate and service firm Kemin Teollisuuskylä Oy, and the business incubator that is a part of the K-TUAS.

According to the firms' materials, 13 of the firms have offices also in Oulu, 7 in Rovaniemi, and one in Kalix and Haparanda. 13 firms have offices on a national level, and 12 belong to corporations operating internationally. Thus in several cases internal networks cover all levels of innovation systems. According to the case interviews, in 5 of the 6 cases there was cooperation with actors in the nearby city of Oulu.

In their research projects K-TUAS and the local unit of UO have several partners – both firms, and universities, and research centres. According to the status report presented to the steering group of Digipolis Research in August 2007, the university of Oulu (in Oulu) was involved in 7 projects, Luleå Technical University in 8, VTT in Oulu in 2, and the University of Lapland in 1 project. The number of firms participating in the research projects in 2007 was 48, of which 16 were from Kemi-Tornio region, 13 from the North of Finland, 5 from other parts of the country, and 8 from Sweden. The numbers include firms that either finance the projects, or work in the projects.

Kemin Digipolis Oy is a member of the Multipolis association which promotes cooperation and projects between Technology Parks in the North of Finland. Some examples of the activities are the NEO project promoting cooperation and projects between Finnish and Swedish firms and organisation, and MinAct project developing cooperation between firms, and firms and other actors, in the electronics sector.

According to Cooke (2004) a Science Park can be part of a larger regional system, or have links to one or several regional systems. When the regional system is defined, the main criterion should be high 'coherence' or 'inward orientation' with regard to innovation processes (Edquist 2005). When the links between the firms, researchers, and the development firm are explored, Digipolis and the local innovation system are a part of the regional innovation system of Oulu. There are also links to the national innovation system, and internationally.

Where sectoral innovation systems are concerned, the links the firms and other actors have indicate that two sectoral innovation systems are present: some firms, and part of the research and education, belong to the ICT innovation system, while most of the other firms, research, and education belong to the process industry innovation system. Locally the two systems have a small overlap.

From the cluster point of view, a local process industry cluster exists, including supporting industries, associated services, research and education. To the firms, the local industries are a relevant local market but most of them also sell elsewhere. There are R&D activities, as well as industrial cooperation, and industry-science cooperation. (see Paija 2001.) Some ICT firms serve the local process industries but within the sector itself there is no local cluster. The local sectoral collaboration covers some R&D activities, industrial cooperation, and industry-science cooperation but on a small volume. There is almost no local market to function as a base to develop products, and the closest market is regionally located in Oulu. The ICT firms and related research and education activities belong to the ICT cluster of Northern Finland.

According to Etzkowitz (2002) the central points in a Triple-Helix analysis are: intensity of interactions within institutional spheres, openness to interaction across institutional spheres, linkage mechanisms, public venture capital, and regional authority.

In the process industry service sector and especially in the ICT sector, the institutional spheres overlap. Research and development, as well as related services, such as electronics testing, work in close cooperation with the firms. Kemin Digipolis Oy utilises a programme manager system where experienced experts work closely with firms and research institutes to identify needs, new forms of cooperation, and firms willing to establish a subsidiary in the Technology Park. It also directs the research with the help of partial financing to projects.

The knowledge space has been built since the 1960s when engineering education started, and especially from 1988 when applied research started. In 2006 the research volume was 24 man years, and 2 million €. Gaps in the knowledge space have been filled with close cooperation with the University of Oulu and VTT in Oulu, and LTU in Luleå. The forming of consensus space has been assisted in several ways. Firms have representatives in the board of Kemin Digipolis Oy, the research units actively seek research needs; etc. Some mutual goals – especially sectoral – have been set, but the consensus space has not been fully achieved. The innovation space has been achieved partially: some firms, research and education, and Kemin Digipolis Oy – representing the municipality – have reached a collaboration level where the organisational roles have been hybridised.

Referring to the central points of study by Etzkowitz (2002), the intensity of interaction among organisations within institutional spheres is high in the process industry sector and low in the ICT sector. Openness to interaction across institutional spheres has risen in recent years in the process industry sector, and in the ICT and electronics sectors. Some linkage mechanisms exist and new ones are developed. Public support to firms and research is close to the role of public venture capital but venture capital itself is missing. The local and regional governments are committed to the development.

Social capital

Two methods for activating local social networking are identified in Digipolis: the Digipolis business breakfasts, and joint coffee room in one of the office premises. Digipolis business breakfast is a regularly repeated open meeting where one actor presents its activities, and others have the possibility to ask questions and discuss. On the other hand, several key persons in the firms live in other locations, which lowers the intensity of local networking.

Strong ties to managers or employees in other firms are rare. In the early years parties were arranged to strengthen the ties, but they ended when the number of employees and firms has risen. Where cooperation between firms and research is concerned, the ties formed in long-term cooperation are quite strong while in short term projects they have not developed as well. The ties among the researchers in various research teams and the two official organisations have strengthened since the Digipolis Research collaboration started in spring 2004. The methods involve a joint management team, joint use of personnel, and joint projects. Since September 2007 all the researchers work in the same office building.

When firms are concerned, the number of strong ties bridging the innovation system to regional level is high as a result of the location of branch or main offices, and the residence of some key persons. In some cases, the personnel of the firms have acted as intermediaries for the links to the research personnel.

Within research, the managers and team leaders have first created links with actors in Oulu, and later they have brokered the ties to other researchers. The same phenomenon has later been repeated with LTU.

5.1.2 Kalix – Electropolis

When Electropolis is regarded as a geographical area, the Technology Park itself consists of one building with six firms. The other six are located in various parts of the town. Therefore, the spatial definition of the Technology Park covers the whole town. Kalix Electropolis Ab's activities are limited to developing, producing, and offering services to firms within the ICT sector. The six firms provide jobs for 150 persons.

All except one of the 12 firms were founded in Kalix. Subsequently, two firms have been sold out, and are now units of larger firms: one of a national, and one of an international firm. The incubation strategy is the dominant one even though there is no official business incubator (see Ylinenpää 2001).

The Technology Park history starts from the 1970s. There were two major bankrupcies that led to four new firms founded on the basis of the former departments. The products and activities of the bankrupt firms clearly affected the choices made in the new ones regarding technologies and products, and the existing competence utilised. The declines and bankruptcies cut the growth in the end of the 1990s but the new firms succeeded in growing so that in 2007 the number of jobs is higher than ever before. According to Breshanan *et al* (2001) in a new cluster the entrepreneurs have to turn away from a saturated market and complete the existing technologies and cluster rather than compete. When the earlier firms ended their activities, their shares of growing niche markets were taken by the new ones. At the same time the number of actors rose. This gave an opportunity for a new small local cluster to emerge and develop. The factor conditions do not have all cluster characters.

At the local level, 7 of the 12 firms cooperate locally in product development or production – 5 with 1 other firm; 1 with 2; and 1 with 3 others. Knowledge is exchanged also informally. Some of the firms are to some degree rivals with each others. All the firms belong to the sectoral innovation system in ICT.

Local education is available on vocational level. Higher education has been arranged as projects, and short courses are organised when needed by the firms. Recruiting graduates with higher degrees has been difficult. On the other hand, Kalix Electropolis Ab has built good links to LTU. As a result, learning projects as well as Master and doctoral theses have been done on the firms' needs. There is no localised research, but research on firms' needs is conducted in cooperation with LTU, universities in the South of Sweden, K-TUAS and UO in Kemi, and the University of Oulu. In one interesting model a researcher works part-time in a firm in Kalix, and the rest of the time at LTU – having thus also the role of an intermediary and broker between Electropolis and the university. One third of the firms cooperate in research with the universities. Additionally, students' learning projects have been run, as well as testing services at LTU and K-TUAS.

The other actors in Kalix Electropolis are the development firm Kalix Electropolis Ab, and the municipality which owns some real estate.

According to the firms' material, one of the firms has units on both national and international level; one of the firms in Kalix is a department of a national firm; and one is a daughter firm of an international firm. As a result, most of the firms do not have internal networks to transfer knowledge to Kalix from other locations.

The operative spatial region of Kalix Electropolis Ab has been widened to cover Pajala, Övertorneå and some firms in Luleå. This implies growing interaction on the regional level. According to the interviews, three Kalix firms cooperate with a total of four regional ICT firms in product development. Additionally regional customers exist and there is a regional ICT cluster.

Cooke (2004) indicates that a Technology Park or local innovation system can be part of a larger regional system. The small ICT innovation system in Kalix is a part of the regional innovation system of Norrbotten. Additionally it has strong links to the national Swedish innovation system, and links also to the north of Finland. The firms belong to the sectorial innovation system in ICT and the customers belong to several other sectorial innovation systems.

With regard to the knowledge space, the problem is the lack of research and higher education that there has recently been an attempt to correct with close cooperation with LTU and K-TUAS. The consensus space exists between the local authorities and firms. Higher education and research has been bridged by having a university representative on the board of Kalix Electropolis Ab, and by building closer cooperation with higher education institutions. The development of the innovation space is ongoing. The hybridisation of organisational roles has been advanced by the ProcessIT Innovation network (industry – SME – university research and development cooperation network led by the LTU); active intermediary role of the Managing Director of Kalix Electropolis Ab and some other persons, organisations, and projects. When the central points of study by Etzkowitz (2002) are concerned, the intensity of interaction among organisations within the same institutional spheres is very high between the firms. Openness to interaction between the spheres is positive but the interaction is quite low because of the lack of a local HEI. However, linkage mechanisms are being developed. As in Digipolis, public venture capital is available in the form of project financing. The local and regional authorities are committed to the development.

Social capital

In Electropolis many of the firms' key persons have a common background in a previous firm, and they may have known each other for more than a decade. After the founding of several new firms 5 to 10 years ago, those ties weakened. In 2003, Kalix Electropolis Ab's role was changed from real estate development to business development, and the board was reconstructed to consist mainly of key persons in the firms. The regular meetings serve to strengthen trust and ties between the persons. The present Managing Director started at Kalix Electropolis Ab at the same time, and he has paid attention to bringing people together. In addition to the joint work on the board, shared training, and Christmas parties have been arranged. The trust building has led to confidential discussions between persons, and to joint development projects between firms.

The ties to the research personnel have been developed by nominating a Professor from LTU to the board of Kalix Electropolis Ab. This brings positive effects, and facilitates close cooperation between research and industry, when needed. The interviews indicate that the ties to research personnel are not strong. On a regional level, there are some strong ties with certain firms in Pajala and Luleå. Additionally some persons have some relatively strong ties on a national level both with component suppliers, and universities. Ties with Finland – especially in research and testing services – are developing.

The Managing Director of Kalix Electropolis Ab has adopted the role of bridging the social network in Kalix to actors in other regions. He also acts as an intermediary and broker for other actors in Kalix.

5.1.3 Cross-case analysis

Innovation system

Digipolis and Electropolis differ from each other spatially. Digipolis is a compact spatial area, while the firms in Electropolis are located in various parts of the town. With regard to size, the number of firms and the number of jobs are over 2.5 times higher in Digipolis than in Electropolis.

In Electropolis most of the firms have been set up locally by private persons, and 8 of the 12 firms are still locally owned. Some firms have been merged with larger firms with main offices elsewhere. In Digipolis the business incubator has helped set up 13 firms, some of which have been sold to larger firms. In 2007, 12 of the 30 firms are locally owned. Electropolis has followed the incubation strategy, while in Digipolis both the incubation strategy and attraction strategy have been used.

In Electropolis more than half of the firms collaborate with each other on a commercial basis, while in Digipolis only a few collaborate. In Electropolis all the firms belong to the same sectoral electronics and ICT innovation system. In Digipolis the firms belong to two separate sectoral systems: i.e. ICT, and the process industry. The overlap and cooperation between the sectors is small. Some of the firms in Electropolis are rivals to each other while in Digipolis there is almost no rivalry.

In Kemi, higher education and applied research are available locally in the Technology Park, while in Kalix there is only vocational college level education, and no local research. According to the interviews, the majority of the employees in the firms in Electropolis have earlier worked in the earlier firms, while in Digipolis most of the personnel – especially the most recent recruitments – is sourced from K-TUAS graduates. In terms of research, 1/3 of the firms in Digipolis cooperate locally.

With regard to other actors, there is a development firm, and a separate municipal real estate owner in both of the Technology Parks. In Electropolis there is no business incubator. Neither of the parks has local venture capital available locally, but in both cases public development project financing partly replaces it.

Over 40% of the firms in Digipolis also have regional offices in Oulu, and over 20% in Rovaniemi. 40% of the firms are offices or divisions of international or national firms. In Electropolis 25% of the firms have offices on national and international levels, and 2 of the 12 firms (17%) are departments or daughter firms of national or international larger firms. In this sense, the firms in Kalix operate more independently but, on the other hand, the firms in Kemi have natural internal regional and national networks.

In the area of research, both in Digipolis and Electropolis the firms have direct links to regional and national universities and research centres. 1/3 of the firms have this type of collaboration in both Technology Parks. In Digipolis 1/3 of the firms cooperate also with the local research unit, that cooperates especially with the universities in Oulu and Luleå, and VTT in Oulu.

Both of the development firms have networked regionally: Digipolis is a member of the Multipolis association of Northern Finland, whereas Electropolis has extended its own operations to cover the whole province of Norrbotten. In the north of Finland, the cooperation covers the coordination of development activities between Technology Parks, and joint projects with the goal of developing the firms, new products, and new services e.g. in testing. Kalix Electropolis Ab focuses more on working closer to the firms' process level by seeking new needs, knowledge etc. The geographical enlargement means that it manages most of the networking activities on a regional level by itself. The obvious reason is that the smaller size and number of firms, and focus on one single sector makes it manageable.

Digipolis is a part of the Oulu-centred regional innovation system, and Electropolis is a part of the innovation system in the north of Sweden. Both are linked to the national innovation systems.

Where sectoral innovation systems are concerned, Electropolis is a part of the ICT innovation system, while most of the customers belong to other sectoral innovation systems. In Digipolis two separate innovation systems – have a small overlap – are present: ICT; and process industry. Most of the customers belong to the same sectoral systems as the firms.

In Electropolis there is a group of firms in the ICT sector, but because of its gaps, in factor conditions, especially in education and research, it does not fulfil the characteristics of a cluster, but it is part of a larger regional cluster. In Digipolis, education and research are present but the interaction between the ICT firms does not fulfill cluster characteristics. Within the ICT sector, Digipolis belongs to the regional ICT cluster of northern Finland. On the other hand, there is a small local cluster within the process industry.

In terms of the Triple-Helix approach, the intensity of interaction between firms is high in Electropolis. In Digipolis, the interaction between firms in the process industry sector is high, but low between ICT firms. Although the knowledge space is more developed in Digipolis, it is still quite narrow. In both of the Technology Parks, close ties to the regional level are used to extend the knowledge space. The consensus space is well-developed among the actors in Kalix, and is widening to regional level to include also research and higher education. In Kemi, the consensus space is not as well-developed even though several actions are taken to develop it further.

A hybrid organisation between actors in different spheres functions partially, especially within the ICT sector in Digipolis, and between the firms and Kalix Electropolis Ab – representing the local government – in Electropolis. When the intensity of interaction between firms is examined, it is very high in Electropolis, quite high within the process industry service firms in the local innovation system around Digipolis, and on a low level between the ICT firms in Digipolis. On the other hand, the interaction between firms and research is quite high in Digipolis, while in Electropolis the research actors are missing on a local level.

Openness to interaction across the institutional spheres is good in both of the Technology Parks but in both of them the interaction itself is still underdeveloped, and in Electropolis the local research is missing. In both Technology Parks the mechanisms to link the spheres and actors exist. Regional and local authorities are committed in both cases, and regional development funds are used as a form of venture capital.

Social capital

The two Technology Parks have different histories: in Electropolis many of the key persons have worked in the same firms and live in Kalix; while in Digipolis the work histories differ, and many key persons live – and have always lived – in other locations. In spite of the joint history, the birth of new separate firms in Electropolis weakened the inter-firm links. Working for the same goals in the same area – the board of Kalix Electropolis Ab and the active role of the development firm have strengthened the ties, and they have noticed that the knowledge exchange benefits all. In Digipolis the social networking was on a high level at the end of the 1980s and early 1990s when the number of firms and persons was small. When the Technology Park grew, little attention was paid to maintaining and developing the ties. This led to a weakening of ties, and today mainly dyad links exist.

The links between the firms' personnel and research personnel are quite strong in Digipolis, where a third of the firms participate in research projects or use e.g. testing services are involved. There are some strong personal ties with researchers on a regional level. In Kalix the ties between firms and researchers are developing but are still quite weak.

In both cases there are some strong links to regional firms. In Digipolis the firms' regional offices have often been the intermediaries for these links, and in some cases by key persons living in other towns in the region. In Electropolis the links have often been brokered by Kalix Electropolis Ab.

Both in Kalix and Kemi some of the non-local ties are built by persons who have taken an active role in developing ties to various actors both locally, regionally, and beyond. This has led to a bridging of networks, and later to intermedaiting links to other persons.

5.2 Firm and product development case analyses

Just like the Technology Park cases, the product development cases of the firms are analysed using replicating logic. The first Section examines the cases in Digipolis in Kemi, and the second one the cases in Electropolis. The third Section presents a cross-case analysis within each Technology Park; and a cross-case analysis between the parks to find the possible differences caused by different circumstances.

The product development projects are analysed to identify the product development processes, direct and indirect knowledge transfer to various parts of the processes, and the knowledge types and sources. Because knowledge is transferred with the help of networks, the interorganisational networks are analysed on dyad and portfolio levels. The first case is presented in more detail to illustrate the analyses in details.

5.2.1 Kemi – Digipolis

Case D1

In *case D1* the firm uses the customer's process even though the product is the firm's. The process starts with a feasibility study and specifications in phase 1, i.e. concept development. Differing from the Ulrich-Eppinger model, a project planning (phase 0) is conducted after the feasibility study, partly parallel with the specifications. Next the system-level design is done. Phase 3, i.e. detail design, is started at the same time with system-level design. Phase 4, testing and refinement, starts with test planning while system-level design is still going on. Prototyping belongs partly to detailed design, and is conducted parallel with detailed design and technical testing. Customer tests started in the middle of technical testing to give feedback to detailed design. Some refinement is done while the product is in test-use by the customer. The process ends in the training of the customer's personnel to use the product.

The process follows to some extent the Ulrich-Eppinger model with the exception that many of the phases are parallel, and thus there are no clear review points between those phases. Phases 0 and 1 form one group, after which phases 2 and 3 are started in parallel. Phase 4 starts one month after that, and it overlaps in phase three with the prototyping that includes development, building, and testing. Customer testing involves two steps: firstly the testing of the prototypes, and secondly user-testing and refinements after prototyping. The process ends with customer training, and the phase starts while customer tests and refinement are still going on.

The subsequent knowledge transfer and interorganisational networking are analysed in parallel on the dyad level followed by a portfolio analysis. Moreover, the personal networks are discussed.

When the direct knowledge flows to the specific product development process are concerned, the source of the product development idea is the key customer. The new product is based on an existing product of the focal firm. The need is expressed explicitly, and the knowledge is transferred as documents and in meetings. This implies that some of the knowledge is tacit. From the whole firm's point of view the relation is dyad, but from the local unit's point of view it is a relation between three units, where the firm's regional unit has the role of broker and coordinator. A regionally located group of the focal firm has a major role in the feasibility stage. The relationship between the units is direct but coordinated by another regional unit. The three first stages – forming the phases 0 and 1 – are conducted in close collaboration with the internal regional group and the customer, which implies that both explicit and tacit knowledge is transferred during the joint teamwork. The first two phases happen in parallel. This indicates that the first major review and decision point is after them even if there are regular project steering group meetings. The customer relationship has a long history which creates trust. The use of the customer's process is evidence of a high level of adaptation the firm has done to make the dyad relation work.

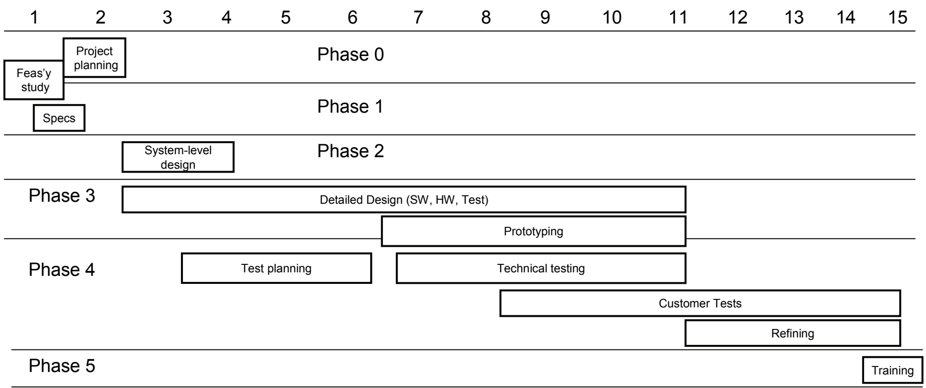


Fig. 40. Product development process in case D1.

When the process reaches phases 3 and 4 – starting in parallel – the role of the customer as a knowledge source declines temporarily. In these phases – until the prototyping starts – two other internal regional expert groups are of high importance. They conduct two specified detailed design tasks that are finished before prototype testing with the customer starts. From the unit's point of view, those can be defined as subsystems. As an internal cooperation between two separate units, the operation is well coordinated and the processes are well adapted.

When the first prototypes are introduced, the role of the customer grows again, and remains high throughout the whole process. In the prototyping, it is obvious that the knowledge transferred includes both tacit and explicit content.

In detailed design phase, the process tool providers have the role as a source of mainly explicit, but to some extent also tacit knowledge. The importance of the knowledge is anyhow smaller than the knowledge of the actors discussed earlier.

The relationship takes the form of a dyad, and – according to the interview – it has developed from an inter-firm relationship to a personal level relationship with an increased level of trust, and also to strengthened ties between the unit's personnel and the tool provider's personnel.

Some knowledge sources are not directly connected to the specific project but have roles in the background. These include a specialised consultant and a component provider with explicit knowledge – a relationship coordinated by the unit. An international university has provided courses and thus transferred explicit knowledge. The relationship has been brokered by intermediary organisations situated in a structural hole, and the tie is weak. The local research units provide both explicit and tacit knowledge in testing and reliability. The relationship has been created on the organisation level. In the beginning, one person has functioned as a gatekeeper and broker. At the time of the interviews the relationship has developed, and strong ties are forming between persons in the organisations. K-TUAS provides new personnel. The organisational relationship is dyadic, and includes some strong and some strengthening ties. Some adaptation has been done to enable learning projects to be carried out, and thesis projects. Also some course level adaptation is done. Internal component experts on a regional level contribute mainly explicit but also tacit knowledge. The firm's various units and personnel form a network – a type of a community of practice – utilised to solve problems with the help of explicit and tacit knowledge. New contacts are found through others situated in structural holes.

Fig. 41 shows the innovation network with the geographic levels and sectoral level with all the identified knowledge sources. Also knowledge types and their importance, as well as the type of the source are introduced.

The key customer and firm's other units on a regional level are the main sources of knowledge. Adaptation is done by the unit, and the customer's knowledge has an important role especially in the early and late phases. The importance of various internal units varies between process phases. The local innovation system has a role as a source of testing knowledge and services, reliability knowledge, a source of new personnel, and as a broker.

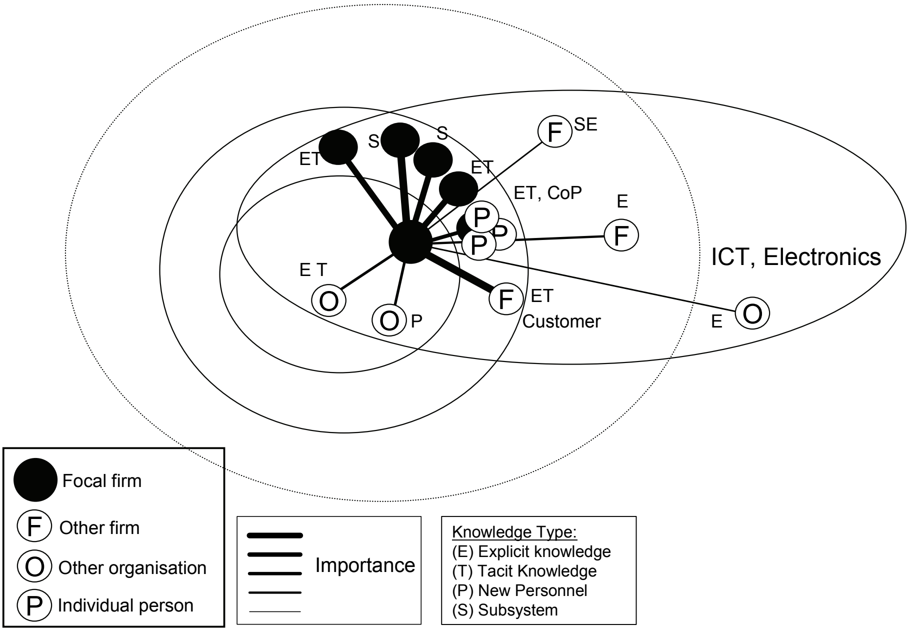


Fig. 41. Case D1, innovation network in the case process.

Case D2

In *case D2* the product development process is always the firm's own, and it is supported with an information system. The standardised process starts with idea screening and concept evaluation including parts of both phase 0 and 1 in the Ulrich-Eppinger model. The second stage is the product specification having elements of phase 2, system-level design. The first two stages are owned by the international corporation which owns the firm, that participates in the second stage. The third stage is setting up the project including also some parts of project planning, phase 0, and a decision point: either to continue, or return to product specification. The fourth stage, design, is owned by the firm, and is conducted mainly in the regional unit. It is followed by evaluation which is a decision point: either to continue, or return to design. The sixth stage is production test development, referring to phase 4 – testing and refinement – in the model. To some extent it could be alternatively included in phase 3, design, because it involves test development but not testing itself. The last stage the firm owns is the production ramp-up that is conducted in cooperation with a production unit on an international level.

The process is standardised. The stages follow each other with gates between them, and without any parallel phases. The main difference compared to the model is that the phase 0, planning, is the 3rd stage after the product specification stage that equals system-level design in the model. This process enables very exact project planning.

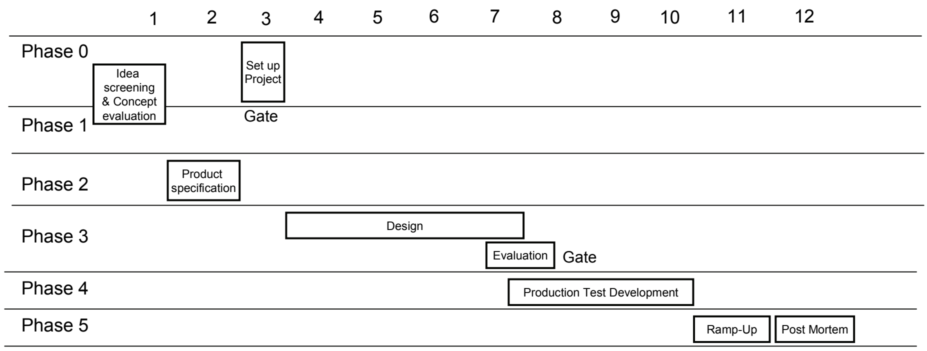


Fig. 42. Product development process in case D2.

From the focal firm's point of view, the source of the idea is always the corporation. Originally some of them are based on the corporation's own market analyses, while the rest are based directly on customer needs. Because the direct knowledge source is always part of the same corporation, adaptation is not needed. The interaction between the firm and the international units is dyadic, and supported by an IT system. The knowledge towards the local unit in Digipolis is brokered by the regional unit.

The concept is defined on the corporation level, and transferred to the focal firm in the product specification stage. According to the interview, most of the knowledge transferred to the focal firm is explicit. The project is set up (phase 0: planning) on regional level. If gaps in the product specification are found, a back-step is needed, and the specification is fulfilled by the corporation level unit. In the design stage – involving the system-level design – the main knowledge sources are support groups and an internal design tool group located internationally.

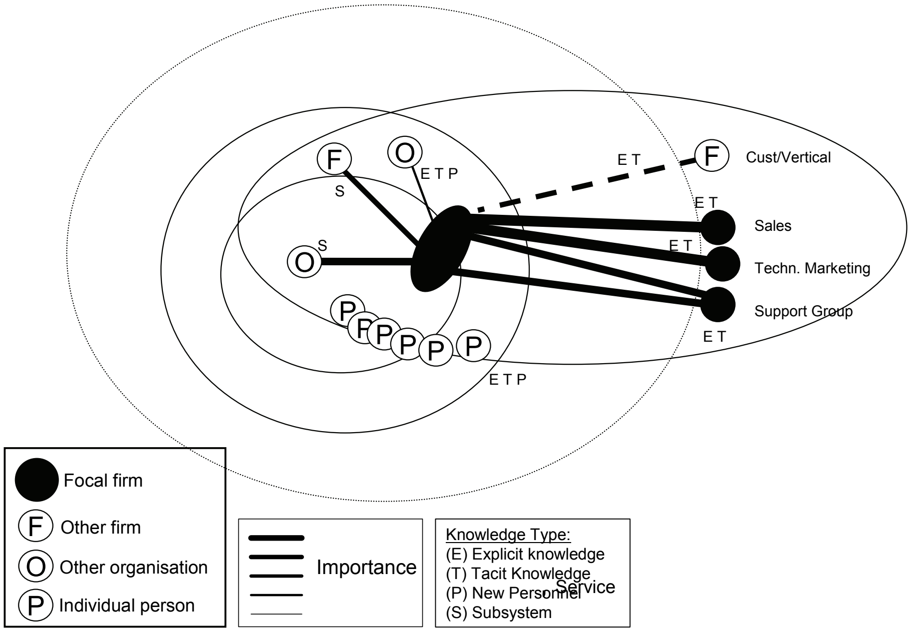


Fig. 43. Case D2, innovation network in the case process.

The evaluation of the design is conducted with the help of a project team consisting of one sales person, one system engineer, and one reliability engineer from the international corporation level as members, and representatives from regional and local level units of the daughter firm. If the product is customer specific, the customer is represented in the project team. In a basic case the relation is dyadic inside the corporation, and in a customer specific case networked between the three parties and brokered by the international unit. Thus the evaluation stage has several knowledge sources, and the team work around a specific design enables the transfer of explicit as well as tacit knowledge.

After the design is approved, production test development is started in Digipolis. The main external knowledge sources are the designers in the regional unit, and the internal specialist groups on an international level. On the local level K-TUAS is used as a source of knowledge and services. A regional firm is used as a subsystem provider in a dyad relation but the knowledge intensity is quite low.

The next stage is the production ramp-up that is conducted in collaboration with a production unit on the international level, which means that also the knowledge transfer occurs on the international level. The choice of the production unit varies between projects. The choice is done by the corporation. The final stage is the evaluation and ending of the project.

When – from the process point of view – indirect knowledge sources are concerned, the regional pool of designers, using the same technologies, serve as an informal source of knowledge, the University of Oulu serves as a source of new personnel and novel ideas, and on a local level K-TUAS serves as a source of new personnel.

The main knowledge sources are the corporations units on the international level. In some products customers have a direct role, but adaptation is not done with customers' processes. The regional level innovation system offers new personnel from the university and other firms, a networked community of practice used informally, and new mainly indirect knowledge on new ideas and technologies. The local level, Kemi, offers mainly new personnel for testing and test development, and testing related services in a dyadic relation.

Case D3

In *case D3* the firm is young and micro sized, and the processes are not accurately defined. The first stage is idea screening presenting parts of the phase 0 planning. It is followed by concept development that, in this case, includes parts of phase 1, concept development, and phase 2, system-level design. The system level design is started simultaneously by collecting data which is utilised in the product's database. The next stage – the detailed design – includes also further data collection and testing, and covers thus both phase 3, detailed design, and phase 4, testing and refinement. Phase 5 is the production ramp-up including the sales.

The process has only four stages but is obviously detailed enough for a small product development project in a small firm.

The source of the idea is the firm itself. The idea was tested with a national organisation – a non-profit association close to the market segment – and a national business sector association in dyadic relationships. The value of the transferred knowledge is evaluated as high.

Within the concept development stage, knowledge was transferred from the business sector association, and another specific national organisation in dyadic relationships. Reviews were done. The knowledge transfer from the associations occurred in face-to-face discussions, which implies that knowledge has been transferred also in tacit form. The national business sector association also functioned as a structural hole or broker for its members with whom the firms' relationship is indirect, and who are the paying customers. The knowledge transferred from the two associations has been of high value to the process.

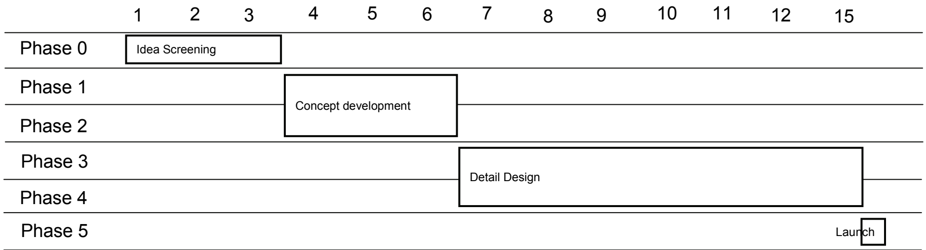


Fig. 44. Product development process in case D3.

The system-level design and detailed design stages were conducted by the firm itself. In the system-level design the business sector association was used as a knowledge source in non-technical questions. Technical testing was done by the firm, while the functional testing was done in collaboration with the business sector association.

The product was launched with the help of the same association knowing the customers.

In the background the firm utilises an unorganised, inter-personal network composed of key persons in 6 to 7 firms using the same technologies. According to the interviewee there was no co-operation on the local innovation system level, but the entrepreneur had graduated from K-TUAS.

Two of the three national level organisations – the business sector association, and the two non-profit associations close to the market segment – have been the main knowledge sources especially in the early stages of the process, and the national business sector association again in the testing and refinement phase. The close relation with several reviews implies that also tacit knowledge has been transferred. During the process the firm has managed a relationship portfolio to transfer knowledge to its needs. The local innovation system has had no direct role but it has affected the background in the form of education.

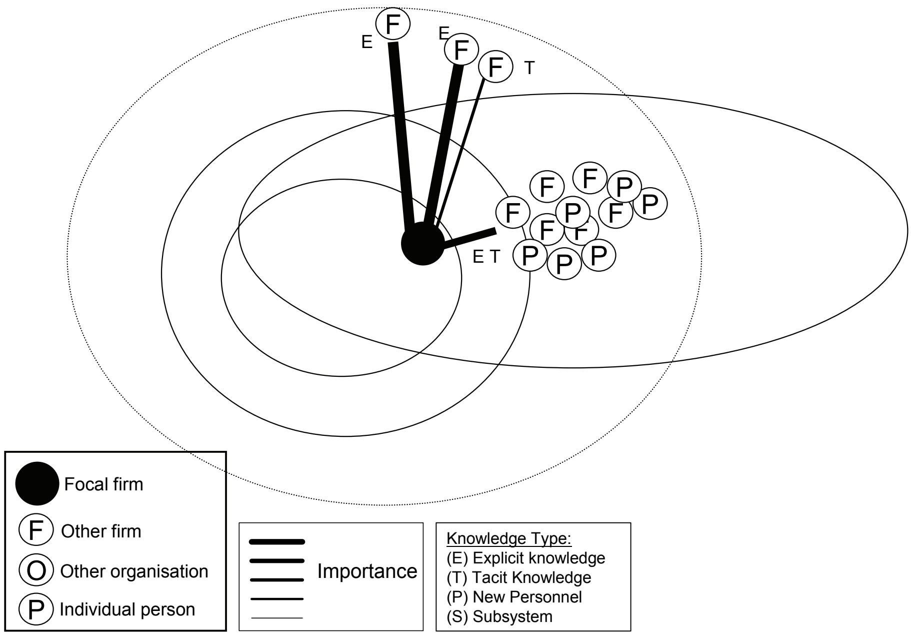


Fig. 45. Case D3, innovation network in the case process.

Case D4

In *case D4* the firm has its own process but in most cases it employs customers' processes when large firms are concerned. In the case their own process was used. The first stages have been done mainly by the customer and a consultant. At phase 0 the firm makes an offer. For the firm the process starts with a specification that can be placed in phase 2, system-level design. The implementation stage involves detail design, phase 3. All the rest of the stages in the process – installation, test use, acceptance, and the six moths guarantee – are parts of phase 4, testing and refinement. The product is software and thus there is no production ramp-up.

The process includes only some parts of the model's phases because of two reasons: the concept is presented by the customer and the consultant, and there is no production to be ramped up. Most of the stages – installation, test use, acceptance, and the six months guarantee – are part of phase 4: testing and refinement.

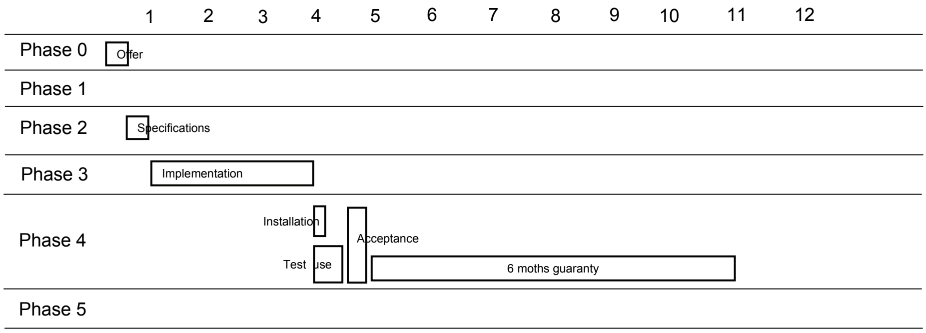


Fig. 46. Product development process in case D4.

The source of the idea is originally from the local customer, but the idea was based on the focal firm's earlier application. Idea screening and planning were made by the local consultant and the customer, except the actual project planning. The knowledge is transferred in explicit form, and it is used by the firm in the next phases. Thus, in the system-level design the customer and the consultant are the main sources of knowledge. The relations are networked with direct links between all the three parties, but the consultant has – to a certain extent – a brokering role.

The detail design employs prototypes and reviews, where the customer and the consultant are of importance. The reviews enable transfer of tacit knowledge. Simultaneously the firm's own internal regional and national network, as well as some private persons in other firms – forming a networked community – and tool providers in dyadic connections are utilised to source mainly explicit knowledge. Subcontractors are used to design some specific subsystems to the product.

Also in the test use and guarantee stages the customer and the consultant are the main knowledge sources. In the stages in phase 4 the knowledge is codified and transferred to the firm. During the whole process frequent reviews are done, and thus the knowledge transfer from the customer and the consultant is almost continuous.

With regard to indirect knowledge sources, K-TUAS organised a training project when the firm started. In the project there was some adaptation done. The education was provided mainly by firms from the national level. Subsequently, some persons were recruited with through courses arranged by a local university unit, some are recent graduates from K-TUAS. The training of existing personnel is arranged through the firm's own network based learning system, and courses arranged in collaboration with competitors and customers.

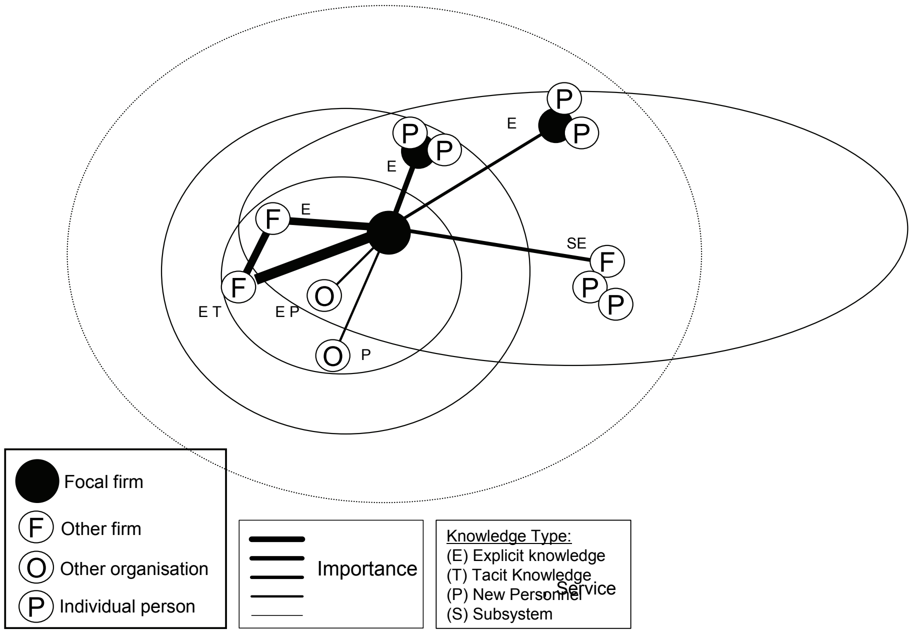


Fig. 47. Case D4, innovation network in the case process.

The local customer and the local consultant are the most important knowledge sources. The ties are strong, and the rate of knowledge transfer is high during the whole process. The firm's own process is used without any major adaptations. The process was conducted almost totally inside the local innovation system. The other local actors – especially in training and education – have had a role in creating the knowledge base when the firm started up.

Case D5

In *case D5* a customer specific product was developed using with the customer's process. The product utilises new technology for an existing design. The idea was the firm's own but the customer gave the specifications. As the focal firm got a ready concept it did not conduct phase 1, concept development. The next stage was design, and prototyping (5 rounds) was run in parallel with the design. The stage included both system-level design, detail design, and testing and refinement: phases 2 to 4 in the model. The design stage was followed by an acceptance decision on moving the product to production ramp-up stage, that equals the model's phase 5. Most of the stages were conducted in a regional unit, while parts of the prototyping stage, and the whole production ramp-up were conducted in the local unit.

Phase 0 in the model is mainly conducted by the customer except for resource allocation. Phase 1 involves technical specifications. The design stage in the utilised model includes both system-level design and detail design: phases 2 and 3 in the model. Prototyping is used and thus phase 4, testing and refinement, is started in the middle of detail-design, and conducted in parallel to it. They are followed by a gate, acceptance. The last stage equals phase 5, production ramp-up, in the utilised model.

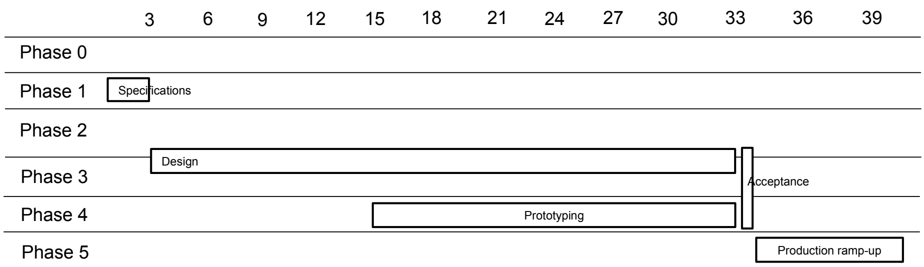


Fig. 48. Product development process in case D5.

The source of the idea is the firm that screened the idea with the customer. The knowledge, including specifications, is based on the customer's existing product, and thus it has been transferred in explicit form. The process involved a lot of meetings which implies that tacit knowledge has been transferred. The design utilised 5 rounds of prototyping which indicates that the customer's role as a knowledge source has been high through the whole process. The relationship is dyadic.

Two firms has been used for design in a portfolio relationship. In other words, knowledge was transferred in the form of subsystems. The customer has brokered the relationship with them. Additionally VTT and the University of Oulu have been used as sources of both explicit and tacit knowledge. All the transfer, described previously, occurred on the regional level inside the sectoral innovation system in ICT. Material providers were used as an explicit material knowledge source on the international level.

In the background the local K-TUAS has functioned as a source of personnel, as well as a source of explicit and tacit knowledge from applied research in production and material technologies. K-TUAS has done adaptation in the dyadic relationship. UO has provided the existing personnel with knowledge intensive services, and with joint research projects. It is thus a source of new personnel, and explicit knowledge. VTT is a research partner and a source of expertise. Especially the knowledge of materials is transferred through personal contacts, which implies that both explicit and tacit knowledge is transferred. With regard to research, the firm applies portfolio management with the research organisations choosing the partner according to what knowledge is needed.

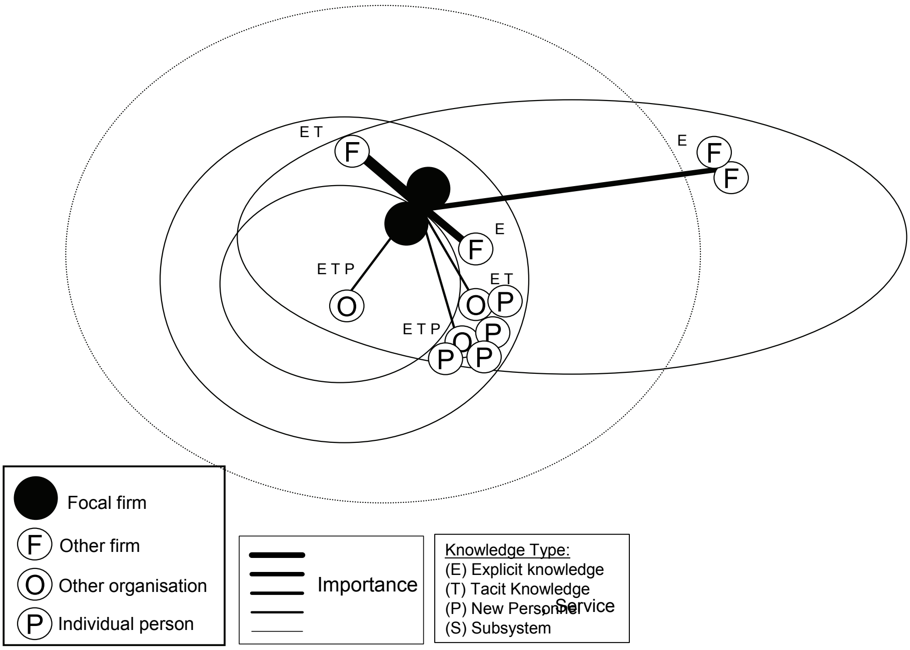


Fig. 49. Case D5, innovation network in the case process.

The customer is the most important source of knowledge both to the firm's regional unit and the local unit through the whole process. The customer's process is employed in the project which implies a high level of adaptation from the focal firm's side. The regional designs firms are the next in importance, followed by the material providers on an international level. Both of them transfer explicit knowledge. All other sources except K-TUAS are on a regional level. The local innovation system level has a role in providing indirect knowledge in the form of research results, new personnel, and training of existing personnel. When the research results and training are concerned, the transfer involves both explicit and tacit knowledge.

Case D6

In *case D6* the development process is defined in the firm's quality system, and employed accurately in every project. The project is a customisation of an existing product platform. Phases 0 and 1 are not included in the process. Phase 0, planning, is made while making the offer. Phase 1, concept development, involves two separate stages: specifications made by the customer with the help of a consultant, and pre-design made by the focal firm. The process itself starts with the specifications stage equivalent to the system-level design in the utilised model. The implementation stage is part of the detail-design phase. It is followed by a factory acceptance test in the focal firm's own facilities including both the test and a decision gate. The next stage is delivery to the site and installation. The process is in every case customisation and installation of the existing platform to the customer's needs. The stage could be defined as a part of the production start-up phase, or as a part of the detail design phase. It is followed by a cold test where the product is tested when it is not connected to the industrial process, and a site acceptance test in which the product is tested in real use. Both are parts of the testing and refinement phase. Finally, in the handover stage the product is transferred to the customer's responsibility. The stage can be compared to the ramp-up phase.

The process differs from the Ulrich-Eppinger model. The first two phases are not included, and in phases 3 to 5 the process jumps back and forth in the phases. The reason is that the process is not exactly a product development process but an adaptation of an existing platform. The result of the process is an application that is used only once.

When the process started, explicit knowledge was transferred from the local customer and the local consultant to the focal firm in the form of system specifications. The product is an existing one, and is tailored to the needs. The relationship is a network of three parties, and the consultant has a brokering role. Additional knowledge is transferred prior to the offer in negotiations with the customer, which implies a transfer of detailed tacit knowledge. The product is used in connection with existing equipment, and explicit knowledge is transferred in a dyadic relation from the equipment manufacturer. In this particular case a national level public authority participated in the negotiations transferring explicit knowledge. In the detail design phase, the consultants on a national level designed some subsystems, as well as one of the focal firm's national level units. The customer and the authority participated in the first test – the factory acceptance test – thus transferring both explicit as well as tacit knowledge. The installation was made by a local installation firm bringing to the process its specialised knowledge. In Fig. 52 it is codified as a subsystem. The firm used several firms, and thus managed a portfolio while conducting the process. In the last two tests – cold test, and factory acceptance test – the customer, the installation firm, and the authority evaluated the product against the specifications and regulations. They transfer their knowledge to the process.

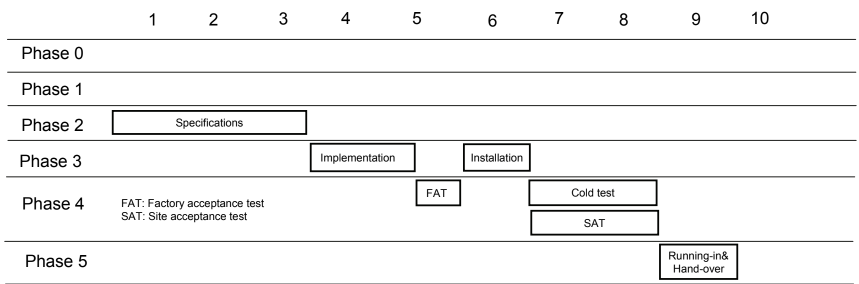


Fig. 50. Product development process in case D6.

K-TUAS is an important source of indirect knowledge as the main source of new personnel. The training of the existing personnel is mainly conducted with the help of in-house courses in a national unit of the focal firm.

The local customer was the main source of both explicit and tacit knowledge through the whole process. The next important source was the local consultant participating in the first phases, and in making specifications. It provided explicit knowledge. The third in importance was the national level unit of the focal firm. It transferred both tacit and explicit knowledge, as well as subsystems. In addition to the customer and the consulting firm there were two other knowledge sources on the local level: the installation firm, and K-TUAS providing new personnel. In the case project, the regional level was not utilised. In addition to the focal firm's own unit on the national level, a consulting firm was used to provide a subsystem, and an authority and an equipment provider to transfer explicit knowledge to the process.

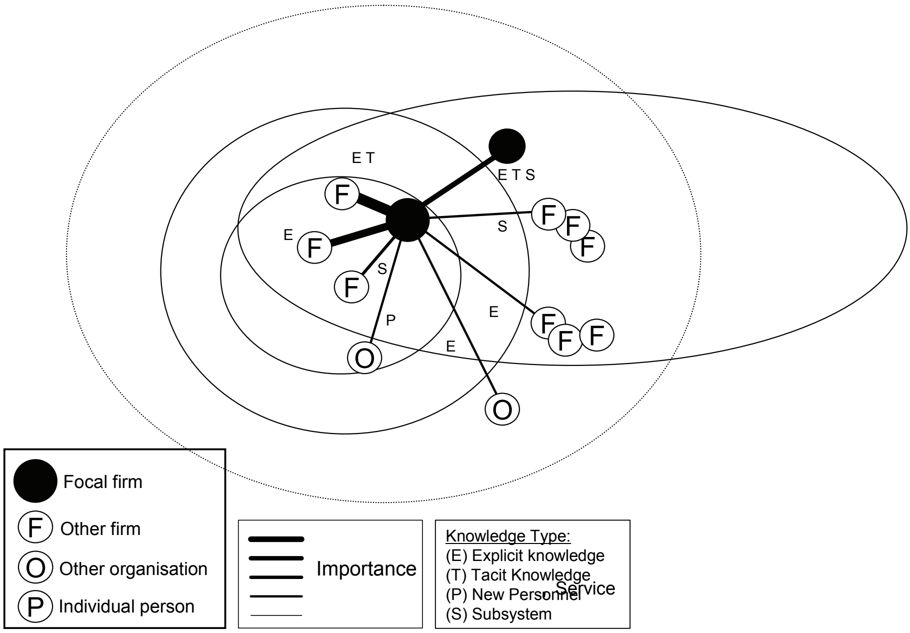


Fig. 51. Case D6, innovation network in the case process.

5.2.2 Kalix – Electropolis

Case E1

Case E1 is an internal platform development project that lasted for several years. The process started with idea screening that belongs to phase 0, planning, in the Ulrich-Eppinger model. The next stage is concept development equalling the concept development phase in the model. The platform development stage includes elements from phases 2 and 3. The platform was first developed to such a level that it could be used in various products, and has afterwards been developed further. First the product was developed on the platform one year after its development was started. The testing and refinement phase was included in the development stages. The last stage is production, referring also to production ramp-up. The firm has a quality system that it follows in product development.

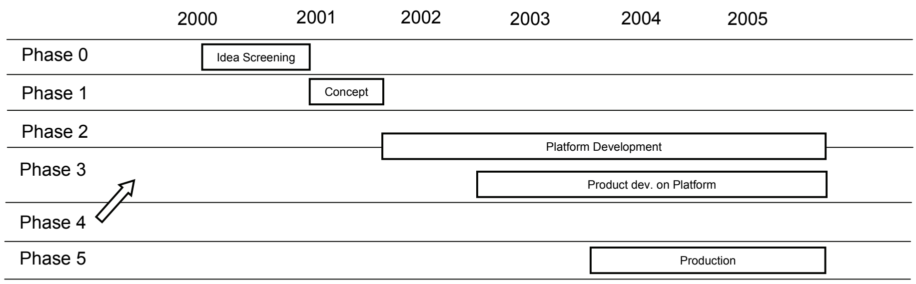


Fig. 52. Product development process in case E1.

The product idea was internal. Three national and international level customers were used to evaluate the idea as sources of explicit and tacit knowledge in a portfolio relationship. The concept was developed by the focal firm, but a regional firm was used to define the software subsystem concept. The link between the two firms is strong and continuous: they form a strategic alliance, and are well adapted to each other in a dyadic relationship. Also the social links are strong. When developing the platform almost all the work was conducted by the firm itself. Some testing was sourced regionally in a dyadic relationship, and the subsystems are produced by regional firms. When products are developed on the platform are concerned, the customer's knowledge is utilised in the system-level design reviews and in the functional testing, which implies a transfer of both tacit and explicit knowledge. The firm has thus a portfolio of relationships.

When indirect knowledge sources are discussed, the local person network around Kalix Electropolis Ab is important. The key persons form an informal community exchanging also tacit knowledge in a fully networked relationship. Additionally, LTU has become important especially as a research partner and a source of personnel.

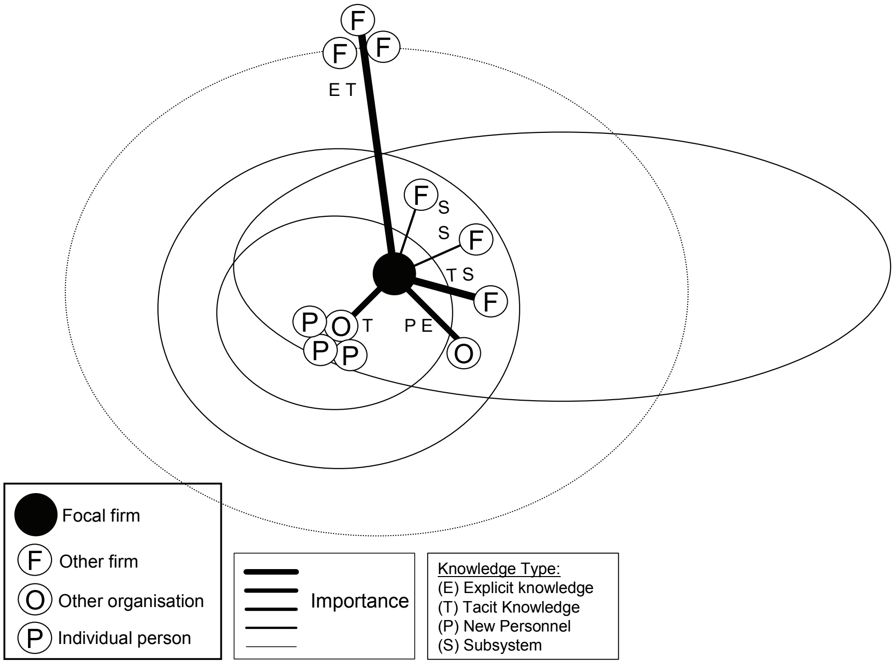


Fig. 53. Case E1, innovation network in the case process.

Case E2

Case E2 is a long term radical product development project that was run as a series of projects, and managed as projects. The product was the firm's first, and the process was not yet defined, according to what the interview implies. The concept development is equal to phase 1 in the model, and lasted for several years. The product development stage includes phase 2 to 4 in the model: system-level design; detail design; and testing and refinement. Production – phase 5 – was started while product development was still going on. Refinement – phase 4 – has been conducted continuously after the product was in sale.

The process is very long, involves several subprojects, and does not follow the model. Parts of the planning phase has been done in forehand, and has obviously been conducted through the years. The concept development stage equals the model, but the product development stage involves several of the model's phases. Production was started parallel to the product development phase, and refinement is a continuous process.

The firm itself is the source of the product idea. It reviews the development of the market and the enabling technologies, and forms a view of what should be done. The idea was tested with customers, one of which is international and committed to the development process. The concept development and the system-level design were conducted in collaboration with the key customer, who was the main external source of tacit and explicit knowledge. The dyadic relationship is based on strong personal links and adaptation.

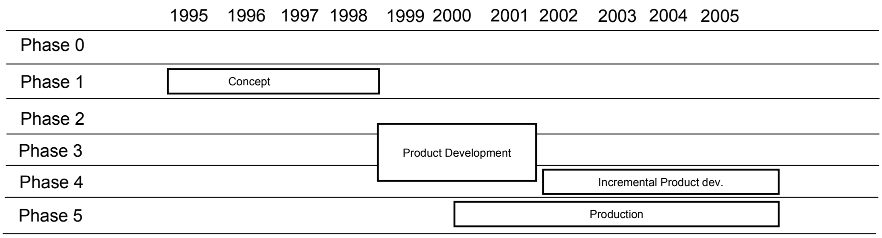


Fig. 54. Product development process in case E2.

In the detail-design phase the main sources of knowledge were a national component supplier with explicit knowledge, a regional subcontractor with tacit and explicit DFM knowledge, a foreign firm with subsystems, and on a regional level LTU providing new personnel. Functional testing was supported by tacit knowledge from the key customer. In all the relationships the personal links have a key role, and they are all dyadic.

With regard to indirect knowledge sources, the local social capital and network around Kalix Electropolis Ab have become very important in the last years in the refinement and further development of the product.

The key customer was very involved from the idea screening to the system-level design, and again in testing and refinement. The commitment was high, and the relationship was based on strong personal links. A subsystem provider was used as a source of DFM knowledge in a dyadic relation. In recent years the local social capital has helped develop an informal community of practice. Each of the knowledge transfer relationships has been built on strong personal links.

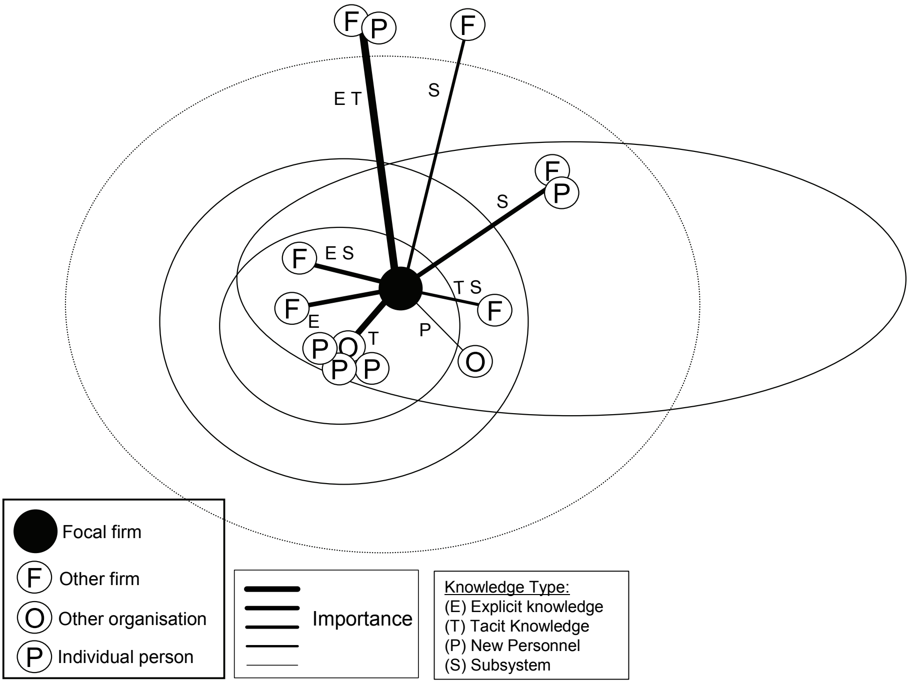


Fig. 55. Case E2, innovation network in the case process.

Case E3

In *case E3* the process started with a prestudy of alternative solutions, price evaluation, and technology and component choice. The stage equals phase 0, planning, in the Ulrich-Eppinger model. This stage was followed by a decision to continue. The concept development stage started while the previous stage was still going on, and system-level design started when the pre-study ended. Detail-design started when concept development ended although system-level design was still going on. At the time of the interview the last stages – testing and refinement, and production ramp-up – had not yet been started.

The process stages are quite exactly the same as the phases in the Ulrich-Eppinger model, but the timing differs. Unlike in the model, the stages are not sequential but overlapping. As the main feature, phases 2 and 3 are parallel.

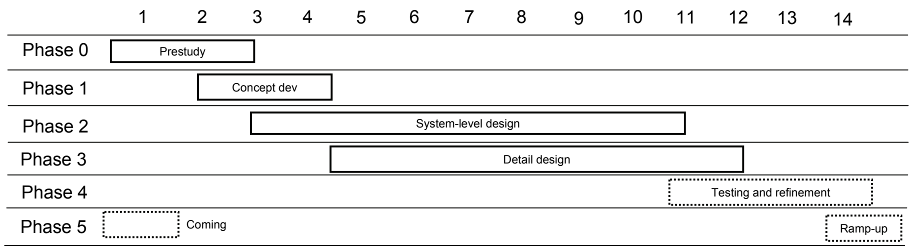


Fig. 56. Product development process in case E3.

The source of the idea can not be exactly defined: it is a result of long term interaction between the two firms' key persons within Kalix Electropolis Ab's activities, mainly board meetings. It is the result of knowledge exchange between persons with strong personal ties, and continuous observation of the business environment. When the time was right, the idea was tested with the final customers.

In the prestudy stage – or planning phase – the customer, and component providers, were the main external knowledge sources. The concept was developed in a dyadic collaboration with the customer, while in the system-level design the suppliers' knowledge was also utilised. In detail-design the customer provided both tacit and explicit knowledge, and subsystems for the product. In the testing and refinement phase the customer is the main external source of knowledge.

As indirect knowledge transfer, some student projects have been conducted. The local social network built around Kalix Electropolis Ab is the most important indirect knowledge source.

The project is an outcome of local social networking between the key persons in the firms. The project itself was conducted in a very close dyadic collaboration between the two firms.

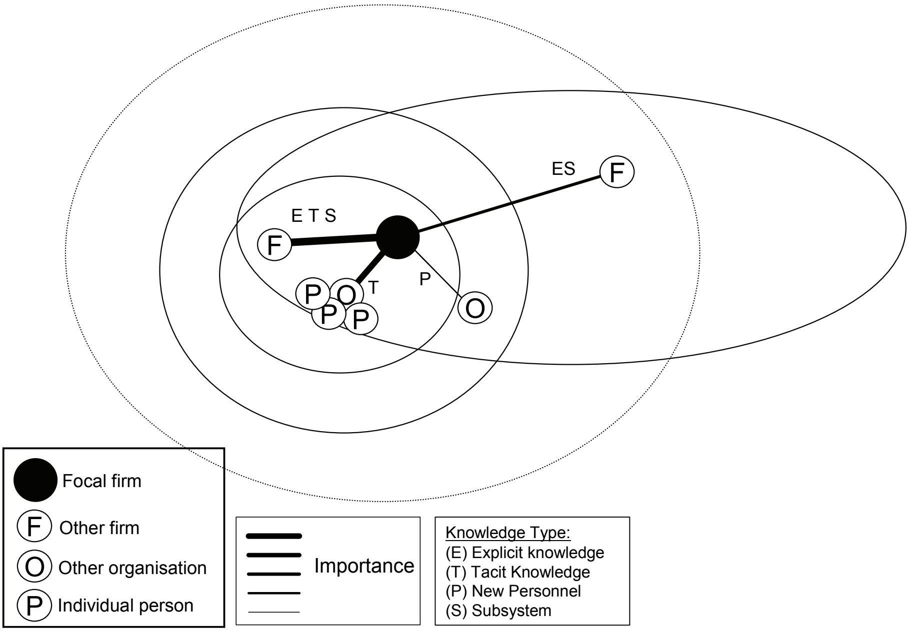


Fig. 57. Case E3, innovation network in the case process.

Case E4

The process in *case E4* is a customer specific product development project, and the customer uses the product as a subsystem in its own product. Idea screening was conducted by the customer before the focal firm was involved. In the focal firm the process started with a planning stage. After the planning stage concept-development, system-level design, and detail design were started simultaneously so that system-level and detail-design were parallel throughout. Testing and production ramp-up ended the process.

The process closely resembles the Ulrich-Eppinger model with the exception that phases 2 and 3 (system-level design; and detail design) are parallel.

The original idea came from the customer who had tested it with its own customers. The link was brokered to the focal firm by Kalix Electropolis Ab. In the planning phase it also provided the firm *who-knows knowledge* to find partners and suppliers while the need itself is transferred by the customer. Both knowledge flows included explicit and tacit knowledge.

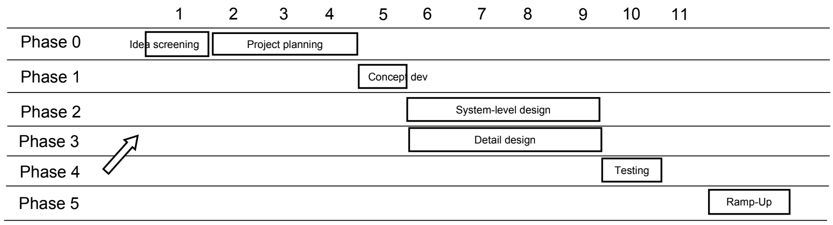


Fig. 58. Product development process in case E4.

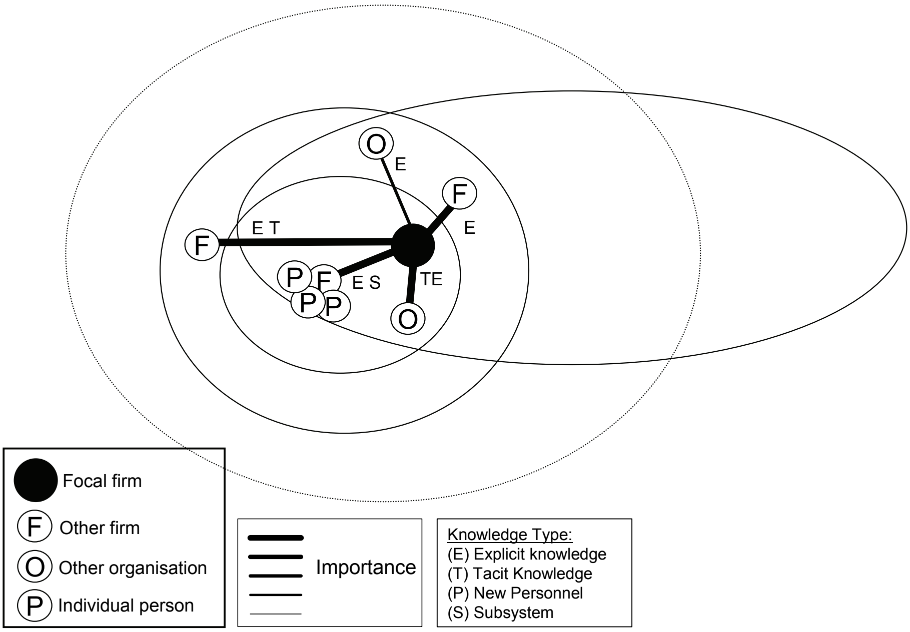


Fig. 59. Case E4, innovation network in the case process.

In the concept development phase one person at LTU transferred both explicit and tacit knowledge. A local firm participated by supplying the engineering design as a subsystem, and a regional firm another part of the design. Both designs represent explicit knowledge.

With regard to indirect knowledge transfer, the role of the social network around Kalix Electropolis Ab is emphasised. It has also a role as a broker and intermediate. The whole process is conducted in a network with dyadic and networked links, and knowledge transfer, which made the project possible. The focal firm itself has adapted its operations extensively to meet the customer needs.

Case E5

In *case E5* the process is several years long. It started with idea screening, followed by concept development. The system-level design stage started in the middle of the concept development stage, and ended at the same time. Detail design was started just after system-level design started, and continued after the system-level design ended. After the feedback from detailed design, some re-planning was done regarding both concept development and system-level design. In the end, testing and production ramp-up stages followed consequently.

The process stages are close to the phases in the Ulrich-Eppinger model, but the timing is different. Instead of being consecutive, concept development and system-level design overlap. The overlap between detail-design and the two previous phases are caused by the need for replanning. The planning phase is named idea screening.

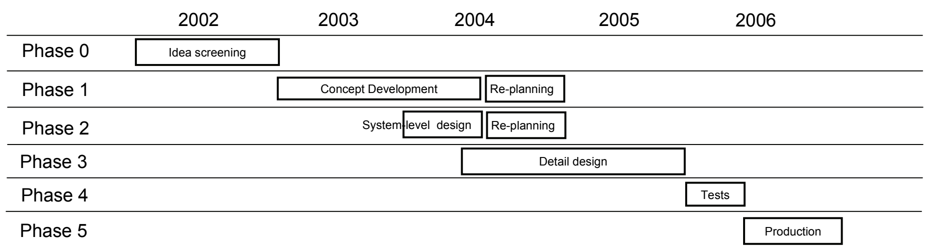


Fig. 60. Product development process in case E5.

The idea for the product was sourced from a Master's thesis at LTU, and the intermediary was Kalix Electropolis Ab. The knowledge was explicit. The product is in a sector that is controlled and standardised by a national level authority, which participated in idea screening, and designed a new national standard to enable the product development. The knowledge transfer with the national authority was bidirectional.

In the idea screening stage – the planning phase – of the process, Kalix Electropolis Ab coordinated a group of local and regional firms to form a network to take charge of the process and – first – to screen the idea and plan the development process. The network is based on a network relationship. One regional and one local firm had major roles in transferring expertise in their own segments both in tacit and explicit form. Additionally a regional production firm transferred DFM knowledge to the project.

In the concept development phase a national association, presenting the end-users, entered the network to transfer tacit knowledge on the usability and features of the product. A national level component provider transferred explicit knowledge but participated in the network actively just for a short period. In the system-level design phase a national level subsystem manufacturer participated in the process to transfer mainly explicit but also tacit knowledge in its special expertise.

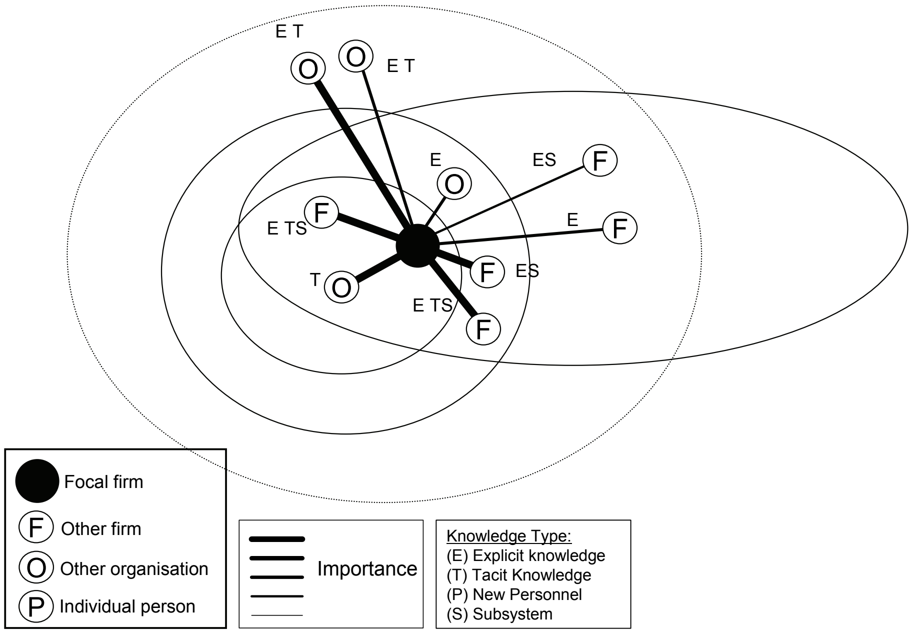


Fig. 61. Case E5, innovation network in the case process.

With regard to indirect knowledge flows, the role of the social network around Kalix Electropolis Ab, and the development firm itself are in central roles. When new staff are needed, the focal firm trains them itself.

As a summary, the case process has two characteristic features: the strong role of the intermediary and coordinator, Kalix Electropolis Ab, the network built to carry out the process, and the networked links between the participants. The main partners are local or regional.

5.3 Cross-case analysis

In the first two Section cross-case analyses are conducted between the product development cases in each of the two technology parksTechnology Parks. The third Section is a cross-case analysis between the cases in the two Technology Parks. In the cross-park analysis the results of the Technology Park cross-case analysis are utilised to study the results against the differences between the parks. Later on – in Section 6.4. – the results will be analysed against the factors defined in the theoretical framwork.

5.3.1 Kemi – Digipolis

None of the product development processes exactly follow the Ulrich-Eppinger model: the names of phases vary, one phase in the model is replaced with several stages in the process; one stage in a case can involve parts of two phases in the model; and often the phases are parallel. There is also some variation in the order of the phases. The large firms use their own well defined processes. When customer specific development processes are concerned, the small and medium sized firms usually use their customers' processes.

A joint feature to all but one of the six interviewed cases is that the business units are not independent, but supervised from other locations – even though two of the units officially are the main offices of the firms. The only fully independent one is a micro-sized private firm. One of the units is – within the firm – responsible for a product line nationally, and another in the north of Finland. The features of the firms and the product development process cases are presented in the Table in Appendix 6.

The units and firms can be divided into two main categories according to their autonomy: *subordinate units*; and *autonomous units*. Units D1, D2, and D5 are subordinate to the same firms' regional offices, while D4 and D6 are autonomous to some degree, and the micro firm D3 is privately owned.

The analysis of the cases (Table 8) shows some similarities between all of the cases. The product ideas originate from the firms themselves either locally, regionally, or internationally; and are based either on firms' earlier products, platforms, or technologies. From the focal units' point of view the relationships with the customers are built around intermediaries. The intermediaries of the *subordinate units* and their customer relationships are the firms' other units. The customers belong to the ICT sector, the innovations are incremental, and in two of the three cases regional units manage the product development processes. None of them conducts all of the phases, at least fully, by themselves.

The three more *autonomous units* (D3, D4, D6) manage the product development processes themselves, and use their own processes. Their customers belong to other business sectors. A joint feature is that ideas are screened locally: in one case by the firm, and in two cases by the customers' consultants. D3 is a private micro firm developing a radical innovation for the national market, while the two others tailor platform based products to local customers. The two cases (D4, D6) are very similar with only minor differences.

In most of the cases customer knowledge – both explicit and tacit – is highly valued throughout the process except in detail design, where it is important where prototyping is used. Tool and material knowledge is important in detail-design, and it is transferred either nationally or internationally in every case.

When indirect – in respect to the product development process – knowledge transfer is analysed, the local K-TUAS is the most important source of new personnel for all the units. The three technology oriented subordinate units source research knowledge locally, and two of them also regionally. Additionally two units use the local HEI's testing services, and two others use the training services.

Most of the firms have built local organisational and personal networks only with the local HEI. The two units with local customers, have larger local networks including other firms and industries. They consist of dyadic and portfolio relationships with their customers and suppliers.

Where *subordinate units* are concerned, the results imply that their role within the firms are close to a subcontractor's role. They are technically specialised, and the customer knowledge is mainly used at both ends of the process. Specialised suppliers have an important role in the detail-design phase. A joint feature in the three cases is that they collaborate closely with local HEIs (K-TUAS, and UO) in testing, reliability, and production knowledge.

Excluding the micro-sized independent firm, the two *autonomous units* – developing customised products on platforms – both have local and other customers. They all conduct the development mainly locally. Only small special tasks are outsourced. In their knowledge transfer processes – at least when the studied projects are concerned – the local consultants are important. The role of both the customer and the consultant is high throughout the whole process.

Table 7. The analyses of the cases in Digipolis.

	D1	D2	D5	D3	D4	D6
Unit type (in practice)	Subsidiary	Subsidiary	Subsidiary	Independent	Subsidiary	Subsidiary
Project management	Local	Regional unit	Regional unit	Local	Local	Local
Customers' sector	ICT	ICT	ICT	Other	Other	Other
Process	Customer's	Own	Customer's	Own	Own	Own
Case customer(s)	Regional firm	Internal international unit	Regional firm	National, presented by an association	Local firm	Local firm
Innovation type	Incremental	Incremental	Incremental	Radical	Platform based	Platform based
Product idea based on	Firm's product	Firm's idea	Firm's idea	Firm's idea	Firm's product	Firm's platform
Source of the product idea	Customer	International unit	Firm	Firm	Local customer	Local customer
Transferred knowledge	Explicit, tacit High value	Explicit High value	No external	No external	Explicit High value	Explicit, tacit High value
Customer relationship	Brokered by a regional unit	Brokered by a regional unit	Brokered by a regional unit	Brokered by a business association	Brokered by a local consultant	Brokered by a local consultant
Idea screening: where, who	Regional unit of the firm	International unit of the corporation	Regional unit of the firm	Locally by the firm	Locally by a consultant	Locally by a consultant
Process execution	Local, partly regional	Detail-design partly Testing fully	Ramp-up local	Local	Local	Local
Customer knowledge to phases	0-4	0-1	1-2, 4-5	0-2, 4-5	0, 2-4	0, 2-4
Tool and material knowledge	Tool support, supplier, National Phase 3	Tool support, internal, International Phase 3	Knowledge of materials, suppliers, International Phase 3	Tool support, informal network, National Phase 3	Tool support, supplier, National Phase 3	Tool support, internal, National Phase 3
Research knowledge	Local	Local Regional	Local Regional			
Local HEI	Testing	Testing	Training		Training	
Personnel	Local HEI	Local HEI Regional HEI	Local HEI	Local HEI	Local HEI	Local HEI
Local networks	HEI	HEI	HEI	HEI	HEI, firms, industry	HEI, firms, industry

5.3.2 Kalix – Electropolis

In Electropolis cases none of the product development processes follows the Ulrich-Eppinger model exactly. Like in Digipolis, the phases have different names, one model phase is replaced by several stages in the process, one stage can include parts of two phases, phases can be parallel, and there can also be some variation in the order of the phases. In Electropolis cases the processes are the firms' own: in some cases defined, and in some cases planned as unique projects. In three of the cases (E3, E4, E5) the firms do not conduct all the phases by themselves but some are outsourced to firms having varied and specific expertise. The features of the firms and the product development process cases are presented in the Table in Appendix 7.

A common feature to all the units and firms is that they are relatively independent. Four of the firms are privately owned, in one firm the majority is owned by a venture capital firm, and one is a subsidiary of a national level firm. The subsidiary is responsible fot a product line within the firm.

Dividing the firms into groups, according to local and non-local ownership or autonomy, does not result in any common product development process features within the groups. In cases E1, E2, and E3 the firms base their activities on *engineering design knowledge*, and none of them have their own production facilities. In cases E4 and E5 the firms' main business is *production related*.

The analysis of the cases (Table 9) shows several similarities between all of the cases in Electropolis. They all are independent at least to a certain level, they manage their product development processes by themselves, and utilise their own processes. In most of the cases the customer belongs to another business sector. They all source customer knowledge for concept development, and testing and refining phases. Phases from planning to testing and refinement are conducted locally by the focal firms, even if in most of the cases subcontracting and networking is used. In one case idea screening had already been performed when the idea was transferred to the firm.

In two cases (E4, E5) Kalix Electropolis Ab had an active role as intermediary communicating the product idea to the firms, and in one case (E3) the interaction around Kalix Electropolis Ab led to collaboration between two local firms. Additionally, in all of the cases, local or regional firms are used as knowledge sources. Close collaboration with trusted relations and the transfer of tacit knowledge has been utilised in all cases: in dyadic relationships in three cases (E1, E2, E3); and in networked relation in two cases (E4, E5).

Comparison of the *engineering knowledge firms* elicits some common features among them. The firms are the original sources of the product ideas. They manage the whole process themselves from idea screening to testing and refinement. In all of the cases they have built trusted relationships: in one with a regional firm with engineering knowledge needed in the project; and in the two other cases with customers. All three firms have sourced new personnel from LTU even though it is problematic. LTU has also been their research partner in actual research projects to student projects.

Table 8. The analyses of the cases in Electropolis.

	E1	E2	E3	E4	E5
Unit type (in practice)	Independent	Independent Venture capital majority	Independent	Subsidiary, relatively independent	Independent
Project management	Local	Local	Local	Local	Local
Customers' sector	Other	Other	ICT	Other	Other
Process	Own	Own	Own	Own	Own
Case customer(s)	National and international	International	Local	Regional	National
Innovation type	Radical	Radical	Incremental	Radical	Incremental
Product idea based on	Firm's idea	Firm's idea	Firm and customer interaction in long relationship	Customer	Research
Source of the product idea	Firm	Firm	Customer	Customer	Research
Transferred knowledge	No external	No external	Tacit, explicit	Explicit, tacit	Explicit
Customer relationship	-	-	Network built around Electropolis	Brokered by Electropolis Ab networked project	Brokered by Electropolis Ab networked project
Idea screening: where, who	Locally by the firm	Locally by the firm	Locally by the firm	Regionally by the customer	Locally by a network
Process execution	Local, partly regional subcontracting from a partner, subcontracting in production	Local, subcontracting in production	Local, no production	Local, partly regional production not started	Local, partly regional and national subcontracting, partly subcontracting in production
Customer knowledge in phases	0-2, 4	1-2, 4	1-4	1-4	1-4
Tool and material knowledge	-	Tool support, supplier, National Phases 2-3	Tool support, supplier, National Phase 2	-	Tool support, supplier, National Phase 2
Local knowledge sourcing	-	-	Customer	Firm Electropolis	Local firm Electropolis
Personnel	Regional HEI	Regional HEI	Regional HEI	Regional HEI	Regional HEI
Local networks	Firm network	Firm network	Firm network	Firm network	Firm network

Comparison of the *production related* firms leads to some common findings that are specific to them. In both of the cases the product idea is external, and the ideas were intermediated by Kalix Electropolis Ab. Idea screening was at least partly conducted beforehand, and Kalix Electropolis Ab was used as a knowledge source in the planning phase. The firms implement the product development project in networks of several actors, and their final goal is to have new products produced. Both in production and product development, tasks and subsystems demanding some special knowledge are outsourced. When new skilled personnel is concerned, in-house training is used.

In all of the cases, customers or end-users are important knowledge sources in concept and system-level design, and again in functional testing. The customers belong typically to different business sectors to the focal firms, and are often geographically located on national or international level. The development projects are conducted independently using the firms' own processes, and the phases from concept development to testing and refinement are conducted locally. Local or regional partners are used for design tasks in system-level and detail design phases. The local level knowledge transfer amongst the firms is very usual.

5.3.3 Cross-park analysis

Table 10 presents a summary of the main differences and similarities between all cases in both of the Technology Parks.

None of the innovation processes in the explored cases in the two Technology Parks follows the Ulrich-Eppinger model exactly which is used as a reference in this study. There are differences in the order and the content of the phases. Larger firms tend to have standardised processes which they utilise in every case. When medium sized firms conduct customised product development, they tend to apply the customers' processes when large firms are concerned. Smaller firms utilise their own processes – even if they are not standardised – both when they are developing their own product or a customer specific product or subsystem.

When the firms in Digipolis and Electropolis are compared, the firms in Electropolis are more independent. Four of the six case-firms in Digipolis were originally independent local firms while the rest two were owned by Finnish corporations. During the years the ownerships have changed. At the time of the interviews one was owned by a foreign corporation, three were owned by units of national corporations, one was in practice a unit of a regional firm, and one was a privately owned local firm. After the interviews some further changes have occurred. Also the strategies change. For example, one production firm with its own product development has focused completely on subcontracting the process, including the product development, to its production customers.

Table 9. Summary of differences and similarities between the cases.

FIRM FEATURE	D1	D2	D3	D4	D5	D6	E1	E2	E3	E4	E5
Official domicile in park		X	X		X		X	X	X		X
In reality a subsidiary	X	X		X	X	X				X	
Customer's sector same	X	X			X						
Customers in own sector	X	X		X	X					X	X
THE CASE PROCESS											
Managed elsewhere		X			X						
Customer's process	X				X						
External idea										X	X
Customers brokered	X	X	X	X	X	X				X	X
Idea screened in the unit			X				X	X	X		
Planning phase in the unit	X		X	X		X	X	X	X	X	X
Concept development in the unit	X		X	X		X	X	X	X	X	X
Concept origin in the firm's earlier products	X	X		X	X	X					
Customer collaborates in concept development with the unit	X		X		X		X	X	X	X	X
System-level design in the unit	X	.	X	X		X	X	X	X	X	X
Detail-design in the unit	X		X	X		X	X	X	X	X	X
Testing in the unit	X	X	X	X		X	X	X	X	X	X
Ramp-up in the unit			-	-	X	-	X		-	X	X
Research collaboration											
locally	X	X			X						
regionally	X	X			X		X	X	X		

X: Valid, - Not done

With regard to the five case firms in Electropolis, three of them have been founded and based on the activities of a firm that had gone bankrupt earlier, the fourth one is based on an outsourced department of another firm, and the fifth one has been set up without any earlier base. Also in Electropolis, changes have occurred: the majority of the fifth case company is now owned by a venture capital firm, and one of the three firms founded on the remains of earlier firms is now a unit of a national private firm.

To be able to conduct the cross-park analysis of the firms' development process cases, the first task is to exclude the influence of other factors: to identify similarities between the firms, and their product development and – especially – knowledge transfer processes. The only common feature in all the 11 product development cases is that a customer or its representative has an important role in functional testing, and someone – not always the unit – has screened the idea with at least one customer. From this fact it can be concluded that it does not matter where a firm adopts a product idea from, how it develops it into a product, or how it produces it. The most important thing is to make sure that the functions satisfy the customers. On the other hand, the analysis illustrates differentials in how the two Technology Parks function. To identify the influence of these factors, the similarities and differences between the cases have to be identified first.

One subgroup of firms, present in both Technology Parks, is *production related firms*. There are three of them: D5, E4 and E5. D5 and E4 are in practice subsidiaries, even though D5 is officially the main office of the firm. E4 is almost as independent as an independent firm, while in case D5 the process is managed – and mainly realised – by a regional unit. E5 is a local private firm. A common feature is that the relationships with the customers are brokered in all three cases: in D5 by the firm's regional unit, and in cases E4 and E5 by Kalix Electropolis Ab. All three were given the task after the product idea had already been screened. Unlike the others, D5 participates in the process mainly from prototyping in the detail-design phase to production ramp-up phase. The others, on the other hand, have outsourced major parts of the development phases.

In cases D3, E1, E2, and E3 each of the firms has chosen *a specific market segment, and a constellation of technologies*. The firms are all *local firms* having all their activities in the respective Technology Parks; and the product ideas are the firms' own or – at least – the firm has actively participated in the idea generation (E3). In all four cases the products use new technologies for known needs which have earlier been satisfied in other ways. In the idea screening phase, the firms tested the ideas with one or several key customers or specific organisations in the business sector. The collaboration continued through all the process phases. The three larger ones used subcontractors to transfer special knowledge, while the smallest one utilised social networks among similar firms. The detail design phase was conducted mainly independently, but whenever necessary they collaborated with other firms or organisations. Most of the technical testing was conducted internally. New personnel has been sourced from the closest universities (LTU or K-TUAS), with which they also collaborate in research. The key persons in the firms in Electropolis belong to the social network, while the key persons in Digipolis firms participate in various informal, geographically larger, social networks, and have almost no local social links to the Technology Park. All the existing links are used for informal knowledge transfer.

Four cases – D4, D6, E4, and E5 – used *intermediated projecst:* by consultants in cases D4 and D6; and Kalix Electropolis Ab in cases E4 and E5. As their main business two units (D4, D6) customise platforms for their customers, one (E4) focuses on customer specialised manufacturing projects and some development tasks within them, and one (E5) is specialised in service and preparation but conducts also some specialised production. In the studied cases all the firms conducted product development projects.

In all four cases, the ideas were screened before they were transferred to the firms. Three of the firms acquired special knowledge in the form of sub-systems. In two of the cases some official sources were used to ensure that the product complies with regulations. Customers' or their representatives' knowledge was used throughout the processes, as well as the intermediaries' knowledge to some degree: in D4 and D6 their role was high throughout the process; while in cases E4 and E5 it decreased after the front end. A common feature to all the four processes is that the local firms' role as knowledge sources was higher than on average in the studied cases. None of the units collaborate with research organisations.

In six cases (D1, D2, D5, E1, E2, and E3) the firms' business is based on *engineering competence*. In the Electropolis cases, the firms are independent and local, while the units in Digipolis are in reality subsidiaries although two of the firms are registered in Kemi. Four of the units develop mainly devices (E1, E2, E3, and D1), and two subsystems either two larger market or customer needs (D2 and D5). In all the cases, the product ideas were internal eventhough not from the local unit. In the Electropolis cases, the ideas were developed locally, while in the Digipolis cases they were transferred from regional or international units. Because of the distribution of work within the firms, the units in Digipolis do not conduct all the process phases themselves. The main similarity in knowledge transfer is the important role of tools, components, and material suppliers, and that all the units collaborate in research with the closest HEIs. A major difference is in the subordinate role of two units in Digipolis (D2, D5): the processes are managed externally; most of the development is conducted in regional units; and the relationship with customers is intermediated by the regional units. Another major difference is the important role the social capital in Electropolis has in knowledge transfer.

When the analyses were conducted between the cases in the two Technology Parks, more similarities within the groups were found. In the following the similarities and differences are analysed by comparing the implementation of each product development process phase between the firms and Technology Parks.

When the *firm features* (Table 10) are compared, D1, D2 and D5 differ from all of the others. They are managed from other locations and cannot make independent decisions, and they do not conduct all the development phases by themselves. In D2 and D5 the product development process is also managed externally. In D5 the unit does not participate at all in the first phases before detailed design, where it has a role in prototyping. D1, D2 and D5 do not manage the customer relations independently but get their development projects from the other departments of the respective firms. The other eight firms and units are relatively independent and thus similar to each other in this respect.

In the *idea screening phase*, there are clearly two groups: D3, E1, E2, and E3 have themselves done the screening, while the others have taken a readily screened idea from their customers, other units within the focal firms, or from research. As mentioned before, the units in cases D1 and D2 taket the projects from the firms' other units, and in case D5 the unit comes into the project at a later stage. The case projects D4 and D6 are conducted in the forest industry sector, where the use of consultants to do the specifications is commonplace. In cases E4 and E5 the firms' basic business is to manufacture products or produce product-related services for other firms. The case projects came via intermediaries. In all the cases the original source of knowledge – used in screening – is the customer, and in three cases several customers. Only in cases E1, E2, E3, and D5, where the product is really generic and the firms are independent, all the knowledge is transferred directly from the customers to the unit. In these cases tacit knowledge is also transferred, and the relationship develops on an inter-personal, social level. One of the ideas was the result of long time social interaction between the key persons and thus a consequence of the local social capital.

In the next step, *planning phase*, the firms' and units' own roles increased. Only in case D5, where most of the design was conducted outside of the unit, the local unit did not participate in the planning phase at all. In case D2 the local unit participated in the planning phase but did not own it, and in the rest of the cases the local units implemented the planning phase. In the planning phase the customers are important knowledge sources in all cases, either directly or through intermediaries (D3, D4, D6, E4, E5). Intermediaries were involved in cases where consultants were utilised by the customers (D4, D6), Kalix Electropolis Ab acted as intermediary for an idea (E4, E5), or the end-users were represented by their national associations (E5, D3). In the planning phase mainly explicit knowledge has been transferred but – concluded from the data – in the nine cases in which the local units were in central roles, tacit knowledge was also transferred.

Where the *concept development phase* is concerned, all the units – except in cases D5 and D2 – have conducted the phase totally or partly. In D2 the concept was designed in an international unit, and in D5 in a regional unit. In two cases (D4, D6) the concept was based on the units' earlier products. The seven other units used customer or end-user knowledge. In two cases (E5, D3) the customers were represented by associations who know the needs, and also tacit knowledge was transferred. In cases E2 and E3 – where a strong personal trust with the customer existed – both tacit and explicit knowledge was transferred. In cases E1 and D1 there was an earlier agreement on the division of work: in case D1 with an internal unit; and with an external partner firm in E1 – some parts of the concept development were done externally, and explicit knowledge was transferred to the concept development phase. In cases E4, E5, and D3 the product was such that the firms did not master all the knowledge needed, and because of it some specific knowledge was transferred to the firms. The problem was solved by forming a network to transfer the knowledge, of which some is purely technical (explicit or subsystems), and some both tacit and explicit non-technical. The transfer itself occurred in dyadic relationships.

In the *system-level design phase* – which some of the firms classified as a part of the detail design phase – the direct or intermediated customer knowledge was essential in 7 of the 9 cases. In the two cases with forest industries as customers (D4, D6) the consultants participated in the process – beside the customers – transferring knowledge of the customers' analysed needs. In cases E5 and D6 the authorities were consulted for knowledge on regulations. In cases E1, D1 and D2 strategic and internal partners continued in the process. In addition to the earlier phases, the suppliers' knowledge about tools, equipment, components, and material from both national and international level was applied (D1, D2, D4, D5, D6, E2, E3, E5). The knowledge they transferred was mainly explicit.

In the *detail design phase* the knowledge sources were mainly the same as in system-level design. In this phase also the unit in case D5 participated in the process. The type of transferred knowledge changed while the external actors started to develop subsystems (D1, D6, E1, E2, E3, E4, E5). The units that did not source subsystems were in the software business (D3, D4), or produced specialised components (D2, D5). This implies that all the knowledge needed in this phase was part of their core capability.

The *testing and refinement phase* was conducted fully locally in all cases, except in D5 in which the regional unit conducts the major part of the work. As discussed earlier, the customers are the main source of knowledge in functional testing. The knowledge involves in most cases both tacit and explicit knowledge while the feedback from technical testing was explicit. Parts of the technical testing were outsourced (D2, E1, E3, E4) especially when some specific equipment was needed.

The production ramp-up phase differs a lot between the cases. In some cases there is no physical product to be ramped up (D3, D4, D6, E3), in some cases the production is outsourced (D1,E1, E2), while some of the firms are specialised in production (D2, D5, E4, E5) even though the production site is elsewhere (D2). In this phase some physical subsystems were ordered in several cases (D1, D6, E1, E2, E4, E5) both regionally, nationally and internationally.

Where – from the case projects' point of view – *indirect knowledge* sources are concerned, there are differences between the cases. As discussed earlier, the engineering competence based firms collaborate with the closest HEIs (D1, D2, D5, E1, E2, E3). Additionally D3 has later started collaboration with K-TUAS. Some firms collaborate with several universities and research institutes regionally (D2, D5,E1, E2, E3) or internationally (D1, D2, E1, E2). The international links are typically quite weak.

New *skilled personnel* was said to be of high importance. For the units the closest HEIs are the most important sources (D1, D2, D3, D4, D5, D6, E1, E2, E3). The two production-related firms utilise mainly in-house training (E4, E5).

Various types of *networks* and more or less official or unofficial communities of practice – or similar structures – are utilised. For the firms and units in Kalix the most important and active network is the one built around the Kalix Electropolis Ab, that has developed the local social networks to a level where tacit knowledge is transferred between the firms. In one case an idea for a new subsystem, enabling a new feature for an existing product (E3), was created in such interaction. The firms in Digipolis participate in official and unofficial separate networks. The difference is that the networks, the firms in Digipolis, participate to transfer knowledge mainly between the employees and to solve acute problems, while the network in Kalix functions between the key-persons and transfers knowledge they can utilise in longterm development.

5.4 Cross-case analysis against the framework

Based on the literature review, the role of the four factors affecting knowledge transfer from and through a local innovation system was discussed earlier in Section 2.7. Implications from the theory. The relevant factors are the innovation system, social capital, knowledge needs in firms' innovation processes, and organisational networking. In the following sections the role of these factors is analysed by each of the sub-questions, and in summary the Section 5 answers research question 2.

5.4.1 Innovation systems as a knowledge transfer enabler

> *Sub-question 1: What is the role of the local innovation system in enabling knowledge transfer to firms' product development processes in small Technology Parks?*

As seen in Section 5.1.3, Electropolis activities are based on the incubation strategy, while in Digipolis both the incubation and attraction strategies are utilised. Two thirds of the case firms in Electropolis are locally owned, while in Digipolis the number is 12 out of 30, even though 13 of the firms have originally been founded with the help of the local incubator and the total number has thus been higher. During the years, some firms in both of the Technology Parks have merged with non-local firms that have their management elsewhere: in the region, elsewhere in the country, or even abroad.

The attraction strategy, and the development in the firm ownerships are the reasons why three of the studied firms and units in Digipolis lack independence in conducting innovation processes, and choosing what knowledge is transferred and from where. Two other subsidiaries in Digipolis are located there mainly because of the recruitment base – even if they have some local customers, too. These units focus on customising product platforms, while the generic product development is conducted elsewhere. In these five cases most of the core knowledge is transferred from other locations mainly within the firms' boundaries.

According to the literature, other firms in an innovation system are important knowledge sources for firms' innovation processes, and this study confirms the argument. In Digipolis the firms serving process industries have both local and non-local customers. This is true in two of the six interviewed cases, and in 13 of the 30 firms in the Technology Park. In all of these cases the firms supply either customised applications or services, instead of generic products. In Electropolis the firms have local customers in cases where one of the focal firms develops subsystems for another. In both local innovation systems some customer knowledge is available locally but most of it is transferred from other locations.

When equipment, material, component, and subsystem suppliers are concerned, only some subsystems are transferred locally. Local rivalry is said to enable mutual knowledge transfer. In Electropolis there is some rivalry – in Digipolis almost none – but they do not transfer knowledge mutually, nor participate in the same research programmes. In training and knowledge transfer from suppliers, some collaboration is apparent.

Neither of the two Technology Parks has any anchor tenant that would challenge the firms to innovate in response to demand. In Kemi the process industries have the role especially where services are concerned.

The evidence shows that there are some alliances, but no longterm ones locally. In Electropolis there are projects where local partnerships and outsourcing are utilised to create local knowledge transfer processes: in one case the knowledge is transferred in tacit and explicit form, while in some others mainly the subsystems are transferred. The first one extends the firms' knowledge base while in the latter ones the knowledge is transferred to single products but not to the firm and its employees.

The role of knowledge intensive business services and other intermediaries is to intermediate knowledge and information, as well as to influence the structures and dynamics of the system (Smedlund *et al* 2005, Howells 2006, Coombs *et al* 2003). Both in Kalix and Kemi the development firms have intermediary functions. The first one searches actively for new knowledge about needs and potential, and transfers it to the firms. Also when who-knows knowledge is needed, the development firm assists in finding it. Kemin Digipolis Oy works in a different way: the goal is to assist other actors (e.g. research, incubator) to transfer and create knowledge for the firms, to participate in networks to enable knowledge transfer from other sites, and to market the Technology Park. Its role is mainly to influence the structures and dynamics of the system.

A big difference between the two local innovation systems is in local higher education and research. In Digipolis there is the technology department of Kemi-Tornio University of Applied Sciences, and Meri-Lappi Institute's Technology Unit – a department of the University of Oulu. K-TUAS confers Bachelor degrees in Engineering, and both of them conduct applied research in collaboration with each other. Many of the units and firms in Digipolis are dependent on the recruitment base of K-TUAS, and some have located in Digipolis because of it. In research, both of the organisations seek needs from the firms while, at the same time, focusing on certain chosen research areas, and thus they cannot directly respond to all the needs. External research organisations are used to complement the service.

There are relatively more internal links inside the local innovation systems in Electropolis than in Digipolis. In Electropolis the links exist among the firms, and between the firms and Kalix Electropolis Ab. In Digipolis links among the firms are rare which hinders the knowledge transfer between them, and the links between the firms and Kemin Digipolis Oy are of a different type: it does not have an active role in responding to immediate needs. On the other hand, one third of the firms collaborate with local research units, and most of them have some kind of interaction with education.

The links and interaction indicate that Digipolis as a local innovation system is a part of the regional innovation system of Oulu, and consequently Electropolis is a part of the Norrbotten's regional innovation system. Both have links to national and international levels as well. Electropolis is clearly a part of the sectoral innovation system in ICT, even though the firms sell mainly to other sectors. In Kemi the firms belong to two sectoral innovation systems: the process industry, and ICT. The local innovation system in Kalix is closer to a small cluster eventhough there is a lack in factor conditions in research and education. Because of this it is a part of the ICT cluster in Norrbotten. In Kemi the firms serving process industries belong to a local process industry cluster together with the pulp, paper, and steel industries in the Kemi-Tornio region. The ICT sector in Digipolis does not have the features of a cluster.

When Triple-Helix analysis is applied, the local innovation system analyses and the firms' innovation process analyses together evidence that the intensity of interaction among firms in Electropolis is high, as well as among the process industry related firms in Digipolis. However, among the ICT firms in Digipolis it is low.

Openness between the authorities – including the development firms representing the municipalities – and the firms is relatively high in Electropolis and also in Digipolis in the ICT sector. Between the process industry related firms and the authorities, it is lower.

In Electropolis the academic element does not exist, while in Digipolis its interaction it is relatively high with regard to the ICT firms, and growing among the industry related firms; and at a high level with the authorities. The linkage mechanisms between the spheres exist in both innovation systems. The maturity level of the innovation space is relatively high in Digipolis, but in Electropolis the academic sphere is missing locally. The consensus space is well developed in Electropolis, but the gaps in the links between firms makes it lower in Digipolis.

In Electropolis realising goals and experimenting is on a high level. Local venture capital is missing but, to some extent, it is replaced by project financing. Even with these gaps, the innovation space is well developed.

In Digipolis experimenting is low outside the research, and no venture capital is available except as project financing. The innovation space is still quite well developed.

From a knowledge transfer point of view, the two local innovation systems are quite different. The strengths of Electropolis in Kalix are:

- the firms are mainly locally managed, and thus implement their own product development processes,
- interaction between firms is intensive, enabling mutual knowledge transfer, and the creation of new ideas;
- local partnerships and outsourcing are common factors enabling knowledge transfer;
- Kalix Electropolis Ab is active in seeking the firms' needs and, on the other hand, in searching for new product ideas and new knowledge from outside the local innovation system.

In terms of the weaknesses in Electropolis, the most important ones are:

- there are no local customers – except on a small scale within some projects between the firms – to facilitate the knowledge transfer from key customers to the firms' product development processes, and to have the role of sophisticated local customers (Porter 1991);
- there is no local higher education or research and the knowledge and new highly educated personnel has to be found elsewhere, which is problematic.

In the local innovation system in Digipolis in Kemi, the strengths in knowledge transfer to product development are:

- because many of the units are owned by larger firms, they have good links to knowledge from other locations e.g. within the regional and national innovations systems;

- many of the firms have local customers in proximity which fosters the transfer of customers' knowedge;
- Kemin Digipolis Oy is an active participant in joint development projects and thus fosters knowledge transfer;
- local higher education and research institutions serve the firms with new personnel and research knowledge;
- good links with actors in the Oulu region enable knowledge transfer from a regional level.

The major weaknesses hindering knowledge transfer in the local innovation system in Digipolis are:

- many of the firms are managed from other locations, often only parts of the product development processes are conducted locally, and the firms lack independence to make decision making, which together mean that the units do not transfer knowledge to or from the local innovation system;
- interaction between the firms is low which hinders mutual knowledge transfer between the firms.

In summary, in Electropolis the firms' independence enables intensive knowledge transfer between the firms in several modes: tacit knowledge, explicit knowledge, and subsystems. Kalix Electropolis Ab is an active intermediary in transferring knowledge from actors in another location. The lack of a local HEI and customers forces the firms to transfer research knowledge from other locations, and makes it difficult to find new experts.

As a result of the attraction strategy and local supply of skilled personnel, many of the firms and units in Digipolis are subsidiaries which enables knowledge transfer from other locations but diminishes local knowledge transfer. Kemin Digipolis Oy fosters networking and knowledge transfer with the help of projects, and by partially financing research and development projects. The local higher education and research enable knowledge transfer and creation locally, and supplies the firms' product development processes with new skilled personnel.

5.4.2 Social capital as a knowledge transfer enabler

Sub-question 2: What is the role of social capital in enabling knowledge transfer to firms' product development processes in small Technology Parks?

In Electropolis many of the key persons have earlier worked as colleagues in the same firm, and they live in the same small town. Both facts support the creation, existence, and development of social networks. After the bankruptcies and increase in the number of firms, the ties weakened. They were strengthened again through measures taken by Kalix Electropolis Ab: by forming its board of firms' key persons, arranging mutual training and other events, and brokering new customers and opportunities with other firms.

In Digipolis the key persons have different backgrounds, and many of them live – and have always lived – in other locations. The social networks among the firms' management and personnel are poorly developed. Some actions have been taken but the results have not been as successful as in Electropolis. There are even so personal relationships between the research and firms.

The key persons in Digipolis have – because of the ownerships and residences – social networks on a regional level, while in Electropolis they have been fostered and created by Kalix Electropolis Ab during the last few years.

When the firms' product development processes in Electropolis were analysed, it was found that often the ties to key customers' key personnel developed close to the level of personal relationships. In Digipolis the same phenomenon was not found. The knowledge transfer analysis shows that in the Electropolis cases, tacit knowledge was transferred more frequently than in the Digipolis cases, which can lead to the conclusion that by developing personal ties the possibility to transfer tacit knowledge is improved.

The strength in Electropolis is the well developed local social networking enabling interorganisational knowledge transfer including also tacit knowledge, and the tendency to develop customer relationships on a personal level to foster trust and knowledge transfer. A weakness is in the small number of personal ties with the research communities.

In Digipolis the strengths are the geographically wider social networks, and local ties between the firms and research personnel. A weakness is in the lack of local social networks between key persons in the firms.

Both cases show that the local social networks easily disintegrate, but it can be fostered by promoting mutual work towards mutual goals, that foster businesses.

5.4.3 Knowledge needs in product development processes

> *Sub-question 3: What kind of knowledge is needed in the various phases of firms' product development processes in small Technology Parks?*

As mentioned earlier in the cross-case analysis, none of the product development processes in the explored cases follows the Ulrich-Eppinger model exactly, which is used as a reference in this study. The larger firms follow their own processes, SMEs utilise customers' processes when large firms are concerned, and the smaller ones utilise their own often non-standardised models. Subordinates with a low level of independence, do not usually own all the process phases, but some of them are performed other units, and the process is managed externally as well.

The characteristics of a firm were found to affect the kind of external knowledge needed in the product development process. In *production related firms*, the first process phases were usually conducted before the firm or unit was involved. In the concept and detail-design phases external knowledge was needed in the form of subsystems and sub-designs. Because the firms' or units' own expertise was mainly focused on production, the screened product idea and most of the design were transferred to the firms.

Local firms with a specific market segment and a constellation of technological capabilities were independent in conducting product development processes. The case projects were based on the firms' own capabilities in specific technologies, which they used to develop new products or subsystems that replaced existing ones. The products were based on the firms' own ideas which they had tested with customers. When some specific knowledge was needed, it was transferred to the process either as explicit knowledge or subsystems from various geographic levels. Component and tool suppliers' knowledge, as well as subsystems and designs, were needed in system-level and detail design phases, and customer knowledge in the testing and refinement phase – especially in functional testing.

In the cases where the idea was *intermediated* to the firm or the unit, the idea was transferred when it had already been screened. Knowledge intermediaries had an important role through the whole process, and local firms had a high value as knowledge sources. In these cases the goal was customisation, and both tacit and explicit knowledge, and subsystems were transferred through the whole product development process.

In cases where the business was based on *engineering* competence, the source of the idea depended on the independence of the unit. In the cases in Digipolis the units were subordinate, the product ideas were transferred from higher organisational levels, the processes were in most cases managed from other locations, and major parts of the tasks were conducted in other units. In the Electropolis cases the firms were independent, the product ideas were the firms' own, they managed the processes independently, and they purchased system-level and detail design special tasks that they did not have in their core expertise. Tool, component, and material suppliers on international and national levels were utilised as knowledge sources, and they collaborated with the closest HEIs to source research knowledge.

The knowledge needs in the product development process were not directly dependent on the Technology Park or the structure of the local innovation system, but more on the type of a firm – production, engineering, etc. – and independence of a firm. There are differences in what kind of firms there are in each of the Technology Parks, but between the same kind of firms the differences in the knowledge needs in various product development process phases are small.

5.4.4 Networking and knowledge transfer to product development processes

Sub-question 4: How does interorganisational networking function in knowledge transfer to firms' product development processes in small Technology Parks?

The ownership and independence of a firm or a unit affect interorganisational networking. In Digipolis many of the firms are subsidiaries, and their main knowledge flows are – from the firms' point of view – internal from other units in other locations. When knowledge is needed, the normal choice is to search it first within the firm, and thus from other locations.

In the cases of *production related firms* intermediaries were involved in the relationships with the customers. How the relationships developed further, depended on the independence of a unit. For example, in the subordinate unit in Digipolis, the knowledge was intermediated to the unit, and the relationship did not develop. In the Electropolis cases the links were brokered to the firms in the early phases of the product development processes, and they developed functioning relationships with the customers. They also had networked relationships with firms that supplied subsystems to their product development processes. Most of the suppliers were already members of the same existing organisational and social networks as the firms. In all the cases the firms adapted to the customers' organisations: the firms in Digipolis utilised the customers' processes, and the firms in Electropolis built product development networks to satisfy the needs.

The local firms with a specific market segment and a constellation of technological capabilities had all their own product ideas, and they built dyadic relationships with customers for knowledge transfer. The firms in Electropolis developed these relationships towards social links to enable the transfer of tacit knowledge. They had also dyadic relationships with important suppliers. In one case the firm had a longterm partnership with a regional firm. The key persons in the firms in Electropolis belong to a local social network, described earlier in the context of innovation systems that they utilise for knowledge transfer. In the Digipolis case the personal network is nationwide, but relationships within the local innovation system are rare.

In four cases, the projects were *intermediated* to the firms by external brokers: in two cases in Digipolis by consultants; and in two cases in Electropolis by the development firm Kalix Electropolis Ab. In the cases where consultants were used by the customers, the consultants had a brokering and leading role through the process. In neither of these cases was adaptation necessary. In the two Electropolis cases the intermediary helped to organise an inter-organisational network to conduct the process, and had itself a coordinating role.

In *engineering* firms, the ownerships and firms' internal division of work determined the networking structures. In all the Digipolis cases the subsidiaries' relationships were intermediated by regional units, and locally they collaborated only with the local HEI. The Electropolis cases are the same as in "the local firms with a specific market segment and a constellation of technological capabilities": the relationship with customers and suppliers is well developed and trusted, and the local social network fosters networking.

When networking with indirect knowledge sources is concerned, the firms in Digipolis had a closer relationship with the local HEI than the firms in Electropolis had with the regional HEI, LTU. As a local actor K-TUAS adapted its activities to the needs of the firms in Digipolis, more than regional LTU has adapted its activities to the needs of the Electropolis firms.

In summary, there were differences in organisational networking between the two local innovation systems: in Electropolis the relationships were usually developed towards social inter-personal relationships, and the firms built networks to satisfy the customer needs, while the firms in Digipolis put most of their effort into organisational adaptation – e.g. the use of customer processes, and had a closer relationship with the local research personnel. The differences are based mainly on the intense local social network in Electropolis, the subsidiary role of many of the firms in Digipolis, and the presence of a HEI in Digipolis. In the key-customer relationships, the firms in Electropolis tend to develop these relationships to interpersonal level while in many of the cases in Digipolis the customer relationship was intermediated.

5.4.5 Knowledge transfer to product development processes

Research question 2: How is knowledge transferred from and through the local innovation system to firms' product development processes?

The results of the study in the two small Technology Parks – Digipolis in Kemi; and Electropolis in Kalix – and the local innovation systems around them imply that, at least in these cases, the local innovation system affects the knowledge transfer to firms' product development processes.

In Digipolis there is a local HEI enabling access to new educated employees, and the Technology Park has partially adapted an attraction strategy. As a result, national and international firms have founded subsidiaries, and bought locally and regionally owned SMEs in the ICT sector. The firms' internal networks were found to be the most important ones in knowledge transfer, and most of the knowledge was transferred directly from firms' other units. Most of the ICT firms did not have local customers or suppliers, and the only local links were to education and research. Many of the key-persons lived in other locations which weakened local social networks.

The firms in the process industry cluster had local customers. They recruited personnel mainly among the K-TUAS graduates. The firms' activities consisted mainly of services and platform customisations. Generic product development and other more innovative projects were rare. Among these firms the main knowledge flows were from local and other customers, consultants, and internally from the focal firms' other units. Personal networks were more developed than among the ICT firms, but still not very active.

In Electropolis some firms are local and the rest relatively independent subsidiaries. Many of the firms had been founded on the capabilities that became available when some earlier businesses went bankrupt. There is no local HEI, and the personnel have a background in the earlier firms. This mutual background and Kalix Electropolis Ab's efforts have developed the social networks active. Strong ties, and the intermediation by Kalix Electropolis Ab between the firms and potential customers, have developed the group of firms into a small local cluster. The main knowledge flows came from customers, other local firms, and suppliers. The knowledge transfer among the local firms occurred with the help of the social network with strong personal links, and enabled tacit knowledge transfer as well as mutual creation of new knowledge and new ideas. The focal firms attempted to develop quite strong key-customer ties, especially when firms with own generic products were concerned. The lack of a local HEI made the recruitment of new skilled personnel difficult, and links to research relatively weak.

How and what knowledge is transferred to a firm's product development process, depends on the capabilities the firm has built. The capabilities it has built depends on the choices in basic business: the development of own products; selling product development services to other firms; specialised production; customisation of platforms; unique products or application etc. The independence of a firm, and a unit's role in a larger firm have a major influence on how they utilise the possibilities. If a firm or a unit is a part of a larger firm, it naturally prefers using internal sources in other locations, and often it does not conduct all the phases locally.

The Technology Park and the local innovation system do not influence the needs directly but they affect which types of firms are set up or locate in the Technology Park as described earlier in this chapter.

6 Conclusions

The aim of this chapter is to highlight the main contribution and implications of this study, to evaluate the validity of the study, and to identify avenues for further research.

6.1 Contribution

6.1.1 Theoretical contribution

The literature review confirms that there are not many earlier studies on small Technology Parks. Jauhiainen's study (2006) on the Multipolis network in Northern Finland is one of the rare studies in this area. Its focus is on a regional innovation system level, while in this study the focus is on local innovation systems and firms' internal processes.

Ylinenpää argues that clusters – and Technology Parks – emerge as a result of local and often tacit knowledge that is transformed into marketable products and services. He defines "attraction strategy" and the "incubation strategy" to be the main strategies for a Technology Park. They should not be combined, but either of them may be successful. According to him, the attraction strategy emphasises e.g. the role of the recruitment base. (Ylinenpää 2001b.)

Digipolis has applied to some degree the incubation strategy, but mainly the attraction strategy. Because of that, and several mergers, many of the firms are subsidiaries. New jobs have been created but most of the knowledge is transferred within the firms' boundaries from other locations, and not locally between firms. Electropolis is based mainly on the incubation strategy, and most of the firms are local. Also tacit knowledge is transferred between the firms, and new generic products and services have been developed. As an addition to Ylinenpää's (2001b) findings, the results in this study suggest that even if the attraction strategy is successful in the number of jobs and firms, it can lead to a firm constellation that hinders local knowledge transfer.

According to the literature, intermediaries have significant roles in innovation systems both in knowledge transfer and in influencing the structures and dynamics (Muller & Zenket 2001, Czarnitzki & Spielkamp 2000, Smedlund *et al* 2005, Howells 2006). The role intermediation has on firms' operational level in

Electropolis, and in influencing the structures and dynamics in Digipolis, confirms this as true independently of the level on which it is conducted.

The results confirm also that other firms are of the highest importance for firms product development processes (e.g. von Hippel 1986, Nieminen & Kautonen 2001). This was clearly approved by the results when the number of other firms used as knowledge sources is compared to the total number of sources.

The role of local higher education is emphasised in the literature (Fink 2001, 2003, Moesby 2005, Nieminen & Kautonen 2001), as well as the role of local research (Nieminen & Kaukonen 2001, Leydesdorff & Etzkowitz 1995, Mowery & Bhaven 2005). The results of this study confirm the importance of that role. Many of the firms in Digipolis depend on the K-TUAS in recruitment, and some of them have chosen the location because of it, while firms in Electropolis have difficulties to recruit new highly educated personnel, and all the firms in Digipolis that collaborate with research organisations, do so at least locally.

The maturity and functionality of the local innovation system was analysed using the Triple-Helix model (Leydesdorf & Etzkowitz 1996). According to Leydesdorf *et al* (2006) statistical analysis is needed. In this case study, qualitative analyses were conducted, and they gave results that indicate the maturity and functionality of the innovation system.

Social capital is argued to form the base for networking between organisations (Powell *et al* 2004). Direct ties serve as sources of resources and information, indirect ties as sources of resources and information, and structural holes expand the diversity of information (Ahuja 2000). The highly developed social network with strong ties is one of the most important reasons for the transfer of tacit knowledge among firms in Electropolis. In Digipolis the local social networking is less intense, as well as knowledge transfer among firms. The study corroborates the importance of local social networks in inter-organisational networking and knowledge transfer.

The knowledge needs in the product development process phases differ according to the characteristics of the firms. Production and production related firms do not usually conduct all the phases by themselves because their own area of expertise is production, not product development. Local firms with specific market segments and a constellation of technological capabilities are independent in conducting product development, and use subcontractors and partners when external knowledge is needed. When intermediaries are involved, they have important roles through the whole process. When engineering firms are concerned, knowledge sources depend on their independence. All the firms collaborated in product development, and the knowledge needed in various phases depended on the type and independence of the focal firm. This confirms that firms collaborate in product development to find complementary resources (Littler *et al* 1995, Becker & Dietz 2004, Emden *et al* 2006, Ebersberger & Lehtoranta 2005, von Hippel 2005 etc.).

The simplest model of interorganisational relationship is a dyad, one-to-one relationship with personal ties in essential roles (Halinen & Salmi 2001). Another relationship type is the portfolio one-to-many relationship which can be open or closed depending on whether the firm in the structural hole controls the transfer or not. The closed model is a small network where all participants may be connected to each other. (Ritter *et al* 2004, Andersson *et al* 2007.)

The results of the study show that the three types of relationships exist and are utilised in different situations. When an outsourced task demands continuous transfer of some special knowledge, dyad relationships are used to build a partnership between the two organisations. In Electropolis the ties in the relationships tend to get stronger over time. If the knowledge is easily available from several sources, a portfolio relationship with several competitors is used. In the networked product development cases in Electropolis the relationship structures are closed portfolios, and networks where all the participants are linked with each other. The results, especially from Electropolis, confirm that personal contacts and strong ties count in a dyad relationship, while most of the portfolio relationships are built with actors competing with each other. The product development networks in Electropolis are an exception to this.

Traditionally, when innovation systems and product development processes are studied jointly, the innovation system is used as the research unit. On the other hand, product development processes are studied mainly on firm level, inter-organisational level, and network level but little attention is paid to the influences of innovation systems or social interpersonal networks within it. This study contributes to the theory by combining the two traditions and several theories in one framework for analysing a local innovation system.

6.1.2 Empirical contribution

There are some interesting findings on the role of a local innovation system as a knowledge transfer enabler. Many of the firms have chosen to locate in Digipolis as a joint result of the attraction strategy, and the presence of K-TUAS enabling the access to new educated personnel. Because of this and some mergers, many of the ICT firms are subsidiaries with very few links to other local firms, and almost no local customers. Knowledge is mainly transferred internally from other locations. Also the customer relationship is usually managed and intermediated by another unit, and many of them conduct only some of the development phases themselves. The firm characteristics influence the whole innovation system's innovativeness: proximate external knowledge sources are often critical for innovation. Additionally an organisation's upper level unit has a gatekeeper role in the transfer processes, which weakens the absorptive capacity of local units (Cohen & Levintahl 1990). In practice, subsidiaries do not automatically expand the knowledge space of a local innovation system from the other firms' point of view. Benchmarking of opposite cases could produce some practical knowledge on potential methods to change the present situation.

On the other hand, the knowledge transfer from other internal units, and from K-TUAS in the form of graduates and research, have enabled the firms' departments and subsidiaries to locate in Digipolis, and the units have strong links to the Oulu centred regional innovation system. Thus new subsidiaries create new jobs and wealth.

The other sectoral innovation system, Digipolis belongs to, is related to the local process industries. All the firms have local customers, and thus they acquire customer knowledge locally. This enables the development of new products (Furman *et al* 2002, Porter 1991). Because of most of the firms are subsidiaries, their knowledge is mainly transferred internally. Their roles within the firms' limits are mainly to customise product platforms that have been developed elsewhere, and the existing possibility is not utilised. Again, the benchmarking of opposite cases would be useful for planning future efforts to gain the opposite development.

The presence of K-TUAS gives access to graduates, research results, and some services, and has attracted new firms and subsidiaries to Digipolis. The firms that actively acquire research knowledge locally from K-TUAS, usually collaborate also with regional universities and research institutes. In many of the firms the majority of the personnel are K-TUAS alumni. This confirms the role of local higher education in Digipolis.

In Electropolis there is no local HEI, and the research collaboration intensity is lower. All the interviewed firms had difficulties in finding new skilled employees. The problem has partly been solved by bridging the local innovation system at regional level to LTU, but the interaction with research is lower than in Digipolis. According to the literature, when there is no higher education present, strong links to universities are needed to ensure access to new skilled personnel; and often special measures are needed (Herstad 2003, Andersson & Karlsson 2004). In practice, the benchmarking of similar cases could give some new knowledge on how to develop the links further.

The local innovation system around Electropolis in Kalix has grown around the competence created in earlier firms, and is mainly based on local entrepreneurship, incubation strategy, and strong local ties. Several of the firms are previous departments that have been incorporated. Because the organisations are in fact older than the firms, the weakening effect of the young age of the firms on their absorptive capacity is less than it might seem (see Gray 2006).

The strong ties between key-persons are based on the shared background in the same firms in the same small town. When the firms split into several new ones, the social network at first disintegrated, but it was later raised again through the fostering efforts of Kalix Electropolis Ab. The main effort has been common work towards common goals in the board of Kalix Electropolis Ab. As a result of the strengthening ties in the local social network, the collaboration between firms has developed, and they acquire knowledge from each other, as well as combine and create new knowledge together. In addition the common intent, the common trust, and the similarity of the firms' knowledge bases facilitate the conjunct absorptive capacity (Nieminen 2005, Lane & Lubatkin 1998).

In Digipolis the ties among the key-persons in the firms is quite weak, which is one of the reasons for low interaction among the firms. However, the effect cannot be distinguished from other influencing factors, such as being subordinate to the firms' other units in other locations.

The study shows clearly that social networking and ties among the firms' key-persons can be fostered, and they can disintegrate easily. Strong ties foster mutual transfer, combination, and creation of both tacit and explicit knowledge and subsystems. In Electropolis the firms and their key-persons tend to develop customer relations on a social level which fosters the transfer of tacit knowledge. The study confirms that the social networks and strong ties are enablers of inter-organisational networking and knowledge transfer, and reports and analysis methods that have been successfully used to develop this enabler. The results can be used to improve the social networking in other locations.

In both Technology Parks, intermediaries and brokerage have important roles. Kemi Digipolis Oy has fostered collaboration and networking on the system level, and collaboration within applied research. Kalix Electropolis Ab operates mainly on the operational level of the firms. In addition to the influence on social networks, the brokerage on the business process level of the firms has fostered collaboration between the local firms. The results indicate that business process level intermediation and brokerage can be used to improve knowledge transfer among the firms, while on a system level it can be used to improve knowledge creation and transfer in university-firm collaboration.

6.2 Implications

6.2.1 Theoretical implications

The results of the study suggest that neither research on the innovation system level, research on the firms' innovation process level, nor on the firms' interaction within innovation processes are adequate to explain how, from where, and what type of knowledge is transferred to the product development processes of firms. A framework of analyses was used consisting of enablers (the innovation system, and local social capital), processes (product development process, and interorganisational networking), and the knowledge transfer processes. The study shows that the framework functioned at least in the two local innovation systems. To understand knowledge transfer to the product development processes of firms, research has to be conducted on multiple levels.

A small Technology Park is not an adequate unit to study knowledge transfer as the whole local innovation system has to be explored, as well as links to regional, national, and sectoral innovation systems. Also all significant events in the history of a Technology Park have to be examined because they influence the choices the firms make, and also the social ties and thus the networking and knowledge transfer among firms. A study on social capital –from the perspective of social networks and personal ties – is necessary to understand networking among firms and other actors.

Subsequently, actions taken to foster social networks and personal ties need to be explored. Local actors, their existence, and activities have to be studied because they affect what types of firms locate in a Technology Park, how they transfer knowledge, and what type of knowledge is transferred.

When the product development processes of firms are studied, detailed data on realised product development projects should be used. The processes have first to be fitted to a standard process model to analyse the knowledge transfer in various process phases. The results of the analysis include data on what type of knowledge has been transferred, its source, and in what type of relationship.

6.2.2 Managerial implications

Technology Park management can use the results of the study directly to develop the Technology Park as an innovation system, and indirectly to develop firm level processes by involving the firms' key persons in common activities.

The presence of local higher education is a factor in attracting firms to set up units in a Technology Park, through its potential for providing trained personnel. It is also a way of creating jobs in the Technology Park. Subsidiaries usually transfer most of the knowledge from the firms' upper level units in other locations, and do not tend to collaborate with other local firms. On the other hand, these subsidiaries have good links to geographically higher level innovation systems but the knowledge transferred through the links is not usually laterally transferred in the Technology Park, and does not extend the knowledge base. To enable further transfer of the knowledge, the units' key persons should be involved in common activities (e.g. work groups, info sessions, training) with practical goals for the firms' operational level. Getting to know colleagues develops social capital and trust in others as persons, as well as ultimately in their processes and capabilities.

If there is no local higher education, the recruitment of highly educated personnel is problematic, and access to research knowledge is poor. Special measures are needed to bridge Technology Parks to regional or other universities. According to this study, joint research projects are useful sources of explicit and even tacit knowledge, although access to new personnel is more difficult to achieve. The practice of having a student part time in a firm and part time in a university – used in one case in Electropolis – is worth further development.

Social networks and personal ties are important enablers of networking and knowledge transfer. Actions should be taken to create and foster social networking. Social networks disintegrate easily and, therefore, fostering should be a continuous process. A functional model to build interpersonal ties and trust among key-persons is to use common practical efforts towards commonpark-wide goals, as described earlier in this chapter.

Where brokering and intermediaries are concerned, the best response is achieved by working as closely to the firms' everyday needs as possible. In practice it means searching and intermediating new potential product ideas and customer needs, arranging training and intermediating knowledge on short or medium term needs, building joint development projects etc. With good organisation, this work also fosters social capital.

From the firms' perspective, building trust and interaction with other local firms and actors opens possibilities to mutually exchange, combine, and create knowledge locally, which may lower the cost and in the near future create new mutual business opportunities. In other words, it fosters change towards an open innovation model, and opens possibilities to new types of products and new markets, and thus economic growth.

6.3 The reliability and validity of the study

This study is built on two case-study designs. The two case Technology Parks were studied with a multiple-case design, while the firms' innovation processes were studied using an embedded multiple-case design along with the firms' product development cases in the two case Technology Parks.

Table 11 lists the four tests and related tactics to assure the validity of the results. The main difficulties in establishing construct validity are the failure to develop a sufficient set of operational measures, and subjective judgements in the data collection. The way to avoid this is to define correct operational measures: to use multiple sources of data, to establish a chain of evidence, and to have a key informant review the draft case study report.

Several tactics can be used in the data analysis to ensure the internal validity, where the main risk is in concluding the causalities between two factors without knowing of the existence of a third factor that may have been the actual cause for the event, and in making inferences about factors when the event cannot be directly observed.

The external validity topic deals with the generalisation of the results. In single case studies, it is recommended to use a theory to avoid the problem. In multiple case studies, replication logic is the main tool to avoid false reasoning.

With regard to the reliability of the study, a case study protocol is used to enable other researchers to follow the same procedures to repeat the study and to obtain the same results. Another tactic is the development of a case study database that can be reused. (Yin 2003).

Some researchers are critical of Yin's replication logic. Bryman (1989) argues that replicated studies are difficult to interpret for numerous reasons: wrong theory, a different place, a different time period, etc.

Table 10. The validity and reliability of a case study research (Yin 2003).

Tests	Case study tactic	Phase of research in which tactic occurs
Construct validity	Use multiple sources of evidence	Data collection
	Establish chain of evidence	Data collection
	Have key informants review draft case study report	Composition
Internal validity	Do pattern-matching	Data analysis
	Do explanation- building	Data analysis
	Address rival explanation	Data analysis
	Use logic models	Data analysis
External validity	Use theory in single-case studies	Research design
	Use replication logic in multiple-case studies	Research design
Reliability	Use case study protocol	Data collection
	Develop case study database	Data collection

6.3.1 Construct validity

The testing of construct validity is said to be especially problematic in case study research. The main problems mentioned are the failure to develop a sufficient set of operational measures, and subjective judgements in the data collection. To avoid the problem some operational measures are suggested: the use multiple sources of data, establishing a chain of evidence, and having a key informant review of the draft case study report. (Yin 2003.)

In this study the basic construct is on *collecting data from multiple sources*. The data on the firms were collected by interviewing key-persons of the firms and the Technology Parks, from the firms' official publications, and from several years' observation. The product development case data were collected through interviews, from material on the products, and interviewing the key-persons in the Technology Parks. The Technology Park data were collected in all of the interviews, from project reports and other documents, other publications, and several years of observation. In summary, multiple sources of evidence were used in the data collection to enable data triangulation.

The other tactic (Table 11) is *to establish a chain of evidence*. The report describes all the phases from the case studies to the case study reports and analyses, so that the research process can be followed through the whole process.

Key informant reviews have not been used. During the interviews a time-line with timing for all events was drafted in collaboration with the interviewees. A standard form was filled in for each actor who was in the interviews named to have affected the process. These methods assure the correctness of the data. The correctness of the data was confirmed during the interviews.

6.3.2 Internal validity

Several tactics in data analysis can be used to ensure the internal validity where the main risk is in concluding the causalities between two factors without knowing of the existence of a third factor that may have been the actual cause for the event; and in the inferences between factors when the event cannot be directly observed (Yin 2003).

Both the Technology Parks, and firms' product development processes were analysed first by using replicating logic. The Technology Park case studies are mainly descriptive, as are the product development process single case studies. The product development process cross-case analyses were started by identifying the similarities and differences between all of the characteristics of the cases. Next, some subgroups in the cases were made, and cross case analyses within them were conducted to find the similarities and differences among them in each Technology Park, and between the two Technology Parks. The method led to some explanations that are independent of the Technology Park, and thus the Technology Park related findings can be classified as valid.

6.3.3 External validity

The study consists of two Technology Park cases, and within them a total of 11 product development cases: 6 in Digipolis, and 5 in Electropolis. 4 to 10 cases is said to be an adequate number (Eisenhardt 1989). The interviews were ended when they did not add any new knowledge to the earlier interviews. This confirms that the results can be generalised to the other firms and product development projects in the respective parks. Two Technology Parks were studied, and that number is too small to allow the generalisation of the results to other Technology Parks.

The reliability of a study depends on how well the study can be repeated afterwards with the same cases. This can be ensured by using a case-study protocol and a case-study database. (Yin 2003.) The case study protocols used in this study are presented in the text and in the appendices.

A case study protocol was built to steer the Technology Park interviews, The data consist of interview recordings, and various types of written documents, reports and information releases. Reports were prepared on each of the cases shortly afterwards, and archived both as computer files, and printed documents. The analyses followed the same steps in both cases.

The data collection in the innovation process cases was based more on pre-designed forms. The material consists of an interview guideline, a formula for the basic data about the firm, a time-line and a predefined method to illustrate the process, and a form for each actor that has participated in the process (Appendix 4). Additionally, memoranda were written. Each of the cases were reported shortly after the interview, and archived both as computer files, and as printed documents. The single case analyses were based on a standard procedure, and were archived for later use both as computer files and printed documents.

Some detailed data are not available in the dissertation to respect business confidentiality.

6.4 Future research

This study showed that a local innovation system – of which a Technology Park is a part of – influences the type of firms founded and located in a Technology Park. This has a major effect on what type of product development processes they implement, how they are implemented, and how they transfer external knowledge to the processes. Social networking is an important factor as an enabler of knowledge transfer.

The study was conducted in two Technology Parks. A larger number of Technology Parks should be studied to find out if the results can be generalised. The study should include 2 to 8 other Technology Parks, and a total of 8 to 80 innovation process cases should be studied.

An interesting result, in this study, was the extent to which the social networks and interpersonal ties influence knowledge transfer processes, and how the ties can be forged in a fostering environment. From a practical point of view, a study on the influence of different types of actions would benefit the development of, at least, small Technology Parks.

This study was designed to describe the knowledge transfer processes. As such, it does not answer how changes in the factors influence the knowledge transfer processes over time. However, a study on this question would be constructive to inform Technology Park managers about the value and interaction of such actions.

7 Summary

Technology Parks exist both in large cities with large research universities, and small peripheral towns with limited knowledge related services and a small number of actors. One of the main tasks Technology Parks has is to foster knowledge transfer among firms and other actors to enable innovation processes. The Parks have been founded to foster economic development in their localities, and thus they have at least local value. Even though they have existed for decades, studies on them and their functionality are rare.

The goal of this thesis is to understand how a local innovation system – with a Technology Park as a part of it – and social capital – especially local social networks with strong ties – enable interorganisational networking and product development processes. These processes trigger knowledge transfer from and through a local innovation system to firms' product development processes.

The study is an embedded multiple case study. It was conducted in two small Technology Parks: Digipolis in Kemi in the north of Finland, and in Electropolis in Kalix in the north of Sweden. The study was conducted on two levels: the Technology Park with its functions and processes, and firms' product development processes. The data were collected from interviews, written material, and observation.

Analyses were conducted on several levels and in different ways. First, single-case analyses with replication logic were conducted for both of the Technology Park cases, and after that cross-case analyses were done between the Technology Parks. The product development cases were first analysed as single cases, then the cross-case analyses were conducted between the product development processes in each of the parks, and finally the cross-case analyses were conducted between the product development processes between the parks. In the analyses Eisenhardt's (1989) approach based on 'building theories from case study research' was utilised.'

The two Technology Parks differ in several ways. For example, the knowledge bases and the sources of new personnel differ: in Digipolis there is higher education and research available locally, while in Electropolis they are based to a large extent on earlier firms that had been declared bankrupt, and links to universities (especially in Luleå).

Interpersonal ties – forming the base for trust needed in networking – are overall much stronger in Electropolis than in Digipolis, which is a result of the common background and common efforts and goals of the board of Kalix Electropolis Ab.

In Electropolis the main strategy has been incubation strategy – new firms have been started locally – while Digipolis has utilised both incubation and attraction strategies, which has resulted in a large percentage of subordinate units. This has affected the social capital, as well as causing a lower knowledge transfer between the firms: the firms' internal knowledge flows are used first, locally knowledge is transferred in a limited way, and the subsidiaries seldom conduct the whole product development process by themselves.

There are differences in, how the firms in the two Technology Parks conduct their product development processes, and transfer knowledge. When mixed grouping of the cases was used, the result was that most of the differences were explained by other differences than the Technology Parks. Because of the differences in the innovation system, the constellation of firms differs.

The social networks with strong ties, and brokering in Electropolis affect the product development processes: trust fosters local knowledge transfer, and brokering fosters networked product development processes, and open innovation.

The framework was applicable and useful for studying the functionality and knowledge transfer in – at least – small Technology Parks. It was also able to measure the conditions for open innovation in a local innovation system, and the level of openness in firms' product development processes.

The study produced some practical implications that are useful for the further development of the two Technology Parks. Local social networking is of high importance, it can decrease easily, and it should be fostered by implemention a functional practice which proved to be a successful model in this study: i.e. working together towards common goals that benefit all. When local research and education are not available, specific action should be taken to ensure access to new personnel.

The study was conducted in two Technology Parks, and the results are valid with regard to this small scale study. To prove that the results can be generalised, a larger study of some more parks should be carried out.

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Appendix 1 Technology park interview structure

InnoCentra Project **Interview Design**

21st January 2007

1. ***Park history***
   - First electronics firms in Kalix?
   - Important steps after that
   - Today and future goals
2. ***Kalix Electropolis Ab***
   - Founding year
   - Ownership: Now and earlier
   - Activities
   - Financing
   - Projects: Plans and reports, if possible
3. ***Firms***
   - Basic information
4. ***Inter-Firm Cooperation (local, regional, larger)***
   - Trade between firms
   - Product development
   - Technology transfer
   - Production
   - Marketing
   - Social networks
5. ***Intermediate organisations***
   - Municipality's role
   - Kalix elektronikförening
   - Kalix Electropolis Ab
   - Regional organisations
   - State organisations
   - Others: organisations, projects… (E.g. NEO, TRIP…)
6. ***Education and training***
   - UniverCity
   - Other local organisations
   - Universities
   - Others
7. ***Projects***
   - Education & training
   - Research
   - Development
   - Business environment development

Appendix 2 Firm interview structure

1. ***Research project:***
   - Main project and goals
   - Goals and content of this interview
2. ***Company background information***
   - Form
3. ***Products development project, case***
4. ***Description of standard product development process***
   - If defined
   - If not, typical
5. ***PD process in the case***
   - Graph, time line
6. ***Knowledge flows to the process***
   - Explicit, tacit
   - Personnel
   - Subsystems, subcontracts, partners
   - Who, what, to what stage of process, importance
   - Added to time line
7. ***Partner and knowledge data***
8. ***Some background influencers?***
9. ***Value and role of:***
   - Technology Park firm
   - University, university of applied sciences
   - Research institutes

Appendix 3 Background of interviewed firm

Basic information
Company name:
Founded (year):
Ownership (originally/today):
Number of employees:
Turnover:
Main products:
Person interviewed
Name:
Position:
In the company since:
Background in founding the company
Persons (background, education):
Original ownership:
Original products:
Main steps of development/Chain of decisions made during the years
New product development projects/launches:
Idea to the case product: From, when, how, with whom tested?

Appendix 4 Sources of Knowledge, Subsystems, Personnel…

Organization:
Location: ☐ SP ☐ Local ☐ Regional ☐ National ☐ International
Sector:
Size:
Significant impact in which stage: ☐ Idea ☐ Concept Development ☐ System Level Design ☐ Detail Design ☐ Testing and Refinement ☐ Ramp-Up☐ Other
Knowledge Type: ☐ Tacit ☐ Explicit ☐ Personnel ☐ Subsystem / artefact ☐ Knowledge transfer ☐ Knowledge creation ☐ Services ☐ Funding ☐Other,______________
Value to the Process: Low ☐☐☐☐☐☐☐ Necessary
What has been given in exchange (money, knowledge…)
Why has this actor been important / negative in this specific period
Reasons for change, if changed:
Other notes:

Appendix 5 Interview report model

Day of interview: yyyy-mm-dd
Firm:
Web address:
Technology Park:
Interviewee:
Position:
Turnover
Employees:
Main products:
Ownership

Personal background:

Firm history:

Development Process Description:

Product:

General Information:

Development Process Description:

Product: **Name describing the product**

General Information: More detailed description

Consortium designing the product:
Firm a, Content
Firm b Content
Firm c, Content
Firm d, Content
…..

Other actors:

Actor 1 Year/Month
What was the role, what did happen

Actor 1 Year/Month
What was the role, what did happen

Actor 1 Year/Month
What was the role, what did happen

Timing:
Year/Month Content
Year/Month Content
Year/Month Content
Year/Month Content
…

Appendix 6 Cases in Digipolis

Case	D1	D2	D3	D4	D5	D6
Unit type (in practice)	Subsidiary	Subsidiary	Private, local	Subsidiary	Subsidiary	Subsidiary
Project management	Local	Regional unit	Local	Local	Regional unit	Local
Customers' sector	ICT	ICT	Other	Other	ICT	Other
Process	Customer's	Own	Own	Own	Customer's	Own
Process execution	Local, partly regional	Detail-design partly, Testing fully	Local	Local	Ramp-up local	Local
Case customer	Regional firm	International internal unit	National, presented by an association	Local firm	Regional firm	Local firm
Innovation type	Incremental	Incremental	Radical	Platform based	Incremental	Platform based
Product idea: knowledge sources, type; relationship; importance						
Source of the product idea	Customer, based on firm's product	Firm's other unit, international	Firm	Local customer, based on firm's earlier product	Firm	Local customer, based on firm's platform
Transferred knowledge	Explicit, tacit High value	Explicit High value	No external	Explicit High value	No external	Explicit, tacit High value
Relationship	Brokered by a regional unit	Brokered by a regional unit	Brokered by a business association	Brokered by a local consultant	Brokered by a regional unit	Brokered by a local consultant

Case	D1	D2	D3	D4	D5	D6
Phase 0. Screening: knowledge sources, type; relationship; importance						
Conducted	On regional level by the firm	On International level by the corporation	Locally in the firm	By a consultant locally, except project set-up	On regional level by the firm	By a consultant locally, except project set-up
Sources			A national organisation Tacit Dyad High value		Regional customer, Explicit Dyad High value	
Phase 0. Planning: knowledge sources and types; relationship; importance						
Conducted	Locally	Regionally	Locally	Locally	Regionally	Locally
Sources	Customer Regional Explicit, tacit Trust, dyad Brokered by regional unit High value	Internal international customer, Explicit, Brokered by regional unit High value	National business sector association presenting customers, Explicit, tacit, Dyad High value	Local customer, Explicit, tacit, Networked High value Customer's local consultant, Explicit, tacit, Networked and brokered High value	Regional customer, Explicit, tacit Trust, dyad High value	Local customer, Explicit, tacit, Networked High value Customer's local consultant, Explicit, tacit, Networked and brokered High value

Case	D1	D2	D3	D4	D5	D6
Phase 1. Concept development: knowledge sources and types; relationship; importance						
Conducted	Regionally, locally	Internationally on corporate level, partly locally	Locally	Locally, based on firm's earlier product	Regionally Totally	Locally, based on firm's earlier product
Sources	Regional customer, Explicit, tacit Brokered by a regional unit High value Regional unit, Explicit, tacit High value	Transferred to the unit from corporation High value	National business sector association presenting customers, Explicit, tacit, Dyad Brokered relation with customers High value National organisations (2) Explicit, tacit Dyad High value		Regional customer, Explicit, tacit Dyad High value	

Case	D1	D2	D3	D4	D5	D6
Phase 2. System-level design: knowledge sources and types; relationship; importance						
Conducted	Locally	Locally, Included in detail-design	Locally	Locally	Regionally Included in detail-design	Locally
Sources	Regional unit, Explicit, tacit High value Regional customer, Explicit, tacit Brokered by a regional unit High value	International internal unit 1 Explicit High value International internal support group Explicit High value International internal support group Explicit Medium value	National business sector association Explicit, tacit High value	Local customer, Explicit, tacit Networked High value Local consultant Explicit, tacit Networked, broker High value	Regional customer Explicit, tacit Trust, dyad High value Regional engineering firms (2) Explicit Portfolio Brokered by the customer High value	Local customer, Explicit, tacit Networked High value Local consultant Explicit, tacit Networked, broker High value National Equipment supplier Explicit, tacit Dyad High value National authority, Explicit Dyad High value

Case	D1	D2	D3	D4	D5	D6
Phase 3. Detail design: knowledge sources and types; relationship; importance						
Conducted	Locally	Regionally and locally	Locally	Locally (prototypes used)	Regionally	Locally
	Regional customer, lower role until prototyping Brokered by a regional unit Explicit, tacit Medium value Regional units (2) Subsystems High value National tool supplier Explicit, tacit Dyad Medium value	International internal unit Explicit High value International internal support group Explicit High value International internal support group Explicit Medium value International internal group Explicit Medium value	None	Local customer Explicit, tacit Networked High value Local consultant Explicit, tacit Networked, broker High value National tool supplier Explicit Dyad Medium value	Regional customer Explicit, tacit Trust, dyad High value Regional engineering firms (2) Explicit Portfolio Brokered by the customer High value International material suppliers Explicit Dyad Medium value	National firms Subsystems Portfolio Medium value Local customer, Explicit, tacit Networked Medium value National internal groups Subsystems Dyad Medium value

Case	D1	D2	D3	D4	D5	D6
Phase 4. Testing and refinement: knowledge sources and types; relationship						
Conducted	Locally Customer Prototyping Explicit, tacit High value	Locally Internal regional unit Explicit, tacit High value International internal unit Explicit High value Local HEI, services Dyad Minor value Regional firm Subsystems Portfolio Minor value	Locally National business sector association Explicit, tacit Dyad High value	Locally Local customer Explicit Networked High value Local consultant Explicit Networked, broker High value	Regionally Regional customer Explicit, tacit Dyad High value	Locally Local customer Explicit Networked High value National authority, Explicit Dyad High value
Phase 5. Production ramp-up: knowledge sources and types; relationship						
Conducted	Regionally External	Internationally Internal Regional unit transfers knowledge outwards	Locally, No production, launch National business sector association, customer knowledge Explicit Dyad High value	Locally, Assembly	Locally Internal	Locally, External Locally External firm Services Portfolio Medium value

Case	D1	D2	D3	D4	D5	D6
Indirect sources vs. the process: knowledge sources and types; relationship						
	National special consultant, Explicit Dyad	Regional HEI Explicit, tacit Dyad	National informal inter-firm network Explicit, tacit Networked	Local HEI Training Explicit	Regional HEI Research Explicit, tacit Networked, dyad	National in-house training
	National component supplier Explicit Dyad			National other firms, Courses in collaboration Networked	Regional research centre Research Explicit, tacit Networked	
	International HEI, courses Explicit Brokered by local HEI					
	KTUAS Testing Explicit, tacit Dyad	KTUAS Testing Explicit, tacit Dyad		KTUAS Training Explicit Dyad	KTUAS Training Explicit Dyad	
	KTUAS Research Explicit, tacit Networked	KTUAS Research Explicit, tacit Networked			KTUAS Research Explicit, tacit Networked	
Indirect sources vs. the process: new personnel						
	KTUAS	KTUAS Regional HEI Other regional firms	KTUAS	KTUAS	KTUAS	KTUAS

Appendix 7 Cases in Electropolis

Case	E1	E2	E3	E4	E5
Unit type (in practice)	Independent	Independent Venture capital majority	Independent	Subsidiary	Independent
Project management	Local	Local	Local	Local	Local
Customers' sector	Other	Other	ICT	Other	Other
Process	Own	Own	Own	Own	Own
Process execution	Local, parts sourced regionally	Local	Local	Local	Local
Case customers	National, international	International	Local	Regional	National
Innovation type	Radical	Radical	Incremental	Radical	Incremental
Product idea: knowledge sources, type; relationship; importance					
Source of the product idea	Firm	Firm	Firm and customer interaction in long relationship	Customer	Research
Transferred knowledge	-	-	Tacit, explicit	Explicit, tacit	Explicit
Relationship	-	-	Interaction in long relationship	Brokered by Electropolis Ab	Brokered by Electropolis Ab

Case	E1	E2	E3	E4	E5
Phase 0. Screening: knowledge sources, type; relationship; importance					
Conducted	Locally	Locally	Locally	Regionally by customer	Locally
Sources	3 national and international firms Explicit Portfolio High value	International firm Explicit, tacit Dyad High value	Local customer Explicit, tacit Dyad High value		National authority, Explicit Dyad High value
Phase 0. Planning: knowledge sources and types; relationship; importance					
Conducted	Locally	Locally	Locally	Locally	Locally
Sources	Regional firm, partnership Explicit, tacit Dyad High value	-	Local customer Tacit, explicit Dyad High value	Electropolis Ab Explicit, tacit, network building Dyad High value	Electropolis Ab Explicit, tacit network building Dyad High value Regional firm Explicit, tacit Dyad High value

Case	E1	E2	E3	E4	E5
Phase 1. Concept development: knowledge sources and types; relationship; importance					
Conducted	Locally	Locally	Locally	Locally	Locally
Sources	Regional firm, partnership Explicit High value	International customer Tacit, explicit Dyad High value	Local customer Tacit, explicit Dyad High value	Regional customer Explicit, tacit Networked High value	End-users presented by a national association Tacit Networked High value
	National and international firms Explicit, tacit Portfolio High value			Regional HEI Explicit, tacit Networked High value	National authority, Explicit Dyad High value
					Regional firm Explicit, tacit Networked High value
					Regional firm Explicit, tacit Networked High value
					National supplier Explicit Dyad Medium value

Case	E1	E2	E3	E4	E5
Phase 2. System-level design: knowledge sources and types; relationship; importance					
Conducted	Locally	Locally, Included in detail-design	Locally	Locally	Regionally Included in detail-design
Sources	Regional firm, partnership Subsystem Dyad High value National and international firms Explicit, tacit Portfolio Medium value	International customer Tacit, explicit Dyad High value Regional firm Explicit, tacit Dyad Medium value National supplier Explicit Dyad Medium value	Local customer Tacit, explicit Dyad High value National supplier Explicit Dyad Medium value	Regional customer Explicit, tacit Networked High value Local firm Subsystem Networked High value Regional firm Subsystem Networked Some value	End-users presented by a national association Tacit Networked High value National authority, Explicit Dyad High value Regional firm Explicit, tacit Networked High value Regional firm Explicit, tacit Networked Some value National supplier Explicit Dyad Medium value National firm, Subsystem, Explicit, tacit Dyad Medium value

Case	E1	E2	E3	E4	E5
Phase 3. Detail design: knowledge sources and types; relationship; importance					
Conducted	Locally	Locally	Locally	Locally	Locally
Sources	Regional firm, partnership Subsystem design Dyad High value	National supplier Explicit Dyad Medium value Regional firm Explicit, tacit Dyad Medium value International firm Subsystems, explicit Dyad Medium value	Local customer Tacit, explicit, subsystems Dyad High value	Regional customer Explicit, tacit Networked High value Local firm Subsystem Networked High value	End-users presented by a national association Tacit Networked Some value National authority, Explicit Dyad Some value Regional firm Subsystem, explicit, tacit Networked High value Local firm Subsystem, explicit, tacit Networked High value Regional firm Explicit, tacit Networked Medium value National firm, Subsystem, explicit, tacit Dyad High value

Case	E1	E2	E3	E4	E5
Phase 4. Testing and refinement: knowledge sources and types; relationship					
Conducted	Locally	Locally	Locally	Locally	Locally
Sources	Technical testing, Regional firm, Explicit, subcontracting Dyad Medium value	Functional testing International customer Tacit Dyad High value	Local customer Tacit, explicit Dyad High value	Technical testing Regional firm Tacit, explicit Dyad High value	Functional testing by end-users, Brokered by association Explicit High value
	Functional testing, 3 national and international customers, Explicit, tacit Portfolio Medium value			Functional testing Regional customer Explicit, tacit Networked High value	
Phase 5. Production ramp-up: knowledge sources and types; relationship					
Conducted	Assembly locally by the firm	Outsourced regionally and internationally	No production	Locally	Locally
	Regional firm Subsystem Dyad Medium value	Regional firm Subcontracting, explicit, tacit Dyad Medium value		Not yet conducted	Regional firm Subsystems Dyad Medium value
		International firm Subcontracting, explicit Portfolio Medium value			
Indirect sources vs. the process: knowledge sources and types; relationship					
	LTU Research	LTU Research	LTU Student projects		
Indirect sources vs. the process: new personnel					
	LTU	LTU	LTU	In-house training	In-house training

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ACTA UNIVERSITATIS OULUENSIS

ISBN 978-951-42-9058-9 (Paperback)
ISBN 978-951-42-9059-6 (PDF)
ISSN 0355-3213 (Print)
ISSN 1796-2226 (Online)

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