

Tampere University of Technology

Industrial Management

PhD proposal

”Regional Science-based Clusters -
Understanding the interaction patterns behind the emergence”

RESEARCH PLAN

“short version”

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1 Introduction

A lonely wolf is a poor predator. Thus, the importance of the interfirm cooperation and networks are nowadays seen as a key asset to success. In the modern business environment companies need good networking skills, i.e. understanding of the logic of value creation in the networks, ability to work as a part of the networks and ability to adopt a role that creates value for the network (Möller, Rajala & Svahn, 2004). For an individual actor, network represents a source of resources and information as well as business opportunities and challenges (Håkansson & Johanson, 1992). Håkansson et al. (2009) offers two metaphors to illustrate the networks: 1) a jungle, a landscape characterized by deadly competition between the companies that populated it, and 2) a rain forest, emphasizing the variety, motion and relatedness of the business landscape.

A review on network literature reveals that we already know something about networks. For instance, taking a look at the work done by IMP (Industrial Marketing and Purchasing) Group (e.g. Håkansson & Snehota, 1995; Håkansson & Waluszewski, 2007; Håkansson et al., 2009) indicates that we know something about the structure and managing of the networks (agreed by several other scholars, e.g. Lamming et al. 2000). We also have already several taxonomies and typologies of the inter-firm networks (see e.g. Huggins, 2000).

For 'a cluster' there is not a unique definition (Teräs, 2008) but where we can agree is that clusters may be considered as small, special kind of networks or nets (the relation between networks and clusters is also discussed by Håkansson & Waluszewski, 2007). Furthermore, they may be pictured as geographically proximate group of interconnected companies and associated institutions in a particular field linked by complementarities and complementaries (Porter, 1998). The extensive previous research has dealt with clusters and industrial districts (Steiner & Ploder, 2008) but only limited research has explored differences in same clusters over time (Felzensztein et al., 2009). Already Schutjens & Stam (2003) have called for more detailed research on variations in networks, its explanations and in particular the dynamics in networks over time.

Based on the literature review and several discussions and feedback (for instance, in Jönköping at the 19th Nordic Workshop on Interorganizational Research in August 2009), the most significant contribution to the network literature seems to be the understanding of the emergence and dynamics of the network. Thus, in this study I will focus on the emergence of the selected case, trying to capture the key events of the evolution and the factors explaining them. More specifically, I am interested to capture the interaction patterns between individuals and organizations in the initiation and creation phase of the cluster. We need to understand what has happened and what has been changing, but more importantly we need to understand "*how* the emergence happens" and "*how* the emergence is initiated".

The remainder of this proposal is arranged as follows. In the next section, the empirical case, the laser cluster, is briefly introduced. Second, the theoretical point of departure is explained. In the section 4, the objectives of the study are introduced before explaining the methodology to be used in this study in section 5.

2 The empirical case: Laser technology in Tampere region

The empirical part of the study will focus on the laser cluster, a university-based high-technology cluster in Tampere region. Based on my preliminary research (see Figure 5, phase 1) on the cluster and its emergence the case seems to fulfill the requirements as an emerging network (see the short description in Appendix 1). All the main categories of actors of a cluster (co-located and linked industries, government, research community, financial institutions, and institutions of collaboration) proposed by Sölvell et al. (2003) seem to be represented. It also seems that I have adequate access to the relevant information sources. In addition, laser technology offers interesting context for the study since it is applied in various industries. Thus, the cluster has emerged on several quite different networks (telecommunications, metal industry, medicine, defence and security etc.)

Also the actors related to the case call the collaboration as a cluster which actually is in line with Porter's (1998) definition. The cluster could also be classified as knowledge network, since it is dedicated to the creation and dissemination of knowledge assets transcending the boundaries between sectors (e.g. academic, industrial, financial, government) to contribute to sustainable development (Clark, 1999). Moreover, some researchers would find the cluster as a good example of 'triple helix' involving universities, industry and public agencies in symbiotic relationship (Etzkowitz, 2002; Etzkowitz 2004) while others would definitely be interested in university's dominating role as an engine of growth (Chakrabarti & Santoro, 2004; Lester & Sotarauta, 2007).

However, I will deal with the case as an emerging business network, referring the concept to "actors' and relationships' embeddedness within networks of interconnected relationships that provide opportunities for and constraints on behaviour" (Brass et al., 2004; Håkansson & Snehota, 1995). Distinguishing between nets and networks is difficult, but I define the laser cluster as a small net (focal net) and as a part of larger industrial network (see the network boundaries in Figure 4).

3 The theoretical point of departure

Theoretical point of departure introduced here will offer some guidelines in the beginning of the study. However, I am not going to "twist the facts to prove a theory, but rather to adapt theory to provide a better account of the facts" (Cipolla, 1991). To complement the theory we should seek for anomalies and thus, avoid locking-in the existing theory (Carlile & Christensen, 2004).

Networks and clusters

Business networks

In this study I will mainly use the network as the level of my analysis. There are several ways to approach the networks (e.g. see Araujo & Easton, 1996), but my view on the networks and their structure and dynamics is highly affected by the work done by IMP Group. Thus, I will approach the study by using the Industrial Network Model (Håkansson & Snehota, 1995) that captures the networks as an entity where one organizational entity is affected by and affects on other organizational entities. The model approach the network through three layers: Actors, Resources and Activities ("ARA-model", see Figure 1). In the model, the actors carry out the value activities of the network and actors have different roles in network cooperation. These actors are intentionally developing their operations towards their goals through the network. In addition, actors have partial

control over each other's resources through interlinked relationships. (Ford et al. 1990, Håkansson & Johansson 1992, Håkansson & Snehota 1995)

Networks may also be seen as communication system. In well structured networks all actors should know what is happening. Through the ARA-linkages the network also takes into account information from other networks and gives an individual actor an opportunity to know what happens in many technological areas. The network is a product of its history in terms of all memories, investments in relationships, knowledge, routines, etc. Since most partners must accept the changes within the network, the changes tend to marginal and closely related to the past (Håkansson & Johanson, 1992). Thus, the development of the network may also become an obstacle to the change (Håkansson, 1989).

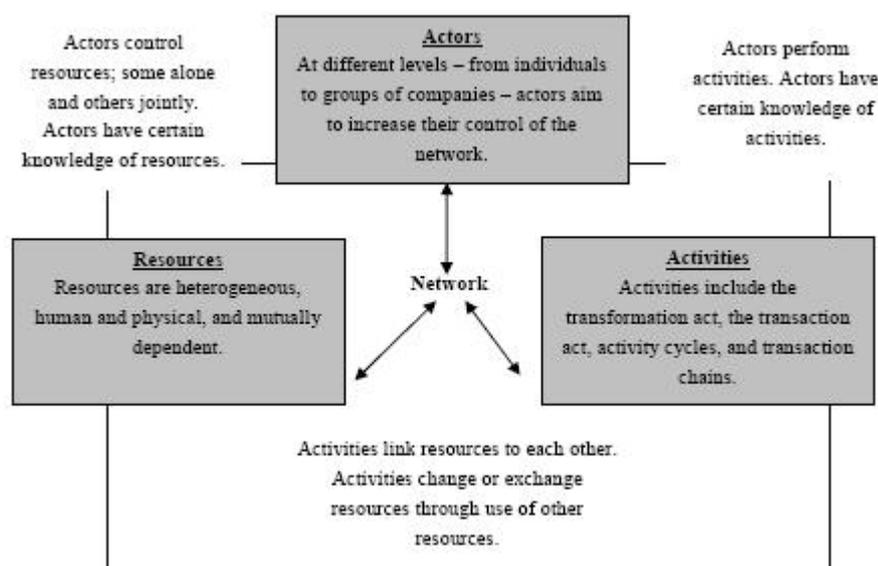


Figure 1. Network model (Håkansson, 1987)

Clusters

As mentioned earlier, for 'a cluster' there is not a unique definition (Teräs, 2008). Thus, one sub-goal is to find out what we can depict as a cluster. However, according to Porter (1998) clusters increase the productivity of companies, drive the direction and pace of innovation, and stimulate the formation of new businesses. DTI (2004) lists the key benefits of clustering, for both business and the wider economy, as follows:

- increased level of expertise;
- the ability of firms to draw together complementary skills;
- the potential for economies of scale;
- strengthening social and other informal skills;
- improved information flows within a cluster;
- enabling the development of an infrastructure of professional, legal, financial and other specialist services.

On the other hand, clusters face the risk of congestion. The cluster may become overcrowded, resulting in an increased number of competitors reducing per-firm sales, prices, per-firm profits, and per-firm growth on the demand side, and an increased competition on the supply side e.g. the cost

of real estate or labour. (Swann, 1998) The cluster benefits are important at an early stage of the cluster's life cycle, while the disadvantages build up later. The analysis on optoelectronics industry at the company and regional level (Hendry & Brown 2006) shows that clustering itself grants no particular performance benefits when comparisons are made of companies not in clusters.

As mentioned, I will deal with the case as an emerging business network and thus, define the laser cluster as a small net (focal net) connected with a larger industrial network. Alongside with this approach I define the cluster similar to Porter (1998).

The models of dynamic evolution

Business networks

As mentioned, there are not that many studies focusing on the emergence and evolution of the network (of course some exist, e.g. network formation: Chaston 1995; network development: Easton 1994, Wilkinson, Young, Welch & Welch 1998). Lundgren (1995) has suggested three partly-parallel but distinct phases in network emergence: 1) genesis, 2) coalescence and 3) dissemination. Möller & Svahn (2003) identified three interrelated phases following Lundgren (1995). 1) The exploration for future business phase is characterized by competition between the actors and collaboration in the exploration and sense making of the application potential for emerging technologies. 2) The mobilization for the applications phase concerns actors competing and collaborating in constructing dominant designs and applications. 3) The mobilization for the dissemination phase covers actors competing and collaborating in scaling up production and distribution networks in the competition to create markets. One should notice that also Möller & Svahn use the term 'landscape of emergent business nets' since distinguishing between networks and nets is difficult.

Möller & Svahn (2003) have also described the environment of the emerging business net(work)s. They approach the environment through four classes of characteristics: complexity, novelty, embeddedness and dynamics. Figure 2 summarizes the elements of dynamic emergence as well as the main phases through which the innovation develops from an idea to commercialization. The increasing size of the ellipses illustrates the expanding networks required to transform an idea into an innovation, and to turn an innovation into viable business.

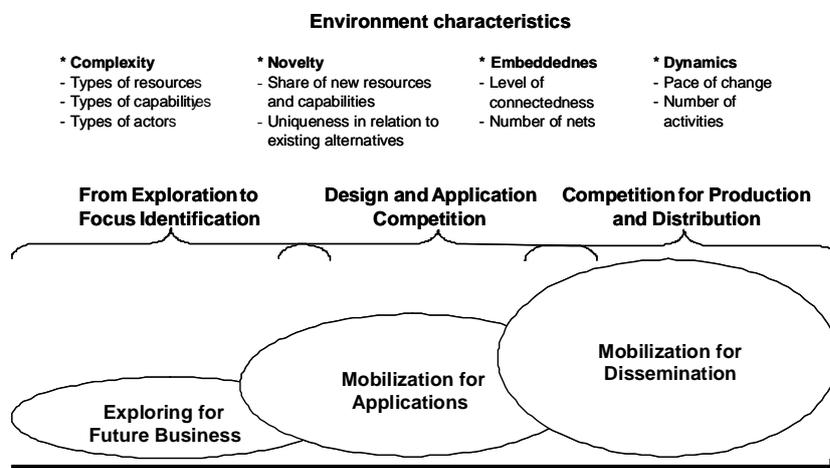


Figure 2. *Landscape of emergent business nets (Möller & Svahn, 2003)*

Clusters

Also clusters are dynamic. DTI (2004) recognise cluster's life cycle as a cyclical process containing four stages. 1) Embryonic clusters are the clusters in the early stages of growth 2) established clusters are the clusters perceived as having room for further growth, 3) mature clusters are those that are stable or will find further growth difficult, and 4) declining clusters are those that have reached their peak and are failing or declining. Clusters in a declining stage are sometimes able to reinvent themselves and enter the cycle again.

Waelbroeck-Rocha (2001) emphasizes the possibility of transformation in the cluster development. During the emerging phase, a number of the actors in the region start to co-operate around the core activity. As new actors in the same or related activities emerge or are attracted to the region, new links develop between them. Formal or informal institutions of collaboration may enter the field. A mature cluster has reached a certain critical mass of actors and internal dynamics. Finally, the cluster innovates and adapts changes, undergoing transformation into one or several new clusters.

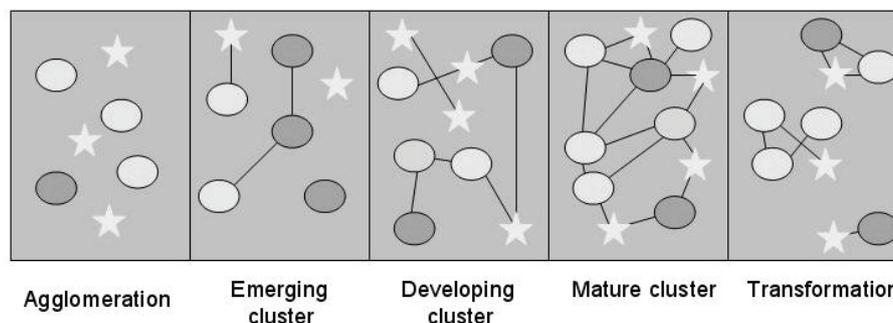


Figure 3. *The cluster life cycle (Waelbroeck-Rocha 2001)*

Other related topics

The interdependence between change and networks

Changes, such as new innovations, technological and industrial life-cycles, are strongly related to the business networks which may comprise several separate and overlapping industries and networks (Estades & Ramani, 1998). For instance, according to Dalum et al. (2005) who studied technological life-cycles in a cluster related to mobile communications technologies, a cluster may experience the passing of several technological life-cycles. The new disruptive life-cycles may initiate the emergence of new regional industrial clusters or create opportunities for further development of existing ones. Nyström (2008) studied convergence (considered as a change process) in the sector of telecommunication in Finland. She noticed that convergence refers to the growing interdependency among the different industries (telecommunications, IT, media). The actors are dependent on each other's resources, also those outside traditional industry borders. Therefore actors are forced to re-evaluate their roles and positions as the development continues.

Especially, according to Eisenhardt & Martin (2000) emergent business networks often take place in times of radical technological change, characterized by nonlinear and unpredictable change,

with blurred market boundaries and ambiguous and shifting market players, with no evidently-successful business models.

Path-dependence

In a sense, there are no new networks since new companies emerge always into existing networks (Lundgren, 1995; Ford & Redwood, 2005). We could say that the actors of an emerging industry take places in existing network of related industries. Thus, the networks are closely related with the concept of path-dependence. The network is a product of its history in terms of memories, investments in relationships, knowledge, routines, etc. (Håkansson & Johanson, 1992). Thus, a network results from the choices in the past enabling more or less stable way to act but restricting the possible ways to evolve.

Also an industrial cluster is the product of time-dependent processes of locational concentration, progress in industrial technologies, market development, and infrastructural and other policy choices in the past (Britton, 2007). According to Bergman & Feser (1999) the concept of path-dependence refers to the general notion that technological choices may assume a dominant lead over alternatives and be self-enforcing, though not necessarily irreversible given a significant enough shock. Because technology can be path-dependent, also regional development trajectories may become path-dependent.

Social networks

Social networks are elements in relationships, at organizational and individual levels (Johannisson, 1995). As mentioned earlier, the level of this research will mainly be the level of the organizational network. However, based on my preliminary study, the network of individuals seems to be the strong basis of the cluster. I believe that mapping the social networks within the case, could help us to understand better the co-operation between the network members and the high acceptance by different actors to invest on the infrastructure development of this emerging business field. For instance, Kari Kankaala, Director of the Economic and Urban Development of the City of Tampere, has background from TUT.

There are three broad types of network (Johannisson, 1995, Felzensztein et al., 2009): 1) Exchange networks involving commercial relationships with customers, 2) communication networks involving individuals who provide a firm with contacts and knowledge to inform business activities and 3) social networks including formal and informal relations, friends and other connections which provide support owner-managers, and which have a broader scope of development, social embedded norms and expectations. Felzensztein et al. (2009) actually noticed that social networking is one dimension that may decrease within a cluster because of the increasing competition over time.

4 Objectives of the study (research problem)

Research questions

There are still some work left with the definitions and the theoretical point of departure. However, it is sure that this study will be about the initiation and emergence of a regional cluster. The chosen cluster, the laser cluster, is operating in emerging business field with characteristics of high

technology, university-environment as well as great future expectations. Thus, the study will contain the aspects of networks (organizations and individuals), as well as innovation, technology management and path-dependence. As mentioned, instead of taking snapshots (*what* has changed) I will try to deal with the emergence as a continuous process trying to answer the main research questions.

RQ1 *How the emergence of a cluster is initiated and managed?*

RQ2 *What are the interaction patterns between the individuals and organizations behind the emergence?*

These tentative research questions are relatively broad since I am not going to pre-structure too much the framework for the study beforehand. This is because my general research approach will be iterative in nature (see section 5).

In addition to the main research questions, the case provides few additional questions. Since the social networks are widely acknowledged as a key element of clusters, it is interesting to know the relationship between the individual and organizational networks.

RQ3 *How have the network structures, organizational and individual, evolved during the emergence?*

RQ4 *How is the evolution of the social networks related to the evolution of the networks at organizational level?*

New networks emerge in existing networks and also a cluster is considered to be a product of the choices in the past. Thus, it is interesting to know the relationship between the history of the local infrastructure and the emergence of a new cluster.

RQ5 *How do the existing industries and networks (path) relate to the emergence of a cluster?*

In his valedictory speech, already retired Prof. Pessa (see Appendix 1) described the laser cluster as "a club". By paying an annual fee a network member gets a better insight to the technological development within the cluster. One could imagine that this kind of commitment (shared resources, social glue) could increase the proximity within the cluster between both individuals and organizations. In addition, Pessa emphasized the strong role of the university research centers to build up the present cluster. Thus, I am interested to find answers to these following questions:

RQ6 *Does "the club model" offer any anomaly to existing theories of network and cluster?*

RQ7 *Does the dominant role of the university offer any anomaly to existing theories?*

Some limitations

As "the emergence" I will consider the time from 1991 (the first spin-off company was established) to present. "The network" contains the core group as focal group (includes the university research units and the university spin-off companies as well as the individuals within these organizations) and its outer network (direct relationships e.g. with adapters and business service providers). This may be considered as "a micronet-macronet perspective", that is suggested by Halinen and Törnroos (2005) as one possible approach for delimiting the network boundaries. Figure 4 illustrates the chosen network boundaries.

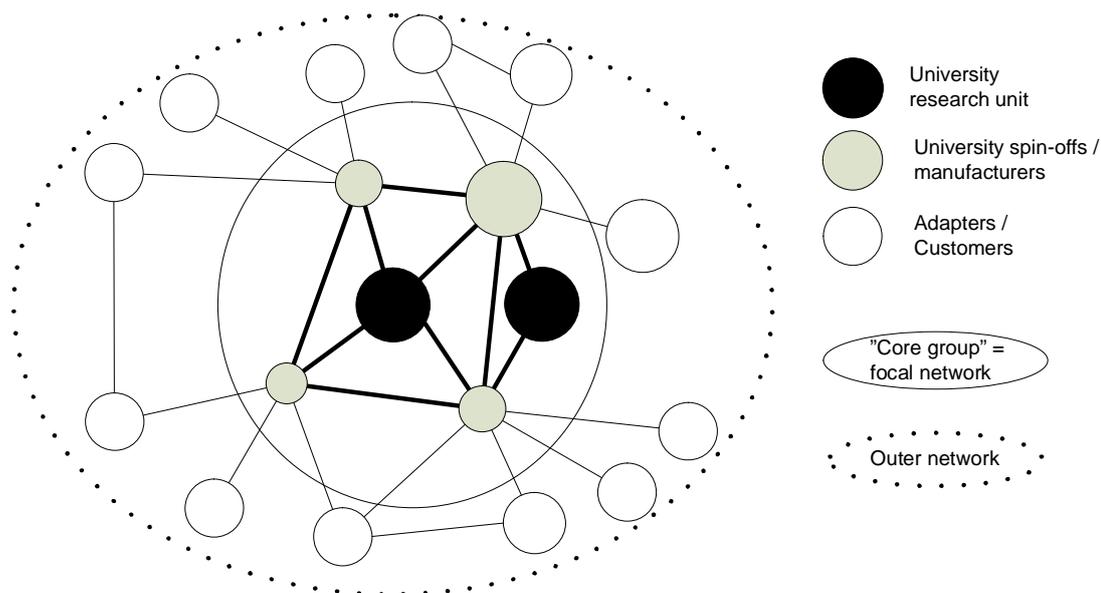


Figure 4. Simplified illustration of the network boundaries

Managerial implications

The results of the research will be useful to all actors that are dealing with emerging business fields and high technology networks and clusters. These actors may learn to align their contribution in business networks with how the field is evolving in reality. They may also learn how to benefit from other actors and to avoid some possible pitfalls in networking. The objective of the study is directly related to the objective of the Department of Industrial Management at Tampere University of Technology in the area of innovation management and industrial marketing.

5 Research materials and methods

The aim of the study is to contribute the literature by developing the quite immature theory of the network emergence and initiation. Thus, the research is mainly empirically-driven and inductive in nature. Based on the sample (the laser cluster, less than 50 organizations involved) and the theory development purposes I prefer qualitative research as the methodological approach.

In this section I first introduce my general research approach. Next, I will discuss briefly the case study as methodology of my study and introduce the information sources. After that I will introduce the other methods used in the research.

General research approach

As said, my general approach for the study is iterative in nature. Normally, a research approach includes preplanned phases to be executed in more of a sequential manner. Thus, the argument for a more iterative approach is the understanding of both theory and empirical phenomenon. In an iterative process a researcher moves between different research phases and alternates between empirical insights and theory development (Dubois & Gadde, 2002). Such an approach is suitable when aiming to develop existing theory which is also the purpose of this study. Several scholars supported using the iterative process (that may also be seen close to abductive) and for instance Dubois and Araujo (2004) propose that neither the phenomenon nor its context is necessarily known in advance but instead the research object and purpose unfolds during the study.

To be a little bit more specific, the research approach that is taken in this study is close to abductive approach, but is actually a combination of separate inductive and deductive phases. The aim is to frame the study as well as develop the theoretical framework and empirical observations over time. A preliminary illustration of the research process is in Figure 5.

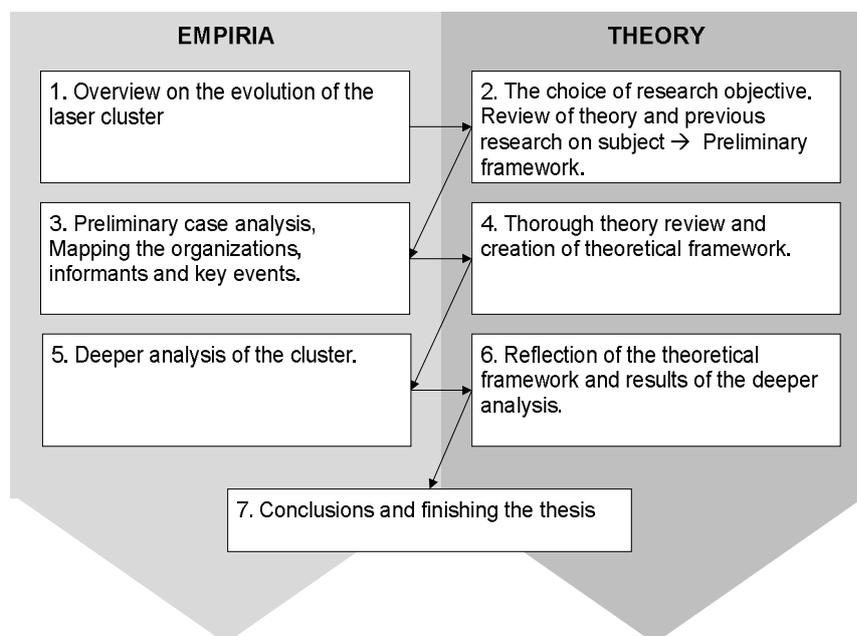


Figure 5. Illustration of the research process.

Case study as the main methodology

To understand a change one has to study it as a continuing process in the context in which it appears (Pettigrew, 1985). Van de Ven describes (1992) this kind of process as a sequence of events and activities that describe how things change over time. Also Pettigrew (1997) describes the process as the underlying mechanisms that shape the patterns in the process. The change as process answers the question “how”, but in this study, in addition to the process, it is also important to understand “what” (e.g. the structure of the network). Thus, the longitudinal, historical and contextual case study approach seems to suit well. According to Pettigrew & Whipp (1991) it is essential to explore three basic concepts (process, content and context) and their interconnections through time.

In addition, according to Yin (1989) a case study is “an empirical inquiry that investigates a contemporary phenomenon within its real-life context when boundaries between phenomenon and context are not clearly evident and which multiple sources of evidence are used”. Easton (1995), Eisenhardt (1989) as well as Yin (1989) recommend the case study as methodology when developing inadequate theories on little known phenomena. The case study captures both contextual factors and process elements in the same real-life connection which make the method strong when studying change processes. Based on the definitions above (+some others, see also Lee, 1989; Valdelin, 1974) Halinen and Törnroos (2005) consider the case study as the most suitable for the study of business network. According to Easton (1995) the attributes of case study research fit well with industrial network phenomena since the richness of the picture helps to handle the complexity of network links and can be used to trace the development of network changes over time.

In addition, the longitudinal case-study may nowadays be seen more as continuous observation than taking snapshots in different points. Case-study will also suit well for my purposes because it allows mixed approach on the research including also some quantitative methods. In this case, this means for instance using existing statistics as empirical data as well as SNA.

I will construct the case study from variety of information sources. This is because the depth of analysis is highly emphasized in case studies (Yin, 1989) and because of triangulation (Jick, 1979). One may notice that also a holistic case study is practically possible, because there have been and still are a limited number of companies in the network.

Sources on data

Informants for interviews (and SNA)

There are a limited number of companies and other organizations involved (see Appendix 1). Most of these organizations have been found already during my preliminary study. However, another way to find all the relevant organizations and especially the most relevant informants (individuals) could be a process, where informants themselves define the network of individuals related to the emergence. Answers to the question “*With whom have you been working with during the emergence*” could construct the sample. Naturally, some persons are mentioned several times, but in a sense this just helps us to delimit the final set of informants. Figure 6 illustrates the tentative choosing process of informants.

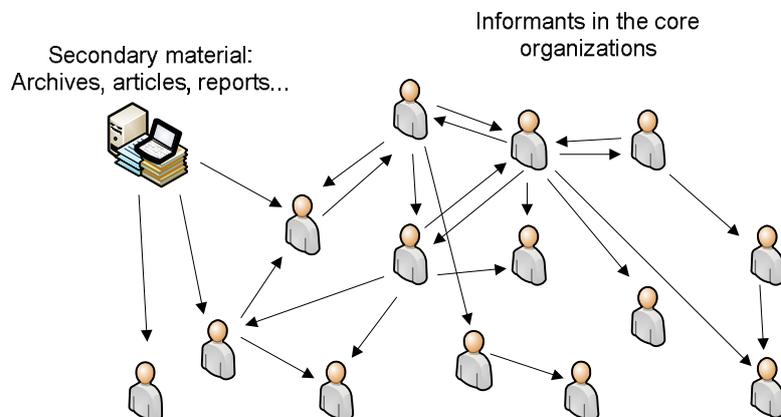


Figure 6. Simplified illustration of choosing informants

As a whole, my further research will include an extensive field study with several actors (also the adapters and other stakeholders), totally 30-40 interviews. Most of the people will be named by other informants, but I have already planned to interview some person that could otherwise be easily forgotten, such as rectors (Osmo Hassi, J-T Erikson) and the administrative director of TUT.

Other data sources

According to several scholars, the strength of the case study is the opportunity to use several different data sources to construct the case description. This also enables strong triangulation (Jick, 1979) for the study. Figure 7 illustrates the information sources on data. The emergence of the laser cluster as well as the main information sources are highlighted in bold letters.

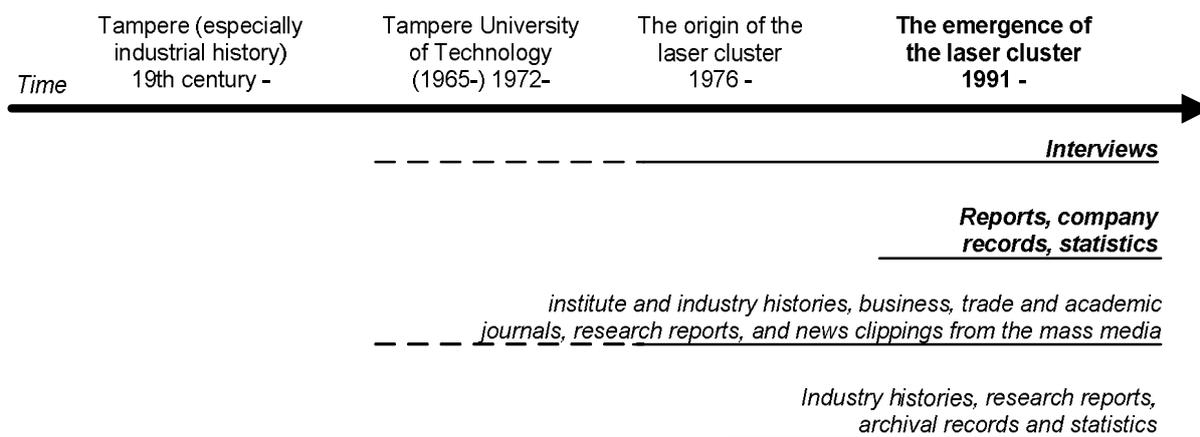


Figure 7. Simplified illustration of different information sources on data

The figure above includes also taking a look at as far as 19th century. This is important since it necessary to understand the path-dependence related to the study as well as the context of the study. For instance, Tampere has been one of the first in Finland to undergo industrial revolution as well as the rise of knowledge economy. There is also a strong background of interorganizational co-operation (public agencies and companies together) on regional development already in the early 1900's. Fortunately, there is a lot of material available to construct "the stories" behind the case (e.g. Kostiainen & Sotarauta, 2002).

Complementary research methods

Carlile & Christensen (2004) emphasize the value of anomalies when discussing about the cycles of theory building in management research. To design anomaly-seeking research they encourage to use different methods towards the object of the study and also studying phenomena within the phenomena. There are a couple of other methods that may complement the research and help to understand and to explain the emergence. Thus, I will introduce SNA and the event networks just briefly as complementing tools to improve the research methodology.

Social network analysis

In the social network analysis (SNA), networks consist of members, referred to as actors, and their relationships. These actors can be either distinct individuals or collective units (Webster &

Morrison, 2004). According to Tichy et al. (1979), several content areas may benefit from the network simulation at the organizational level. At the inter-organizational level, the web of direct and indirect relationships between organizations could be more explicit by a network approach.

In this study, SNA could help us to understand the roles (gatekeeper, mediators, etc.) of individuals and organizations and their impact on the emergence. To apply SNA, we already have relevant informants representing the individuals and organizations related to the emergence (Figure 6). However, there are few challenges related to the time: informants' memories and the changing roles/positions. Thus, it is at least extremely difficult if not impossible to capture the evolution of the network structure as a continuous process. Instead, I will divide the emergence of the laser cluster to max. three phases. To divide the timeline, I need to trace the key events that have significantly affected on the emergence and the nature of the cluster. At the moment, it seems that events would be the establishments of Optoelectronics Research Center in 1999 and Laser Competence Centre Finland in 2006 (see Appendix 1) but to be sure I will employ the event-based networks.

Event-based networks

The emergence may be considered as a combination and a chain of separate but interdependent events and activities over time which have lead to the situation nowadays. Actually these events consist themselves a network that may help to understand the dynamics during the emergence. The longitudinal case study method already captures the key events, but utilizing the so-called event networks could complement our picture on the emergence and provide deeper insight on the case.

Hedaa & Törnroos (2008) argue that extensions of network theory, methods and models can be approached by using connected events as a base. They suggest connected events as a theoretical foundation for the study of time and processes in business relationships. According to the authors, event networks may provide possibility to theoretically understand how networks work in different settings, since there is continuous (past, present, expectation for the future) learning and adaption process going on between the event networks and the actor networks.

Hedaa & Törnroos (2008) suggest using contextual and longitudinal research approaches, when de- and reconstructing events by tracing these over time in specific network context. Thus, my choice of the longitudinal case study actually enables using event networks as a complementary research method for the study.

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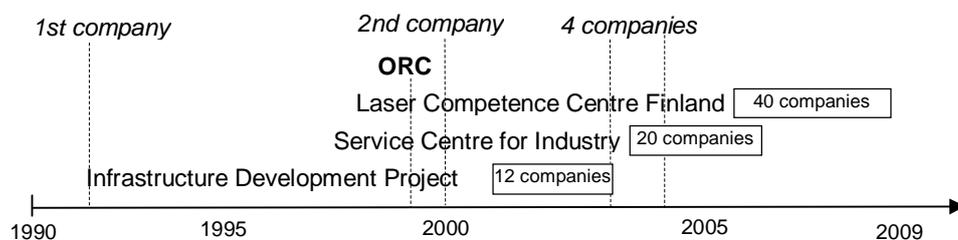
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Appendix 1. Laser cluster in a nutshell

Optoelectronics (or photonics, i.e. lasers) is considered as the alliance of optics and electronics, emphasizing the properties of light. Applications include e.g. compact disc players, fibre optic communication systems, bar code scanners, materials processing, radars, sensors, and mobile phones. United States National Academy of Sciences has predicted 21st century to be as successful to photonics as the 20th century was to electronics (Pessa, Kauranen & Pöyhönen, 2005)

The origin of the laser cluster dates back to the mid 1970's and to the Prof. Markus Pessa. He joined TUT in 1976 and started basic research on the structure of metals at TUT. Later on in the early 1980's he moved to semiconductors, especially multilayer semiconductors. In the late 1980s Pessa was among the first in Europe to develop and apply gas-source and all-solid-source molecular-beam-epitaxy (MBE) crystal growth methods, originally invented at AT&T Bell Laboratories. The early 1990 the group focused on optoelectronics with a quite unclear picture about the future development of the technology and industry. The research has however been seen in Europe and Alcatel took the group into the EU projects. At the same time the first company, Tutcore, was founded. In 1996 a part of the company was sold to a US manufacturer, Coherent, and in 2002 it bought all share capital. Pessa's research group was appointed the Finnish Centre of Excellence in 1995. In 1999 TUT founded Optoelectronics Research Center (ORC) to prevent the knowledge leakage and the loss of key personnel.

Primarily the present laser cluster in Tampere region bases on the research on optics, production engineering and material sciences at TUT in addition to research on optoelectronics. The formation of the industry in the region has been supported by several public-financed infrastructure development projects which have enabled the participation of the adapters from various industries. The circumstances have also enabled several companies directly or indirectly spun from TUT to manufacture or exploit diode lasers, fiber lasers, and light modulation devices. Almost ten years after Tutcore (Coherent Finland) Modulight Ltd was founded in 2000 to capitalize on transmitter laser diode know-how from ORC. Only a couple years later four new companies were established. Cavitar Ltd counts on diode laser illumination technology and offer solutions for monitoring different processes accurately. EpiCrystals Inc develops advanced light sources for the next generation projection display applications. RefleKron Ltd is aiming to be a premier provider of customized solutions for pulsed laser systems. Corelase Ltd was founded 2003 as a result of the walk-out of some of the key personnel from Coherent Finland which did not see the potential of fiber laser in the same way that some of the employees did. Today Corelase develops next generation lasers for material processing applications and it became part of the Rofin Group through acquisition in 2007. A brief timeline of the cluster is shown below.



In 2009 the laser cluster covers several units of TUT and nearly 40 companies and other high education institutes. Cluster's expertise covers the entire development chain including technology oriented basic

research, end users' application development, system integration and testing of lasers, as well as aspects of training and education. Combined turnover of the spin-off companies from TUT was over EUR 20 million in 2007 and estimated turnover in 2010 is nearly 40 million. The whole industry of photonics in Finland including both manufacturers and adapters has over 300 million turnover. ORC's research portfolio is about EUR 5 million of collaborative R&D grants and contracts and it is running about 25 national and international research projects with dozens of universities and companies worldwide. Investments in equipment make ORC one of the best equipped academic research units in Finland and the largest university-based research centre in Europe in the MBE crystal growth technique and complete optoelectronic device processing and characterization facilities.

Table 1. *The key actors in the emergence of the laser cluster*

<i>Academic actors</i>	<i>Companies</i>	<i>Public agencies and other actors</i>
Prof. Markus Pessa and his research group → ORC (Optoelectronics Research Center)	Spin-off companies Adapter companies and research units VC Companies	Tekes (Finnish Funding Agency for Technology and Innovation) The Academy of Finland The City of Tampere T&E Centre (The Employment and Economic Development Centre) of Pirkanmaa VTT (Technical Research Centre of Finland) Technology Centre Hermia Ltd
TUT (Tampere University of Technology) / Administration, University services		
TUT / Institute of Production Engineering (IPE), Institute of Material Sciences (IMS), Applied Optics Group		
+ other research centers as partners		