

Applying Technology Convergence for Innovation in Nordic regions

- Applying converging technologies – competitive advantages achieved through technological development in the gaps between existing technologies or by technological fusion
- Strategic thinking about converging technologies especially in a regional context
- Adopting converging technologies in regional innovation strategies



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Abstract: The report investigates how policy makers can place technological convergence at the top of the agenda in (regional) innovation policies to enable more companies and research institutions to begin to address opportunities for innovation and growth generated through technological convergence. The study draws on a literature review and interviews with experts, companies, mediating organisations, and regional authorities. In addition, we have conducted a survey in the Nordic countries. The survey identified the following main challenges and gaps for companies to engage in innovation projects that address converging technologies: 1) Existing and enabling technologies are important for the converging technology innovation process, and companies need external assistance to get from a stage of being aware of existing and enabling technologies to actually using them actively in an innovation process and for commercial purposes. 2) Companies find it difficult to find new partners outside their traditional networks. 3) Most of the studied companies stated that they would require external assistance in order to identify appropriate partners. Key policy recommendations of the report are the following: 1) Identification of potentials for converging technologies through regional technological foresight exercises, 2) Implementation of a new innovation strategy based on converging technologies; and 3) Further research for strengthening Nordic platforms for developing converging technologies.		
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Executive summary

Main objectives

Converging technologies are increasingly changing the market conditions for companies in many industry sectors. This occurs as new technologies and new combinations of technologies merge, e.g. nanotechnology and ICT technologies. Consequently, existing boundaries between industry sectors become increasingly blurred.

Converging technologies can lead to disruptive changes in the market with new competitors and thus be a threat to companies that do not exploit innovation opportunities. However, technological convergence also offers new opportunities for companies that are able to identify business opportunities and market openings stemming from technological convergence.

The aim of this project has been to analyse business potentials stemming from converging technologies and as a basis for evidence-based policy-making in the field of R&D and technological innovation. To this end, the project has addressed the following questions:

- Which kind of policy measures and development practices are best suited to promote transfer of knowledge and commercialisation in converging technologies?
- Which types of companies and regions could benefit from converging technology approaches?
- What are the implications and challenges for innovation policies in the medium-term in the light of converging technologies?
- Which types of policy measures and instruments are appropriate to stimulate and sustain commercial and broader societal benefits stemming from technological convergence?

The project was initiated to contribute to a broader debate about technological convergence and the business opportunities to be gained if Nordic regional innovation policies take more action to raise awareness about technological convergence and include demonstration projects where entrepreneurial companies can take advantage of changing market conditions driven by converging technologies. Taking its point of departure in technological convergence as a source of innovation, the report presents a number of recommendations and it proposes a set of tools and methods particularly relevant for public sector actors and policy makers pertaining to innovation strategies at the regional level.

Methods

Until now, the concept of converging technologies has not been at the heart of the R&D and innovation policies of the Nordic countries.

First, we conducted a literature review and complemented it with interviews with international experts to introduce and apply the concept to the Nordic policy level and test its principles.

Second, we screened a large number of companies to find relevant examples of businesses cases that have applied the principles of converging technologies. The interviews with these companies resulted in seven case studies, which provide good practice examples of different types of companies' use of converging technologies.

Third, to provide further input to the recommendations we conducted more than 40 semi-structured, in-depth interviews with companies, business/science parks, innovation networks and regional authorities in Finland, Sweden, Denmark and Iceland.

Fourth, we conducted a Nordic converging technology survey to supplement the qualitative information with some quantitative data. We carried out the survey among companies and organisations offering (technological) service to companies. Thirty companies and organisations offering (technological) service to companies filled in a short questionnaire. As the survey only comprised a limited number of companies, the results of the survey have a more explorative character.

Finally, the principles and applications of converging technologies were tested in three workshops with companies, research institutes and international experts (academic and business) in Copenhagen, Reykjavik and Helsinki. The recommendations were also tested in the selected regions through discussions with regional authorities and selected science parks. The results of our analyses are presented in this report.

Through the applied methodology the study offers new explorative evidence of how companies and regional authorities apply technology convergence for business purposes. The findings could thus contribute to introducing technology convergence to innovation policies in the Nordic countries.

Results and conclusions

The report shows that the Nordic companies are taking advantage of converging technologies and this is leading to improved products, niche products or markets. However, it mainly happens by coincidence and is not part of a coherent and explicit business strategy. The Nordic companies are therefore unable to take full strategic advantage of converging technologies at this stage.

The report investigates how policy makers can place technological convergence at the top of the agenda in (regional) innovation policies to enable more companies and research

institutions to begin to address opportunities for innovation and growth generated through technological convergence.

The study draws on a literature review and interviews with experts, companies, mediating organisations, and regional authorities. In addition, we have conducted a survey in the Nordic countries.

Why should policy makers get involved?

OECD countries and regions have already integrated converging technologies in their innovation policies as a strategic tool for improving regional and national innovation strategies and systems. New models emerge in the cross field between existing and enabling technologies and through the deployment of cross-disciplinary commercial and technological skills. Although converging technology is not widely integrated into (regional) innovation policy in the EU and in the Nordic countries, regions and countries outside the EU are increasingly using converging technologies as a strategic tool in policy making. One of the more prominent examples in the literature is Silicon Valley in California. There are also signs that enabling technologies in particular are becoming an integral part of innovation strategies in an EU, national and regional context. Consequently, converging technologies should be more strategically integrated into the innovation policy of the Nordic countries.

The Nordic countries all have strong regional innovation systems that focus strategically on R&D, high-tech companies and strong links to lead users. Furthermore, many innovation initiatives also build on networks and clusters that have a strong capacity building effect. If converging technologies were added to this formula it could create a competitive advantage for the Nordic regions that would not be easily replicable.

What is required to engage in converging technology innovation?

89% of the companies surveyed in this study have previously participated in innovation projects involving converging technologies, but the survey and interviews reveal that the companies generally lack a combination of skills and a knowledge base to take full advantage of the opportunities presented by converging technologies.

The survey identified the following main challenges and gaps for companies to engage in innovation projects that address converging technologies: Existing and enabling technologies are important for the converging technology innovation process, and companies need external assistance to get from a stage of being aware of existing and enabling technologies to actually using them actively in an innovation process and for commercial purposes. To stimulate a broader knowledge about commercial opportunities stemming from technological convergence, regional policy makers could use funds strategically to enable public-private partnerships (PPP) to explore and test potential commercial applications parallel to broader awareness measures. Companies find it difficult to find new partners outside their traditional networks. Partner search is particularly perceived as difficult if it concerns other industry

sectors or if it concerns new fields of technology. Most of the studied companies stated that they would require external assistance in order to identify appropriate partners.

Within the context of technological convergence incubators and networks seem to play a minor role.

Recommendations

The analysis clearly shows that it will require an approach to programme design based on multidisciplinary and activities that address market demand factors to derive potential market benefits from exploiting technological convergence.

Involving programme design methods that draw on the strengths of a given region can be one way to prioritize programme focus. Experience from the Danish process of designing the priorities for the future strategic research in Denmark could be relevant also in a regional context.

Some of the methods through which policy makers in the Nordic regions can explore potentials stemming from technological convergence as part of an innovation strategy could be:

Identification of potentials for converging technologies

- Regional technological foresight exercises
 - Focus on sub-sectors and generic enabling technologies
 - Involvement of companies and mediating organisations in application-oriented testing activities and with a commercial perspective
 - Identify convergence technology trends within the sub-sectors.

Implementation of a new innovation strategy based on converging technologies

- High involvement of mediating organisation (universities, science parks, sector organisations to build innovation capacity among firms)
- Development of a regional convergence technology platform within the region's identified industrial and technological strengths – physically based in a mediating organisation and supported by the regional authorities
- Linking Nordic regions – linking clusters and networks - from different sectors and technologies with a potential for developing converging technology application with a global commercial potential.

Further research for strengthening Nordic platforms for developing converging technologies

At a Nordic level, immediate opportunities from linking existing clusters and networks should be explored with regard to business models, for example by focusing on shared opportunities within converging technologies, in biotechnology and the food industry across existing value chains. By building on existing clusters a sustainable platform for technological convergence may emerge with substantial spill-over effects across sectors and traditional networks. In addition to strengthening the Nordic innovation system, a strategic focus on technological convergence could add a new competitive dimension to Nordic R&D-oriented projects in which companies identify niche areas across Nordic industrial sectors and research areas in which they have unique strengths.

Foreword

This report has been partly (50%) financed by Nordic Innovation Centre (NICE). The report has been prepared by Danish Technological Institute (DTI)¹, VTT², Innovation Center Iceland³, KETEK⁴, Innovation Center Norway⁵ and Øresund Food Network⁶.

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1. INTRODUCTION

One of the major drivers of structural change is technological development. In the last couple of decades technological development has not only increased in the development of single technologies, technologies are also converging and forming new technological combinations and hybrids. Converging technologies are affecting market conditions and business opportunities. Regional innovation policies should therefore address business opportunities stemming from technological convergence including which type of regulatory frameworks may best further commercial benefits from convergence.

Generic and emerging technologies, – such as nanotechnology, biotechnology and information technology – play a key role in the field of converging technologies. Converging technologies do not only have an impact on R&D, they also have an impact on existing boundaries between industry sectors and markets, which become blurred. This has a direct impact on companies as their business models may have to adapt as new competitors enter their traditional business areas as has been seen in telecommunications for instance.

Across the Nordic regions, there is a growing interest in and examples of how companies and actors in one sector can find inspiration from other sectors' technology deployment. This is particularly the case in emerging technologies. There is some evidence that innovation can be sustained and expanded if companies can identify business application areas through deployment of technological opportunities outside their own sector.

A major Danish survey about firm's innovation behaviour during the current crisis suggests that many firms currently suffer from lack of investment capital, and that this affects their innovation activities. However, at the same time some firms have increased their innovation activities during the crisis. Furthermore, studies from previous financial crises suggest that those businesses that can maintain or increase their innovation activities during an economic crisis are likely to gain new market shares due to their innovation investments once the crisis has ended (Boston Consulting, 2009 and Forsknings- og Innovationsstyrelsen 2009). Therefore governments and regional policy makers should assess to which degree the design of their strategic research and innovation policies and platforms are sufficiently geared to stimulate and sustain strategic research activities which build on technological convergence, and which could generate substantial commercial and societal gains once the crisis has ended.

The regions in the Nordic countries have great potential for exploring the opportunities of converging technology, as many regions are specialised and have a high level of technical knowledge. They could expand this knowledge by combining their knowledge with technological knowledge from other sectors not previously associated with their own, either within one region or in collaboration with other Nordic regions. Therefore, regional innovation policy could explore the potential at regional level through the converging

technology measures or schemes identified in this report and bring together the innovation actors of tomorrow. This will improve the competitiveness of the Nordic companies and thus also that of the Nordic regions.

At EU level, converging technologies, especially through enabling technologies, are starting to become part of the EU's main initiatives and projects such as the 7th Framework Programme. If the Nordic regions manage to build on the existing strong knowledge base by focusing on technology in policy-making, they could set the agenda for new types of collaboration in Europe.

1.1. AIM OF THE PROJECT

The aim of this project has been to analyse business potentials stemming from converging technologies and as a basis for evidence-based policy-making in the field of R&D and technological innovation. To this end, the project has addressed the following questions:

- Which kind of policy measures and development practices are best suited to promote transfer of knowledge and commercialisation in converging technologies?
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The project was initiated to contribute to a broader debate about technological convergence and the business opportunities to be gained if Nordic regional innovation policies take more action to raise awareness about technological convergence and include demonstration projects where entrepreneurial companies can take advantage of changing market conditions driven by converging technologies. Taking its point of departure in technological convergence as a source of innovation, the report presents a number of recommendations and it proposes a set of tools and methods particularly relevant for public sector actors and policy makers pertaining to innovation strategies at the regional level.

APPROACH OF THE PROJECT

Until now, the concept of *converging technologies* has not been at the heart of the R&D and innovation policies of the Nordic countries.

First, we conducted a literature review and complemented it with interviews with international experts to introduce and apply the concept to the Nordic policy level and test its principles.

Second, we screened a large number of companies to find relevant examples of businesses cases that have applied the principles of converging technologies. The interviews with these

companies resulted in seven case studies, which provide good practice examples of different types of companies' use of converging technologies.

Third, to provide further input to the recommendations we conducted more than 40 semi-structured, in-depth interviews with companies, business/science parks, innovation networks and regional authorities in Finland, Sweden, Denmark and Iceland.

Fourth, we conducted a *Nordic converging technology survey* to supplement the qualitative information with some quantitative data. We carried out the survey among companies and organisations offering (technological) service to companies. Thirty companies and organisations offering (technological) service to companies filled in a short questionnaire. As the survey only comprised a limited number of companies, the results of the survey have a more explorative character.

Finally, the principles and applications of converging technologies were tested in three workshops with companies, research institutes and international experts (academic and business) in Copenhagen, Reykjavik and Helsinki. The recommendations were also tested in the selected regions through discussions with regional authorities and selected science parks. The results of our analyses are presented in this report.

Through the applied methodology the study offers new explorative evidence of how companies and regional authorities apply technology convergence for business purposes. The findings could thus contribute to introducing technology convergence to innovation policies in the Nordic countries.

1.2. REPORT STRUCTURE

The report is divided into six main sections:

1. Introduction

This section provides an introduction to the report and to the project.

2. Definition of technological convergence

Converging technologies is a relatively new concept in policy terms. Therefore, this section provides a definition of converging technologies based on a review of literature and policy documents and an analysis of case study examples.

3. Background: converging technologies meeting new market needs and creating opportunities

This section provides an overview of the challenges and opportunities of converging technologies from business to policy. Converging technologies may become a feature in firm-based R&D to explore business opportunities stemming from converging technologies or as a firm response to disruptive market changes brought about by converging technologies. At the end of the section, we take a closer look at the *policy level*, including examples of already existing converging technology policy initiatives launched to enable more firms to take advantage of the opportunities and challenges of converging technologies.

4. Nordic companies: challenges and needs for engaging in converging technology activities

This section highlights challenges and needs identified by companies that engage in or expect to engage in converging technologies to exploit new business opportunities. The section is based on the results of the interviews conducted in Denmark, Sweden, Finland and Iceland with companies, academic experts, regional authorities, science parks and the *Nordic converging technology survey*. It also summarizes the results of the workshops and desk research carried out in the project.

5. Nordic regions: possibilities for regional policies on converging technologies

This section discusses existing and potential policy measures pertaining to converging technology innovation particularly as a part of regional innovation strategies. First we present a framework to approach converging technologies as a regional innovation opportunity. Second, we use this framework to identify innovation policy measures and schemes for regions with differentiated knowledge bases. Third, we use it as the basis for the formulation of guidelines for the implementation of new converging technology innovation policies.

6. Summary and recommendations

This section summarises the key findings in the study. It provides recommendations for converging technology innovation policy. The aim has been to formulate the next practices of regional converging technology policies that can be pursued as supplements to traditional regional policies and to more contemporary regional innovation policies.

2. DIMENSIONS OF CONVERGING TECHNOLOGIES

Companies have been utilizing or developing converging technologies for quite a long time as they may conceive converging technologies as part of their product development or may just use other terms such as technology fusion (Kodama 1992) or technology combinations.

There is also a tendency that converging technology has not occurred in a systematic, strategic and explicit manner. A 2008 survey of 1,010 Danish growth-oriented companies showed that the methodology underlying the innovation concept of convergence appears to be widely used in the companies, but not defined using the term 'convergence'.

Table 1 shows that 35% of the survey companies combine different technologies and solutions that are not traditionally used in their industry sector and 41% have searched for technological knowledge or solutions that are not traditionally used in their industry sector.

Table 1: Companies using converging technology in Denmark

Companies combining different technologies and solutions from outside their industry sector	Have you searched for new technological knowledge or solutions, no traditionally used within your industry sector?		
	Yes	No	Total
Yes, often	114 (11%)	10 (1%)	124 (12%)
Yes, now and again	172 (17%)	63 (6%)	235 (23%)
No	129 (13%)	522 (52%)	651 (65%)
Total	415 (41%)	595 (59%)	1010 (100%)

Source: 'Danmarks Vækstlag' - a panel of growth-oriented Danish companies set up to provide input to policy formulation. The survey is conducted by Danish Technological Institute, Centre for Policy and Business Analysis, 2008. N: 1010 growth-oriented Danish companies

The Danish survey indicates that companies search for solutions outside their traditional industry sectors. The survey furthermore suggests that converging technologies may have the potential to become an integral part of the innovation policy agenda in the Nordic countries.

Throughout the 1990s, the concept of converging technology has been implemented mostly in the ICT sector, but also in other sectors, such as the textile sector, through the concept of 'technology fusion' (Kodama 1992). Only recently the concept of converging technologies has started to spread to other sectors and fields of technology. One of the first major studies on converging technologies outside the ICT sectors was 'Converging Technologies for Improving Human Performance, Nanotechnology, Biotechnology, Information Technology and Cognitive Science' (Roco & Bainbridge 2002). The study defines converging technologies as *'the synergistic combination of four major 'NBIC' (nano-bio-info-cogno) provinces of science and technology'* (Roco & Bainbridge 2002).

Table 2 presents some of other the definitions used in the literature.

Table 2: Definitions of technological convergence

Definition	Source
'the transition of knowledge convergence into a potential for technological innovation, allowing inter-industry knowledge spillovers to facilitate new technological combinations'	<i>Hacklin, F (2007), Management of Convergence in Innovation – Strategies and Capabilities for Value Creation Beyond Blurred Industry Boundaries, Zurich</i>
'the growing overlaps between the technologies, services and firms active in each sector'	<i>OECD (2001), Telecommunications and broadcasting: Convergence or Collision, Paris</i>
'the erosion of boundaries that define and isolate industry-specific knowledge'	<i>Pennings and Puranam (2001), Market convergence and firm strategy: new directions for theory and research, The Future of Innovation Studies, Eindhoven</i>
'the growing together of technologies which fundamentally alters the boundaries of previously distinct industry and market sectors and merges them into a new competitive environment'	<i>Bally, N. (2005), Deriving managerial implications from technological convergence along the innovation process, Åbo, Åbo Academy School of Business,</i>
'Converging technologies' point out emerging interactions between previously separate fields of research and technological development. Such shifts result in qualitatively new technological possibilities, with potentially revolutionary impacts.	<i>Doorn, M. (eds.) (2006). Converging technologies. Innovation patterns and impacts on society. STT 71. STT Study Centre for Technology Trends. Amsterdam, Netherlands.</i>

At EU level, converging technologies are defined as '*enabling technologies and knowledge systems that enable each other in the pursuit of a common goal*' (Nordman 2004). Unlike the first definition where focus is limited to four generic technologies, the EU definition includes other types of technologies and sector-specific knowledge.

It is important to note that the vast majority of the definitions and literature are research-oriented and do not address commercial opportunities directly at the firm level. This study has aimed to fill a vacuum in the current knowledge base through an exploration and analysis of the possibilities of converging technologies at a company level and in the context of a regional innovation systems and policies. For this purpose an operational definition of converging technology innovation is needed.

The study has taken its point of departure in existing firm practices by identifying several companies that already work with converging technology innovation and has used these cases as the basis for defining converging technology innovation in practice. The paths for a company to enter the converging technology development process can be many as is illustrated in the three case study examples below:

Case 1: Introduction of nanotechnology – creating solutions and new market opportunities

A Swedish steel producer received a special request from a customer. The company discovered that they needed a special structure and size of steel to solve the problem. They searched for possible solutions and discovered that University of Gothenburg, Sweden, specialised in nanotechnology. By collaborating with the university the end-product proved to be stronger and more flexible. Subsequently, the use of nanotechnology opened up new markets (sports equipment) for the company. Using an enabling and formerly unused technology solved the company's problem and opened up new markets. They still use nanotechnology in both their production and R&D labs.

Case 2: From wood painting and skin cancer to 'sun protecting paint'

The idea is based on a request from a Danish company to DTI. The company wished to improve its wood preservation paint products by reducing the damaging effects from UVA or UVB radiation. DTI's Technology Partnership programme used its global database of approx. 20,000 experts to find an innovative solution to the problem. A professor in dermatology from a German university answered the request and contributed with useful results from research on human skin cancer. This resulted in a joint R&D collaboration and the result of the cooperation led to a *20% increase* in the sun protection effect of the wood preservation product, and the company *increased its sales by 17% in the first season*. Today this specific product development has become a way to differentiate the company in the market.

Case 3: Pro-active approach to innovation

The Danish company Fibertex is a leading manufacturer of needle punch and spunmelt nonwovens. The company's approach to technology convergence is based on two different types of pro-active activities.

- 1) User-driven innovation approach
By attending international university courses and exploring state-of-the-art methods and technology used by clients Fibertex has improved their understanding of the processes and technology used by their clients. This has resulted in new functions for their products and new markets where Fibertex products have substituted products not related to their field of expertise. It is arguable whether this is converging technology, but the client substituted an existing product for a product based on another technology that has better qualities for the same purpose.
- 2) The second approach is the introduction of nanotechnology that came through a request from an individual (inventor) who had purchased a nanotechnology machine from the UK and needed a company to test the methods and technology. This led to a research project (still running) with two local universities specialised in nanotechnology where several methods have been tested, especially within the filtering/absorption capacity of the products. At this stage, the project has resulted in several patents and before long commercialisation of a new product. The introduction of nanotechnology has improved the existing products and is expected to result in new markets for Fibertex.

These examples illustrate just three of many different commercial approaches to converging technologies. For the purposes of this study converging technologies innovation at company level is defined as *'utilization of technology or knowledge which is outside the dominant technology or knowledge platform of the company'*

This definition forms the point of departure for analysing converging technology innovation with special focus on exploitation of converging technologies for commercial purposes through regional innovation policy measures.

3. COMBINING AND CONVERGING NEW TECHNOLOGIES MEET NEW MARKET NEEDS AND CREATE OPPORTUNITIES

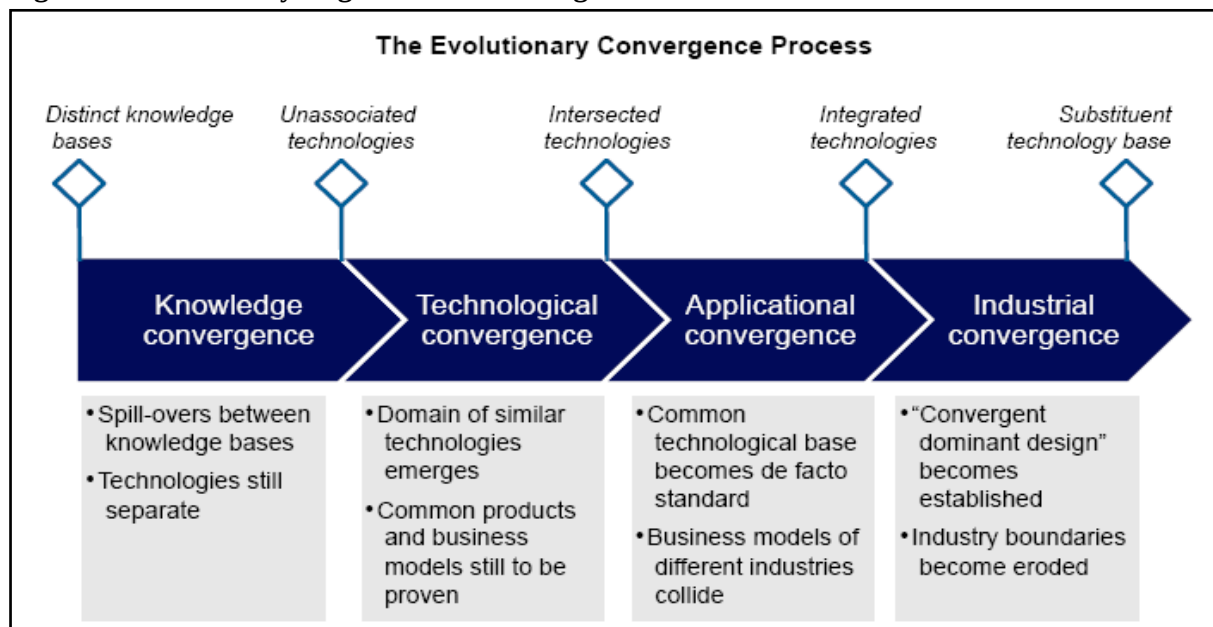
Research organisations and companies that exploit converging technologies induce spillovers between knowledge bases. This can blur the boundaries between industries and therefore have large impacts on economic structures at the firm level as well. This section discusses the mechanisms that change industries and sectors, also at the firm level.

With a better knowledge base about the challenges and opportunities stemming from converging technologies, policy makers will have better means to align regional innovation policies to new opportunities stemming from technological convergence.

EVOLUTIONARY STAGES OF CONVERGENCE

Hacklin (2008) has formulated four stages of an evolutionary convergence process illustrated in Figure 1 below.

Figure 1: Evolutionary stage model of convergence



Source: Hacklin, 2008

The results of the convergence process can provide opportunities for companies, but they can also be a threat to their existence if they fail to respond to the changes that occur because of the convergence process. This is because converging technologies may impact market

conditions in a disruptive manner and open up to entirely new competitors who operate with entirely new business models. This was seen in the field of telecommunication with the introduction of SKYPE, for example.

The *knowledge convergence stage* denotes the emergence of spillovers between previously unassociated and distinct knowledge bases giving rise to the erosion of established boundaries that isolate industry-specific knowledge. This is the premature stage of the converging technology process where technologies are still separate. However, in this stage the initial core ideas of convergence are formed. These core ideas will lead to the second stage - technological convergence.

Technological convergence implies the transition of knowledge convergence into a potential for technological convergence. It allows inter-industry knowledge spillovers to facilitate new technological combinations. In this stage, technologies are converging and forming new, previously non-existing technological domains.

Applicational convergence denotes the transition of technological convergence into opportunities for new value creation through applications. At best, these applications outperform the sum of their original parts. The camera phone is an example of an application convergence where the innovator created a new service model based on convergence of former separate technologies. Today, cameras have become a standard feature of mobile phones. Since the introduction of the camera phone, several new technologies have been combined in today's mobile phones.

Industrial convergence is an advancement of application convergence towards the level of industries. A new commercial platform is formed at the interface of two existing industries. This means that companies from previously distinct industries suddenly become competitors.

Stieglitz (2002), who has identified two types of convergence, namely *technological convergence* and *market convergence*, also supports this view. *Technological convergence in upstream markets* where a production of dissimilar products increasingly depends on the same technological assets. A recent example is the semiconductor industry, and the related discussion about general-purpose technologies, such as nanotechnology and bioscience.

Technological convergence in downstream markets takes place when technological assets of existing industries are used in combination to develop new products or services.

While *technological convergence* has an impact on the technological assets of firms, *market convergence* affects demand patterns in different industries. Product-based substitute convergence involves increased cross-industry competition created by increased overlap in capabilities between two industries. An example from Stieglitz is the growing overlap between the mainframe and minicomputer markets. (Lind 2004)

Product convergence of complementarities occurs if existing products or services become complementary to each other.

The above model indicates how industries can change over time through convergence, and this will naturally have an impact at the firm level. Companies can position themselves at a given stage of the co-evolutionary convergence process and build strategies to manage the situation. In that sense, acting along rules given by the evolutionary stage model may yield early mover advantages compared to those that wait to see the impact of convergence.

3.1. CONVERGING TECHNOLOGIES AT FIRM LEVEL

The evolutionary stages of convergence affect companies as markets, technologies, industries and products converge. All stages of the evolutionary convergence process will create opportunities and challenges for companies affected by the technologies or knowledge areas in the process.

However, many other factors can influence companies in the direction of engaging with converging technologies either triggered by internal or external factors (Bally 2005). *Internal factors of influence*, such as the way a company searches for new knowledge, creative leadership, or new technology, can change the generic picture of the innovation process, especially when companies search for new technology fields.

External factors of influence include specialized customer demands for new product functionalities or improvement of already existing products. These demands can occur as new types of technologies become available in a given market, i.e. through new companies or if an existing company introduces an emerging technology such as nanotechnology and improves a product through this emerging technology. Regulatory factors may also drive technological convergence, for example, environmental legislation.

A firm that engages in technological convergence innovation triggered by *internal factors* can benefit from early-mover advantages. This can provide competitive advantages compared to the nearest competitors, but it can also result in entrance into new markets. In this way, a company may become a competitor to previously un-associated companies and thereby create a new competitive pressure on other companies. (See case example 1)

External factors can accelerate that a company is forced to enter into a converging technology approach to innovation. However, at this point the early-mover advantages will be lost and the company will have to play catch-up. The evolutionary stages of convergence, which can redefine industries and market boundaries, can be one of the external factors that force a company to rethink its business strategy and business model including IPR. These factors illustrate that converging technology is a driver in the ongoing structural adjustment to the market and should thus be a strategic pursuit for innovative and knowledge-intensive firms.

The effect of internal and external drivers is that it becomes impossible to determine the boundaries of a certain market segment clearly. This creates new challenges for companies

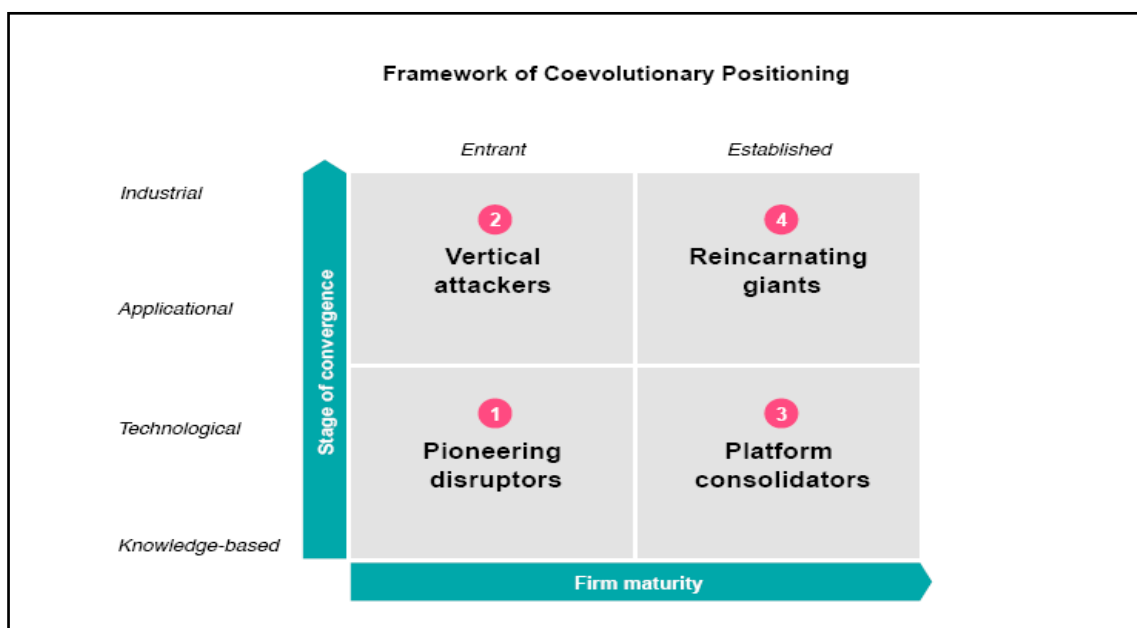
who will have to revisit market assumptions, their position in the value chain and a viable organisational set-up to fully exploit new opportunities.

However, the opportunities for the specific firm depend on the *type of company* and at what point in the evolutionary stage of convergence the company and its related market are.

3.2. TAKING ADVANTAGE OF CONVERGING TECHNOLOGY

To take advantage of converging technologies' impact on industry boundaries and markets, companies need to have certain capabilities and characteristics. Regions and companies in the Nordic regions differ and so do framework conditions including the regulatory environment. Not all regions will have the critical mass and a knowledge base to engage pro-actively in a converging technology innovation process or projects, for example due to a low-tech or one-track industrial base. The implication is that the positioning of companies in the evolutionary convergence process differs. Figure 2 presents four positions and types of companies related to evolutionary process.

Figure 2: Framework for the co-evolutionary positioning of firms



Source: Hacklin, 2008

The entrant companies can take advantage of different stages through visible strategic approaches using a technological asset in the form of either an existing technology asset used in a different market or by introducing an emerging technology to existing products, which creates new opportunities in other sectors or the current market. One of the major strategic approaches for entrant firms is to identify complementary niche areas either in the premature stages or in the commercialisation stage of the converging technology process (Hacklin 2008). The two types of entrant companies, as described by Hacklin, are pioneering disruptors and vertical attackers.

Pioneering disruptors

The close relationship with universities and science parks is a potential asset for companies, especially the rich access to codified knowledge in the form of converging technologies at a pre-competitive stage. This innovation model could be enhanced if a region takes an enabling role in bringing together these partners, and especially if these knowledge hubs represent different scientific disciplines and technologies. The vision that led to the creation of Stockholm School of Entrepreneurship explicitly built on such a model.

Case 4 shows an example of how a university spin-off company with close relations to several faculties at a university created a new product that is a substitute for an existing product.

Case 4: Research-based company in the field of food – biotechnology

The Swedish company Oatly AB is an R&D based food company with focus on functional foods. Most of Oatly AB is owned by a research group in Lund, i.e. Carnegie Foundation, Påengruppen, Industrifonden and Östersjöstiftelsen. An important part of Oatly AB is the patent and know-how of the network based around Professor Rickard Öste at Lund University. Rickard Öste is the founder of this network, and the first commercialisation of functional food products based on liquid oats in 1994 came through the university spin-off company Ceba Foods AB, now part of Oatly AB.

The network's research is vital for the company. It includes the technical and medical faculties at Lund University with focus on the technical, physical-chemical and physiological properties within the food/healthcare industry. The close relationship with the university and the cross-disciplinary research (food-biotechnology) has resulted in a range of non-dairy products made of oats instead of milk. These products are a direct substitute for dairy milk and a new competitor to dairy companies. This is also shown by a R&D project with the Chinese government where the non-dairy oat drinks are given to a large number of Chinese schoolchildren as a substitute for milk.

The research of the company and the research group has also resulted in other new companies, e.g. Aventure AB. In order to minimize risks, a new company is set up every time a new product/field is invented. The reason for this is the high-level R&D needed for these types of products and consequently the higher risks. Consequently, instead of risking an already accepted product, a new company is started to protect the successful product.

Case 5 presents a classic starting point for technological convergence, i.e. the transfer of an idea or solution from one context to another. In Case 5 the material, which had an appropriate durability in one context and was used in model planes, was successfully transferred to another environment that required at least a similar durability, i.e. the human mouth.

Case 5: From glass fibre used in remote controlled model planes to dental care innovation

StickTech Ltd. uses glass fibre to strengthen dental implants and give them flexibility. The idea came from the founder of the firm whose hobby was remote-controlled model planes. He was considering ways to strengthen the model planes in the landing phase. He noticed that glass fibre was particularly useful for that purpose. At the same time, he was also a student of dentistry. He noticed that there was the same need for strength and flexibility in dental implants. He studied the possibilities of using a glass fibre orally and came up with a solution of converging glass fibre with other materials to optimize the dental implant. This glass fibre-based solution is the core of StickTech's business.

Vertical attackers

Vertical attackers are companies with specific technological assets, especially companies that take advantage of their expertise within an emerging technology. These companies can put pressure on existing companies in the commercialisation stages of the converging technology process. SMEs with a product or technology applicable to many industries can make use of new emerging ecosystems based on specialization. These firms can achieve market dominance by being more agile than established companies with more lock-in capabilities and resources. The benefit for these entrant companies is that their technologies can be used in different industries and markets and this also enables a quick exit strategy.

The established mature companies have to play by the same rules as the entrant companies. As the boundaries erode between previously distinct industries, established companies need to find ways to secure their industry dominance and independence among the emerging set of entrants.

The Fibertex case (Case 3) is an example of how a company can enter new markets by improving an existing product to match the needs of an industry.

Platform consolidators

Platform consolidators are mainly established companies that seek to diversify their products by exploring innovation through a converging technology perspective. The established companies may look inside their own organisation to identify synergy by exploring complementary assets across divisions of the company. Such a move allows the company to grow horizontally with the convergence process, especially if strategic learning mechanisms are in place (Berghman, Liselore 2006). An example of this is Fibertex (Case 3). The three main R&D departments with each their technology base came together in a large room in a creative process to identify horizontal synergies with market potentials. The process proved

especially successful after the introduction of nanotechnology, which has created openings in new markets across the three departments.

Reincarnation of giants

Large companies with a strong foothold in an industry may invest in value network activities when the convergence process advances into the mature stages. This way this will transform into a strong value networking partner especially in collaboration with entrant companies that seek to participate in the innovation agenda of the established firms. Opening up of parts of the company, e.g. through providing access to IPR, promises opportunities for further horizontal convergence while other parts of the company might be in direct competition. Possible dominance advantages in one business segment have to be protected from spillovers from other segments – either through established or entrant companies – who may commoditize parts of the company. Some major companies have used this open innovation approach in order to use their technological assets to enter new markets as illustrated in Case 6.

Case 6 highlights that a convergence approach can be utilized as a policy tool to enhance regional or national innovation capacity through policy formulation. However, to engage in such a process a region should be able to identify the assets of the regional economic base, i.e. through identification of the relative position of the leading sectors in the region in the co-evolutionary phase highlighted above.

Case 6: One technology, two markets - Crospon Medical Devices and HP/Compact

A technology developed for the ICT sector is now an innovative new technology in the medical device sector. Micro needles for drug delivery had previously only been used in transdermal patches for nicotine delivery. The Irish company Crospon now uses HP Lab's intellectual property to offer drug delivery for other drugs than nicotine, which was not possible before. The deal between HP and Crospon is an example of a technology transfer (between formerly separated sectors) in which HP, through the IP Licensing Group, is pushing HP Labs's technology and research into new markets. The agreement resulted in part from HP's relationship with Enterprise Ireland where companies can license the intellectual property of HP and access the company's business and technology mentoring.

3.3. CONVERGING TECHNOLOGY AS A POLICY TOOL FOR REGIONAL/NATIONAL INNOVATION

An effective regional innovation system as well as effective regional/national innovation policy measures or schemes can act as *triggers* whereby a firm or a knowledge institution may enter a converging technology innovation process in which companies can take advantage of new emerging markets and industry conditions. Exploring regional strengths in new ways (i.e. through a technology perspective) can improve the innovation fabric in a region and this can lead to inward investment and an improved framework for the local companies as a whole.

Except from companies' search for new technologies outside their traditional industries, convergence of research fields and technologies are more widespread as a research phenomenon. For example, the European framework programme supports EU research networks and universities.

Most of the literature on converging technologies deals with convergence of research areas where the established boundaries of science and technology areas become blurred and in some cases this leads to new disciplines. There are some very interesting examples of this phenomena, e.g. in cases of bioinformatics, bioelectronics and the new emerging science of web and networks.

Under the 6th Framework Programme the European Commission called upon the recognition of novel potential of converging technologies to advance the Lisbon Agreement. An expert group⁷ encouraged wise investments in converging technology to stimulate science and technology research, strengthen economic competitiveness and address the needs of European societies. It also concluded that preparatory action should be taken to implement converging technologies as a thematic research priority, develop converging technologies for the European Knowledge Society (CTEKS) as a specifically European approach and establish a CTEKS research community. These recommendations have directly contributed to the content of the 7th Framework Programme.

Converging technologies are also part of the current 7th Framework Programme, for example under the theme *NMP - Nanosciences, Nanotechnologies, Materials and new Production Technologies*⁸, where two of the actions concern converging technologies, i.e. *Nanosciences and converging sciences* and *Nanotechnologies and converging technologies*. The 7th Framework Programme identifies a clear need to integrate wider society and company level perspectives into converging technology in nanotechnology, where focus was previously limited to a research perspective.

Nevertheless, technological convergence has not been a top priority in the political agenda in Europe, and even to a lesser extent in the Nordic regions despite signs of technology convergence in both research platforms and in the market, such as functional foods and an increase in the use of emerging enabling technologies for commercial purposes.

In this project we have aimed to look at converging technologies in a wider policy perspective as well as at a firm level to discover if Nordic companies and science parks perceive technological convergence as an opportunity or a challenge.

⁷ http://ec.europa.eu/research/conferences/2004/ntw/pdf/final_report_en.pdf

⁸ http://cordis.europa.eu/fp7/cooperation/nanotechnology_en.html

Convergence of different fields of science can be advanced through regionally based SMEs, as is shown in Case 7. The case example describes how convergence of basic medical research and engineering can turn into an innovation utilized in for example the functional foods industry.

Case 7: Microbial analysis innovation for functional food industry based on convergence of medical microbiological research and engineering

CyFlo, a small Finnish biotech company, offers research and development services for the food and feed industry, the life sciences sector and industries dealing with microbes. It has developed a unique method for analysis of complex microbial and bacteriological samples. The method utilizes a flow cytometric technique to detect and calculate bacteria in complex biological samples, such as intestinal samples.

The analysis innovation was based on a PhD research project in medicine carried out at the start of 2000s by the current company CEO. The research project dealt with the question how a person's genes affect the composition of intestinal bacteria. He encountered the following technological problem: most of the bacteriological research methods are aimed at the identification of a single pathogenic bacterium. However, to solve the research problem he would need comprehensive analyses of several thousands of different bacteria in one instance. Also, the idea was to investigate hundreds of samples quickly. The researcher contacted an engineer who at the time ran the unit of flow cytometry at the University of Turku, Finland. Flow cytometry was an analytical methodology originally developed for counting e.g. blood cells and particles some hundred times bigger than bacteria. By combining medical microbiological research and engineering skills together they developed a method that could analyze complex bacteriological samples, including thousands of different bacteria species at the same time.

Before making a research publication they decided to make a patent application that was handed in 2002. The medical doctor and engineer knew that most of the products of the functional food industry are directly connected to the composition of intestinal bacteria. They considered setting up a company based on their innovation and contacted a few potential clients. After getting positive feedback from a few prospective clients they decided to establish CyFlo in 2003. Today, the company offers research and analytical services based on this analytical innovation. The company also sells licenses to this innovation.

Concepts such as 'clusters' and 'innovation' have been guiding the regional policy development in Europe and Nordic countries for more than a decade. In other parts of the world the converging technology approach has played a central role in regional activities and policies. The best example is Silicon Valley - one of the pioneering areas of cluster development. A White Paper published in 2001 by the Joint Venture Silicon Valley Network discussed the focus of the *next* Silicon Valley, i.e. the convergence of bio and information technologies and the application of nanotechnology (NSV 2001). The overall aim of using a converging technology approach in the future strategy of Silicon Valley was described as:

'Fostering networking that renews the habitat for innovation and entrepreneurship. This should be based around the new waves of innovation by connecting Silicon Valley and Bay Area assets in deepening information technologies, promoting convergence between emerging bio and info tech, and applying nanotechnology to our current strengths in semiconductor and computer manufacturing. This requirement especially means better connecting the leadership of the Silicon Valley and Bay Area around the convergence of bio and info technologies.'

The example from Silicon Valley shows that converging technologies have been an active element in one of the most competitive regions in the world. It also shows that regions must renew their approaches to stimulate innovation and entrepreneurship to prosper in global competition. For regional and national development agencies this will not only require an analysis of the regional innovation system including a critical theory-based assessment of research strengths in both businesses and research institutes possibly using benchmark methods.

In Canada, the *Towards Understanding Science and Technology Convergence* initiative was designed to enable Canada's Science & Technology (S&T) community collaboratively and intellectually to take further steps along the pathways of understanding S&T convergence. The aim was to explore the convergence potential through innovation policies and explore the country/region's competitive advantages to identify appropriate niches (cf. STFDO 2005). The Canadian government explored the deployment of foresight methods as a means to anticipating which inventions could likely turn into actual market innovations. As converging technologies have a substantial potential commercialisation span, it is important to identify potential application areas of converging technologies relevant to, for example, industrial structure and identified regional strengths.

One of the key messages is that innovations originating from converging technologies may have such a broad span that some form of prioritisation process is necessary as a means to identify application areas with the largest potentials within the specific regional context. This knowledge could be useful for regional policy makers.

4. NORDIC COMPANIES: CHALLENGES AND NEEDS FOR ENGAGING IN CONVERGING TECHNOLOGY ACTIVITIES

To provide useful recommendations for policy actions at a Nordic level it is important to situate the potentials of converging technology in the industrial characteristics of a specific region

The previous section showed that converging technologies can be a source of innovation leading to new business opportunities, but they can also be a threat to companies if they fail to respond to changes occurring within their industry through the evolutionary convergence stages. Therefore, policy measures should ensure that companies have appropriate sources available to them to spot and assess opportunities and threats created by converging technologies in the different evolutionary stages. The actual windows of opportunities may vary substantially from one company to another. In this process, regional/national authorities could play a vital part in improving the framework conditions for companies and research institutions in their search for opportunities, e.g. through converging technologies through deregulation as well as the knowledge system.

Our analysis is based on 40 semi-structured, in-depth interviews with companies, business/science parks, innovation networks and regional authorities in Finland, Sweden, Denmark and Iceland. We supplemented the interviews with a survey among 30 of the interviewed organisations that offer (technological) services to industry. In the following, the survey is referred to as *Nordic converging technology survey*.

The companies that participated in the survey are mainly high-tech SMEs and start-up companies, including micro-companies. Based on their utilization of converging technologies, and according to Hacklin's classification, they can be categorised in the two entrant categories *vertical attackers* and *pioneering disruptors*. However, the companies do not exploit technological convergence as part of an explicit business strategy.

An explicit strategy could be to take advantage of converging technologies at different stages with the use of a technological asset in a new market, or by embedding an emerging generic technology in existing products, thereby creating opportunities in new industries or by introducing radically altered products in the current market.

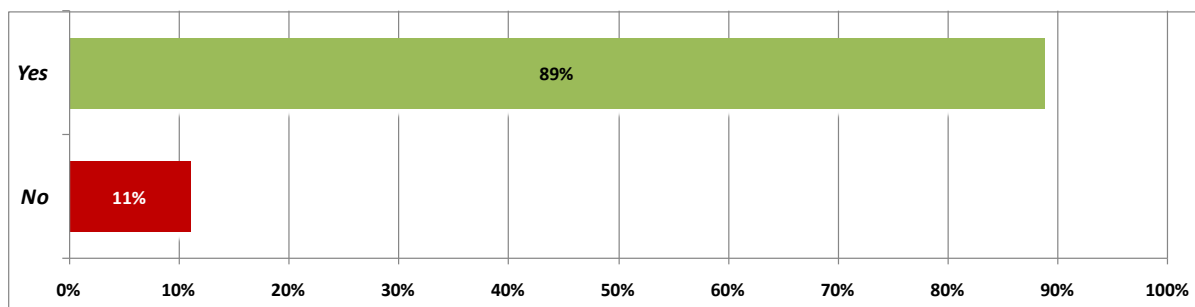
Another strategic approach for entrant companies is to identify complementary niche areas either in the premature stages or at the commercialisation stage of the convergence process.

The survey questions were based on in-depth interviews with companies and mediating organisations. Furthermore, a workshop with converging technology experts also informed the design of the questionnaire. The interviews were used to identify key challenges and potential approaches to improving the framework conditions for companies that engage in innovation through a converging technology perspective.

4.1. USE OF CONVERGING TECHNOLOGIES

The interviewed companies perceived converging technologies as highly relevant to their business since nine out of the ten companies interviewed combined new technologies or technical solutions not traditionally used in their industry, cf. Figure 3. This score can probably not be generalised across the studied regions, as the sample of companies was selected due to their innovative behaviour. Nevertheless, even though the sample is not representative, the analysis indicates that regional and national Nordic policy makers should take into account how more firms can get exposed to technological convergence in a business context. More specifically, they should consider whether existing innovation measures are designed in such a way that companies have access to knowledge sources and develop their internal capacity to assess windows of opportunities and risks associated with technological convergence. Finally, they should consider how these insights can be translated into a competitive and explicit innovation strategy at the firm level.

Figure 3: Share of respondent companies that have developed products by combining different technologies or technical solutions, which traditionally were not used in their industry.



Source: Nordic converging technology survey, 2008, N = 30

The figures in the following sections show what type of challenges companies have experienced when engaging in innovation derived from technological convergence. The tables also illustrate in which areas the companies believe that they lack information and their view on what type of assistance they would need to fully engage efficiently in a convergence technology innovation process.

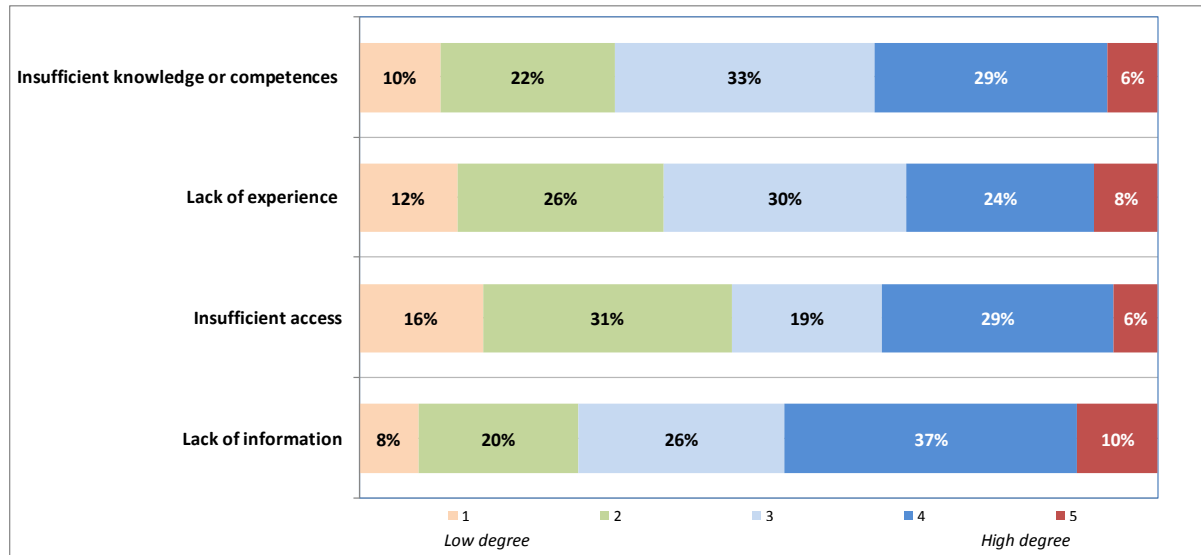
4.2. ENGAGING IN CONVERGING TECHNOLOGY INNOVATION ACTIVITIES

The combination of new technology and knowledge is the basis for a converging technology innovation process that can **challenge companies in a number of ways** (Figure 4). To identify those challenges the companies and mediating organisations were asked a set of predefined questions. Figure 4 shows that the respondents' perceived main challenges are associated with *lack of information*⁹ when engaging in convergence based innovation processes. On the one

⁹ Lacked information about *new emerging market signals; new markets; new technologies; and emerging technologies*.

hand, almost half of the companies mainly perceived the lack of information as a matter of not being able to identify relevant information sources as well as a substantial barrier.¹⁰ On the other hand, almost half of the company sample perceived *insufficient access to the formalised knowledge system*¹¹ as playing only a minor role.¹²

Figure 4: To what extent have you experienced the following challenges engaging in innovation through the combination of different technologies or knowledge disciplines?



Source: Nordic converging technology survey, 2008. N = 30

The survey and the interviews showed that in general the companies have good knowledge about new technologies that affect their industry, but their knowledge about potential new markets is weaker and vaguer.

Figure 5 shows what **type of information companies typically lack**. More than half (53%) of the companies answered that they lacked information about new market opportunities, whereas lack of information and knowledge about new technologies was conceived as less of a barrier.

In the interviews the technology-oriented firms demonstrated a solid understanding of converging technologies connected to their core business, whereas they indicated that they lacked appropriate information about markets and new market trends that could affect their business. Although the survey and interviews show that the companies are aware of the

¹⁰ High degree has been defined as answer in category 4 and 5.

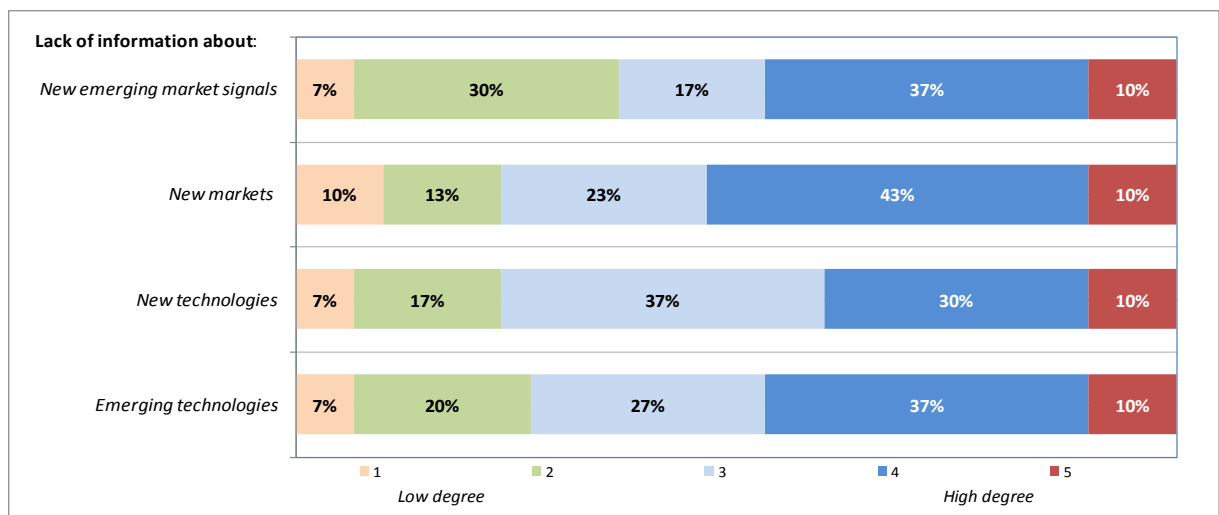
¹¹ Insufficient access to: knowledge from the universities and research organisation; business services and R&D partners for collaborative innovation.

¹² Low degree has been defined as answer in category 1 and 2.

potentials of converging technologies, the interviews nevertheless showed that a converging technology approach to innovation is not used strategically, and that innovation from convergence typically happens as a coincidence or is driven by external factors such as new regulations or customer demands.

In this context, futures methods such as scenarios, foresights and technology road mapping can be methods to identify and explore strategic opportunities and key uncertainties about market behaviours and latent market demand for new or improved products and services based on technological convergence.

Figure 5: To what extent have you experienced the following challenges engaging in innovation combining different technologies or knowledge?

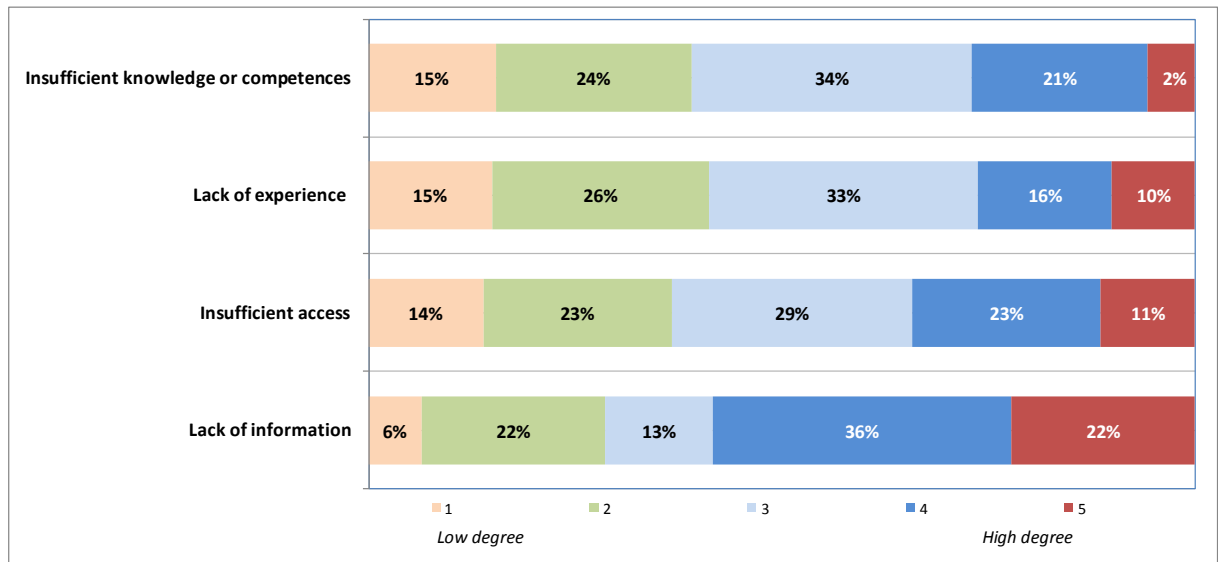


Source: Nordic converging technology survey, 2008. N = 30

Some of the above-mentioned challenges are not critical for companies. Some can be solved in-house or through networks. Others **will need external assistance**. As part of the analysis we asked the firms what types of assistance would strengthen their ability to foster the implementation of a converging technology approach.

Figure 6 shows where the interviewed companies need external assistance to overcome the most commonly mentioned challenges.

Figure 6: To what extent would you need external assistance to overcome the challenges of CT process?

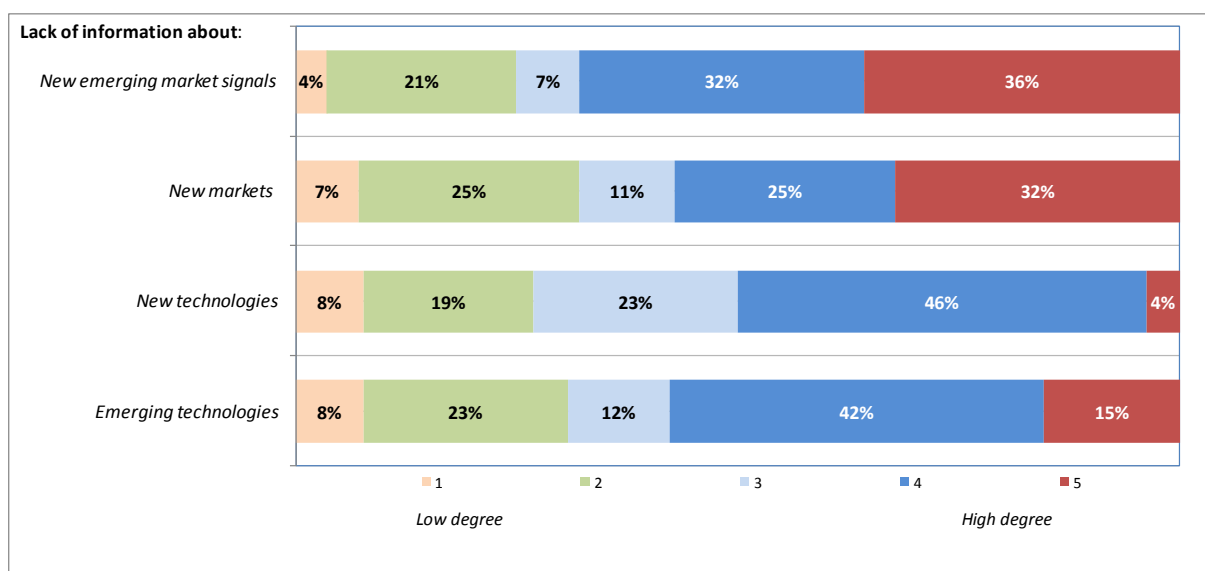


Source: Nordic converging technology survey, 2008. N = 30

Figure 6 shows that the category ***lack of information*** was mentioned by 58% of the companies as a type of challenge that called for external assistance. The rest of the categories were less important. However, the middle category (3) is large, and it could imply that some companies believe they need more information and that they have an insufficient understanding of the challenges, opportunities and threats stemming from converging technologies.

The interviews showed that because converging technologies to large extent is not part of the business strategies then external assistance has not been considered, but those companies that were involved in an innovation process with a convergence approach in general required external assistance either in the form of funded projects (national or EU) or external expertise in new markets or technological disciplines. The interviews also showed that collaboration between firms, as a form of external assistance, was limited.

Figure 7 presents the sub-categories of the category *lack of information*.

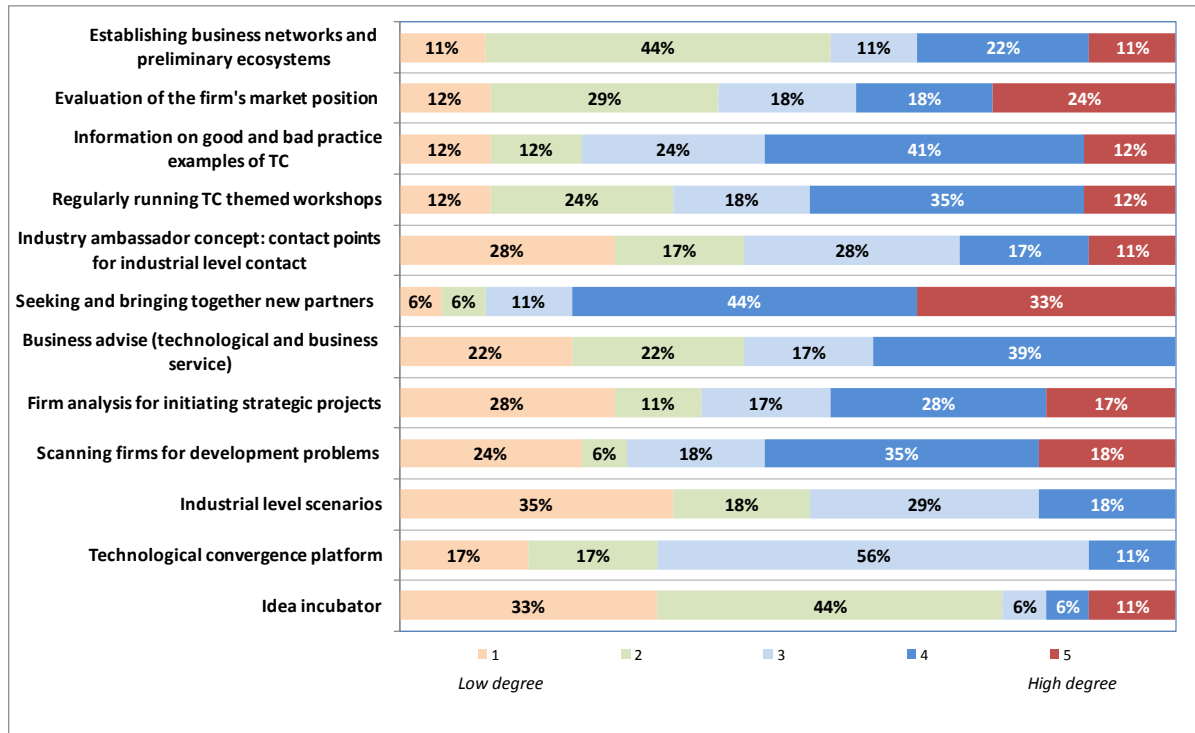


The interviews indicate that companies do not have sufficient capabilities to obtain information needed to engage in a more strategic converging technology innovation process. The companies' stated that they *to a high degree*, need external assistance to identify *new emerging market signals* (68%), *emerging technologies*, *new markets* (both 58%), and *new technologies* (52%). The result of the survey is a perfect match with the results of the interviews with the companies.

At the expert workshop, we identified a number of possible instruments aimed at supporting companies in engaging in a converging technology process. These instruments were tested in the survey (figure 8 below).

Furthermore, the in-depth interviews showed that initiatives regarding convergence should form part of a comprehensive long-term investment strategy rather than 'one-off' events.

Figure 8: Which of the following types of assistance or business service would be of relevance for your company when you combine different kind of technologies in the innovation process?



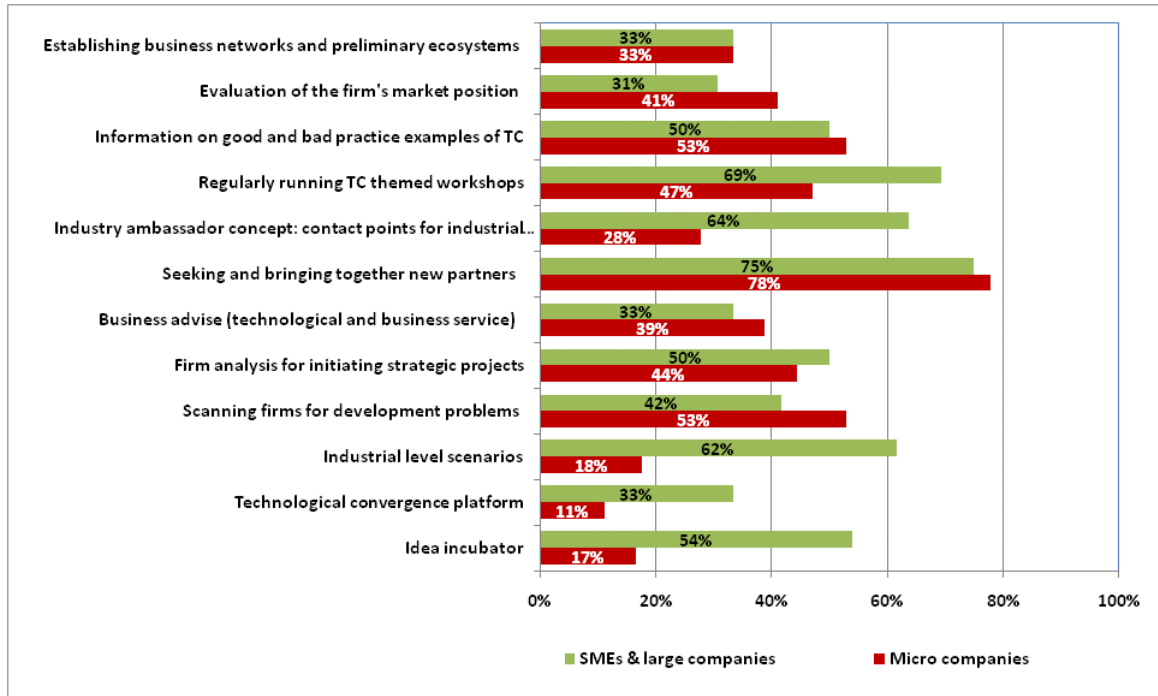
Source: Nordic converging technology survey, 2008

4.4. DIFFERENT CT NEEDS FOR DIFFERENT TYPES OF COMPANIES

The in-depth interviews and surveys showed that there is a difference from firm to firm in the type of the assistance needed for improving the conditions for engaging in an innovation process.

The qualitative interviews gave considerable information about how companies can be positioned according to Hacklin's classification (cf. figure 2). However, an unambiguous grouping of *all* the surveyed companies according to Hacklin's classification has not been feasible within this project because it would require highly detailed information. As an approximation to Hacklin's classification, we have grouped the companies by size in three groups, namely micro-firms, SMEs, and large companies. In general, the SMEs and large companies are more interested in receiving support for converging technology activities than micro-companies. Figure 9 shows the 'high degree' answers concerning the relevance of types of assistance in innovation process.

Figure 9: Which of the following types of assistance or business service would be of relevance for your company when you combine different kind of technologies in the innovation process? (High degree answers)



Source: Nordic converging technology survey, 2008. N = 30

Figure 9 shows that there are differences between SMEs and large companies compared to the micro companies. 62% of SMEs and large companies found that *industrial level scenarios* would be beneficial compared to only 18% of the micro-companies. Also 64% of the SMEs and large companies thought that an *industry ambassador concept* would be beneficial compared to only 28% of the micro-companies and *idea incubators* (54% vs. 17%). Only when it comes to more generic types of assistance, such as *scanning of the firm*, *evaluation of market position* and *converging technology business advice*, the micro-companies have a higher score,.

5. TOWARDS REGIONAL CONVERGING TECHNOLOGY POLICIES IN THE NORDIC REGIONS

This section presents a discussion on design for regional converging technology policy practices that can be approached as supplements to contemporary regional innovation policies. We particularly elaborate on regional policy support activities. First we identify the *regional potential for applying converging technologies as part of regional policies*. Second, we present a number of *policy recommendations for support activities* in converging technologies.

5.1. REGIONAL POTENTIAL FOR UTILIZING CONVERGING TECHNOLOGIES AS PART OF REGIONAL POLICIES

There are interesting emerging opportunities for utilizing converging technologies in the Nordic regions. In this section, we present the regions' potential for applying converging technology initiatives in innovation policy. We categorize the different types of regions in a model that describes different types of knowledge infrastructures in the Nordic regions. Regions with strong innovation systems and high-tech companies are obvious regions for engaging in initiatives related to converging technologies. However, it is important to acknowledge that not all regions have the potential to apply converging technologies to the same extent in their regional policies. When these different regional typologies are mapped against a converging technology perspective, it is possible to make differentiated policy recommendations for the utilization of converging technologies in Nordic regions.

The starting point for our framework is Asheim and Coenen's (2005, 2006) idea of two regional knowledge bases. Asheim and Coenen (2006) make a distinction between regions that have an *analytical knowledge base* and regions that have a *synthetic knowledge base* (cf. Table 3). Regions with a *synthetic knowledge base* often have low-tech industries. Synthetic knowledge base refers to regions where knowledge generation does not play a vital role in local companies. These regions have a high proportion of companies in traditional sectors and manufacturing, such as plant engineering, specialised advanced industrial machinery and shipbuilding. Converging technologies mainly advance through applying and combining already existing knowledge in novel ways. In regions with a synthetic knowledge base, new knowledge springs from processes of testing, experimentation, computer-based simulation and practical daily work.

High-tech based regions usually have a so-called *analytical knowledge base*. This refers to industrial settings, where the production of new scientific knowledge-based R&D is of crucial importance for the companies of the region. Both basic and applied research and systematic development of products and processes are relevant activities. Often, these regions contain high-tech companies in close university collaborations. There will often be strong clusters and

networks with regional brands. Examples are the Øresund Science Region or the Oulu region. The latter has a strong regional innovation network based on the presence of Nokia as well as strong science parks and research institutes.

Table 3: Regional knowledge bases and related industries

Synthetic knowledge base - <i>Regions with low-tech industries</i>	Analytical knowledge base - <i>Regions with high-tech industries</i>
• Innovation by application or novel combination of existing knowledge • Importance of applied, problem related knowledge (engineering) often through inductive processes • Interactive learning with clients and suppliers • Dominance of tacit knowledge due to more concrete know-how, craft and practical skill • Limited access to knowledge (universities and science parks) in the region • Mainly incremental innovation	• Innovation by creation of new knowledge • Importance of scientific knowledge often based on deductive processes and formal models • Research collaboration between firms (R&D department) and research organisations • Dominance of codified knowledge due to documentation in patents and publications • Good access to knowledge (universities and science parks) in the region • More radical innovation

Source: Applied from Asheim & Coenen (2005), see Uotila & Ahlqvist (2008)

Using this knowledge base approach we have made a framework for the identification of policy actions. In our framework we have combined Asheim and Coenen's analytical framework to Hacklin's model of different stages of technology convergence (cf. Figure 1). As presented in Table 3 the level of knowledge in regions differ (regions with low-tech industries and regions with high-tech industries). Furthermore, these regions differ as to their readiness to engage in policies linked to converging technologies. They also differ as regard actors with different potential to engage in converging technologies activities. When the components of a converging technology approach are added to this matrix, a distinction can be made between three types of regional strategies for converging technology utilization.

Table 4 provides an overview of the typology.

Table 4: Regional characteristics and technology convergence

Characteristics of regions with high potential to apply technology convergence	
<i>Regions with high-tech industries</i>	<i>Regions with low-tech industries</i>
• Scientific basic research in the region • Several large high-tech companies with regional sub-contractors • Strong local networks • Active mediating organisations • Strong institutional infrastructure • CT oriented research-based firms and spin-offs: pioneering disruptors, vertical attackers • Regions contain platform consolidators and reincarnating giants	• No scientific basic research, applied research activities might be present • Strong institutional infrastructure • Regional strengths in traditional industries i.e. shipbuilding and local suppliers • Strong local networks • Active mediating organisations • Several sectors have potential to collaborate, i.e. there are common challenges within regional industries that could be solved by applying converging technologies • High number of SMEs
Characteristics of regions with low potential to apply technology convergence	
• Weak scientific base (no universities or science parks) • Few high-tech companies with weak links to local networks • Low-tech companies with low level of similarity • Regional networking is not developed • Regional authorities with limited funds and low level of collaboration and knowledge about other regions • No active or contributing mediating organisations • Institutional infrastructure for systematic utilization of technology convergence is not developed	

Region with high potential to apply converging technologies

Both regions with high-tech industries and low-tech industries can utilize technology convergence successfully (cf. Valovirta et al. 2009). Utilization of technology convergence depends on networking capacities and institutional infrastructure, such as the presence of active mediating organisations, in the region. Moreover, the historical development path of the region affects the capabilities for utilization of convergence (cf. Bathelt & Boggs 2003). There are, however, some key differences with the application of technology in regions with high-tech industries and regions with low-tech industries.

In regions with high-tech industries, there are scientific basic research activities in the region, which enable a situation where the local industry base can utilize, at least to some extent, the results of the scientific activities and more importantly, the knowledge pool created by this research activity. Usually, there are several large high-tech companies with regional sub-contractors and strong local networks in the region. Strong clusters and supporting industries create the critical mass needed to explore new opportunities. An active role of mediating organisations is important as well as a strong institutional infrastructure. Some firms, usually research- and technology-oriented firms, have converging technologies as their core business approach. This type of region will consist of entrant companies and established companies.

An archetype region in this class is Silicon Valley with its varied research actors, constantly evolving companies, regional development companies and mediating support organisations. There are also Nordic examples such as Medicon Valley with its varied high-tech knowledge base and supporting networks and the region of Oulu with its emerging emphasis on converging technologies, such as printed intelligence and strong innovation system.

In regions with low-tech industries there are usually no scientific basic research present, but some applied research activities might be present. Usually, a strong institutional infrastructure backs up the unique regional strengths in the traditional industry. Networking is strong in these regions with active mediating organisations. The key driver of the networking is the potential of collaboration. Thus, there are common challenges within regional industries that could be solved by applying converging technologies. The Lahti region in Finland is an example of this type of region, with its strategic focus on industries such as machinery, sports gear, boards (plywood, chipboards and fibreboard), car parts, clothing, furniture and the environment (recycling). Furthermore, it is important that some regional actors already engage in incremental development of converging technologies as part of their core business. Though firms may not be using the term 'converging technologies' they nevertheless use the basic ideas of converging technologies.

Regions with low potential to apply technology convergence

Regions with low potential to apply technology convergence to regional innovation policy strategies are generally characterized by following factors. They usually have a weak scientific base with no universities or science parks, so entrant companies are rare. These regions may have high-tech companies, but they generally have weak links to local networks. Moreover, the low-tech companies are weakly connected to each other with a low level of identified common challenges. There are no mediating organisations that would actively drive networking and technology convergence initiatives. The institutional infrastructure for systematic utilization of technology convergence is not developed. Finally, there are crucial knowledge gaps that inhibit the utilization of technology convergence.

This does not mean that there is no scope for regional companies to engage in converging technology, but as a region the benefits are likely to be low compared to the other types of regions mentioned above.

5.2. GENERAL POLICY CONSIDERATIONS

As described above not all regions would benefit from applying a converging technology approach to their regional strategy. This section concentrates on the regions with potential - both high- and low-tech - and describes the role of the regions and mediating organisations.

Actors in regions with potential for applying converging technology activities should approach this as a method to further strengthen the competitiveness of the region through the creation of new development opportunities for the local companies, i.e. taking advantage of new emerging technologies or synergies between formerly separated sectors, and thereby form new partnerships.

As we have showed in previous chapters, converging technologies are already playing an important role in many companies, but it is often not a part of their business strategy. A policy option for regional authorities and/or mediating organisations could be to enhance the regional framework conditions for engaging in converging technology activities.

Most regions are aware of their regional assets. They are often presented in regional development strategies as clusters or single industry sectors. However, despite useful knowledge of the sectors, opportunities within new emerging technologies and cross-sector collaboration is generally not part of the diagnostics of the sectors or clusters. In other words, the diagnosis should include technological assets. One of the major benefits of innovation through converging technologies is that the companies involved are often not direct competitors. Consequently, compared to other innovation models, such as open innovation, the risk losing knowledge to competitors is lower and innovation can take place beyond the early stages of R&D projects. Converging technology is not an innovation model as such, but a strategic approach which can be used within other innovation models, i.e. open innovation or user-driven innovation.

The innovative aspect of the converging technology approach is that it aims to join the forces of previously separated technologies or/and sectors to improve the competitiveness of companies, sectors or regions.

In some regions, like Medicon Valley¹⁴, the converging technology approach is a natural part of the development, even if the companies are not using the concept strategically. In other regions the benefits derived from *combining* the regional assets in new ways can create new opportunities for collaboration between local companies. As the converging technology approach is not part of the business strategy in companies, collaboration between formerly separated sectors (companies) and research institutes is unlikely to take place, although there may be opportunities to collaborate, unless it is stimulated through policy actions. Our survey and interviews with companies confirm that finding new partners outside the traditional

¹⁴ <http://www.mediconvalley.com/>

networks and getting information about new markets and partners is a weak point especially for micro-companies and SMEs.

As indicated in the Nordic converging technology survey companies need external assistance to support them in forming new partnerships and networks outside their usual networks. Regional authorities, development agencies and mediating organisations in the Nordic regions could provide this support by including a converging technology approach as part of the regional innovation strategy in awareness creating activities for example.

5.3. CONVERGENCE TECHNOLOGY AS PART OF THE REGIONAL INNOVATION STRATEGY - RECOMMENDATIONS

The study's findings clearly show that potential market benefits from exploiting technological convergence will require an approach to programme design that builds on multi-disciplinarily and which also comprises activities that address market demand factors.

The converging technology approach should be part of the regional diagnostics carried out when developing or up-dating regional innovation/development strategies. This could be done through *regional technological foresight exercises*, e.g. by identifying in detail the main regional sub-sector strengths and explore demand factors relevant to the specific region, their industrial characteristics and technological assets. A sector analysis should not only highlight the strengths of the local companies in comparison with other regions, but also highlight the intake of new technologies, collaboration with other sectors and the strength of the research base (i.e. universities, networks and science parks) in the region.

The strategy should be based on the current and future technologies affecting the regional sectors/companies and the scientific base.

Regional technological foresight exercises can provide the region with a strategic method for an identification of internal synergies between sectors and sub-sectors, i.e. use of new technologies (ICT, nanotechnology, bioinformatics), but also for identification of regions with assets matching the needs of the regions' knowledge base. An example within functional food could be a region with strong traditions in the food industry (Icelandic regions) combined with regions with strong research strengths in pharmaceuticals (Medicon Valley) or in surfaces in West Sweden (nanotechnology at the University of Gothenburg) and Ostrobothnia in Finland with its strong traditions in shipbuilding.

In general, the strategic approach could act as a *push-factor* for the regional innovation system and thereby increase the competitiveness of the region. It could also provide the region with an insight in how and where to invest available funds. Many regions have identified very broad sectors as key sectors (energy, food), but without a clear picture of the regional strengths within the sector (sub-sector) and an insufficient understanding of 'what is next?'

A *regional technological foresight study* should involve the key players in the regional innovation system to boost the level of commitment, but also to get the most relevant information from the actors of the regional innovation system on specific strengths and opportunities.

Converging technologies is a new approach to innovation at regional level, and regions will have to go through two stages to apply a converging technology approach at regional level. We have defined these stages as the *identification stage* and *implementation stage (activities)*.

Identification stage

In order to apply converging technology activities, preparatory work aimed at identifying strengths and opportunities within a region is necessary.

The regional/national policy makers need a diagnostics of the regional assets and synergies based on technology. This can be obtained through a *regional technology foresight exercise* as described above. Regional foresights focusing on the key sectors in the region (both companies and research strengths) will provide a picture of possible synergies with other sectors and applicable emerging technologies.

Companies should also be mapped in relation to their potential within converging technology to make support measures effective. The survey and interviews with the companies show that there are different needs depending of the type of company. A simplified model of Hacklin's definition of companies, as described in Section 3.3, could be used.

It is crucial to recognize that it is not up to the regional authorities to find new partners for companies like Nokia, but it might be beneficial for regional micro-companies and SMEs to take advantage of the Nokia's knowledge about development of niche products (see Case 6, Crospon/HP). Opportunities for spin-off companies within the field of converging technologies also tend to be found in close cooperation with research institutes (see Case 4, Oatly).

To ensure effective implementation of the strategy and support activities, the diagnostics should be based on a governance approach with input and support from all three segments of the industry, academia and public institutions (the triple helix model). To make this happen the regional authorities need to take the first step with launching activities investigating the regional strengths and opportunities in order to define the opportunities for engaging in converging technology activities at regional level.

However, it is important to have mediating organisations (science parks, university departments or sector organisations) closely connected to the identified sectors in the region. They can play an active part in implementing the support activities in cooperation and with support from the regional authorities. A governance approach is important to secure participation and involvement. Especially mediating organisations with technical expertise

(university departments, science parks) need to be actively involved both in the identification and implementation stage. The role of innovation policy is to ensure a long-term commitment through the regional strategy for innovation.

We propose that the Nordic regions launch a *regional technology foresight exercise* including:

1. **Identify strengths within key sectors.** Define the sub-sectors that should be the focus of the regional converging technology innovation strategy. The exercise should identify strengths in both companies and research base.
2. **Identify the types of companies.** It is important to establish a deep insight into the regional industrial characteristics such as value chains, so that action can be aimed at the right type of company (entrant or established)
3. **Identify the sectors, sub-sectors and technologies that are of importance in the future.** This should be based on the sub-sectors identified above. The aim is to find inspiration from other sectors and information about technologies that will likely have an impact on the sector in the future.
4. **Involve key regional actors and experts.** Let the actors from the regional innovation system identify the strengths and weaknesses and find experts within the sub-sectors to identify opportunities.
5. **Identify converging technology trends with the sub-sectors.** In collaboration with the regional actors and sector or sub-sector experts, converging technology trends should be identified and discussed with the key regions key actors in order to provide input to policy.
6. **Include results in a regional strategy.** The results should be included in the regional strategy in order to show commitment and invest in order to help realize the potential.
7. **Include mediating organisation.** The aim should be that a mediating organisation should be the main player for activities, but it should be supported by regional authorities or other public funding so that it is implemented in a sustainable manner by the organisations closest to the companies. As it is based on technology, technological knowledge is therefore a necessity in order to carry out the activities.

Implementation

The aim of the activities is to create an environment/framework within the region's main assets to enhance collaboration between the key actors at regional level to:

- Find relevant partners outside the traditional boundaries for future converging technology development projects.
- Identify and create access to information about relevant emerging technologies and markets relevant for the regional business and regional research base – with focus on a technology that can be applied in more than one regional sector (synergies).
- Identify other regions where the regional assets could be of added value for both regions.

The activities described below can be carried out even if they are not part of an overall strategy for the region. In some high-tech regions (Oulu and Medicon Valley) it might not be relevant because strong clusters and networks are already actively working with converging technologies. In these types of regions the focus and support are already in place. In these cases, it can be argued that the whole regional innovation system is geared towards converging technology innovation. However, some activities could still be relevant for strengthening the linkages with other networks.

Generalizing on the basis of our results, we make the following policy recommendations for support activities that are applicable to the 'high potential regions' identified in Section 5.1.

Based on the interviews, the Nordic convergence technology survey and literature review, we recommend regional policy makers to include the following:

1. **Practices of open innovation should be more widely integrated in the development of the regional capacities in converging technologies.** There should be an open process and platform for utilization of converging technologies in the region that includes universities, companies, public sector and cluster organisations, to name just a few actors.
2. **Partnership services.** Partnership services should be interpreted widely here and could include ideation and brainstorming practices as well as virtual lists of the companies searching for development partners across different sectors and technologies.
3. Regional policies should in general aim towards **linking of networks and already existing, active clusters.** This could be made possible e.g. through common seminars and ideation sessions, or even by organising specific cluster dates aiming towards identification of common possibilities in converging technologies.

4. There is a need for **information and brokering in the process of implementing converging technologies**. The process starts with the elementary questions, such as 'what does converging technology mean for our business and how can we utilize it', and advances towards the actual planning of the converging technology implementation.
5. When the regional actors and networks have started to work with converging technology development they could form a **regional converging technology platform** that widely caters for all the above-mentioned functions. In addition, a regional converging technology platform could act as an umbrella-type of common denominator for regional exercises and create linkages between local research projects on the topic. It should be established as a matrix-structured network. The bigger challenge is to develop common practices that actually work, engage and stimulate local actors.

Furthermore, the policy activities should take into account the following development perspectives.

1. The key factor is not to get stuck in the internal regional perspective, but strive for the **creation of partnerships also with other regions**. Regional policies should engage proactively in linking different environments. By engaging in active networking practices with other regions it is possible to accelerate a cross-pollination of ideas and variety in the application contexts of these ideas.
2. Regional policy actors support initiatives in mediating organisations, whereby **development in relevant technologies and sectors are monitored**, and strive to **understand these technologies from policy perspectives**. This practice can be enhanced, e.g. through monitoring sessions with other regional actors such as universities and business parks, but it could also be enhanced by active brokering and consulting activities.
3. A Critical task is to **organise regional creativity around converging technologies**. It is of paramount importance to find policies that genuinely endorse and fit the regional knowledge capacity. All regions cannot utilize the same policies that work in a specific setting, and all regions cannot be future 'silicon valleys' in converging technologies. Organisation of creativity could be effectively realized by launching a participatory strategy processes with regional actors. Key policy actors in the region should be the home base for these processes and every actor in the region should have the right to participate and engage in the ideation activity. The process should lead to concrete actions that are dedicated under some authority in the region. This participatory nature of the process will increase the likely commitment of the actors. This kind of participatory policy process also benefits from active knowledge brokering and process facilitation by an outside party.

4. Key actors in the regions should engage in **proactive and continuous dialogue on new market opportunities**, such as firms, technology and business parks, universities, research institutes and think tanks. SMEs will benefit from collective external views—if they are made in a credible fashion—and policy makers will benefit from the direct dialogue channel to other actors.
5. **Create a converging technology information contact point for companies** where the business advisors have knowledge about converging technology activities within the key regional sectors (e.g. nanotechnology, steel, food, bioscience, etc.) This contact point could be at a university, like the Functional Food Science Centre in Skåne¹⁵ for functional foods.

At **national or Nordic** level we suggest that:

6. There should be **channels for direct information exchange between the regions**. This exchange could ensure the spreading of information on good practices and success cases across the Nordic region.

A step at a Nordic level could be to analyse the potential of linking the existing clusters and networks based on shared opportunities within converging technologies, i.e. biotechnology and the food industry. This could result in a Nordic converging technology platform where the clusters in the Nordic countries can get information on new trends within converging technologies and find new partners from different sectors outside their traditional networks. Besides strengthening the Nordic innovation system, such an initiative could encourage Nordic R&D-oriented projects where companies identify niche areas across Nordic industrial sectors and research areas.

¹⁵ <http://www.ffsc.lu.se/>

6. LITERATURE

Asheim, B. & Coenen, L. (2006). Contextualising Regional Innovation Systems in a Globalising Learning Economy: On Knowledge Bases and Institutional Frameworks. *Journal of Technology Transfer* 31, 163–173

Asheim, B. & Coenen, L. (2005). Knowledge bases and regional innovation systems: Comparing Nordic clusters. *Research Policy* 34, 1173–1190.

Bally, N. (2005). *Deriving managerial implications from technological convergence along the innovation process*, Åbo Academy School of Business.

Bathelt, H. & Boggs, J. S. (2003). Toward a reconceptualization of regional development paths: is Leipzig's media cluster a continuation of or a rupture with the past? *Economic Geography* 79:3, 265–93.

Doorn, M. (eds.) (2006). *Converging technologies. Innovation patterns and impacts on society*. STT 71. STT Study Centre for Technology Trends. Amsterdam, Netherlands.

DTI 2008 = Danish Technological Institute (2008). *Danmarks Vækstlagsundersøgelse*. Danish Technological Institute.

Forsknings- og Innovationsstyrelse (The Danish Agency for Science, Technology and Innovation) (2009): Erhvervslivets forskning, udvikling og innovation i Danmark 2009 – Den økonomiske krises betydning

NSV 2001 = *Next Silicon Valley: Riding the Waves of Innovation*. Joint Venture Silicon Valley Network, 2001.

Hacklin, F. (2008). *Management of convergence in innovation. An introduction*. Workshop meeting 'Technological convergence', Espoo, 26.09.2008.

Hacklin, F. (2007). *Management of Convergence in Innovation – Strategies and Capabilities for Value Creation Beyond Blurred Industry Boundaries*, Zurich.

Kodama, F. (1992), *Technology fusion and the new R&D*, Harvard Business Review, 70 (4), p. 70-78.

Nordmann, A. (2004). *Converging technologies – Shaping the future of European Societies*, European Commission.

OECD. (2002) *Telecommunications and broadcasting: Convergence or Collision*, Paris.

Pennings and Puranam (2001). *Market convergence and firm strategy: new directions for theory and research*, *The Future of Innovation Studies*, Eindhoven, 2001

Roco, Mihail C. and Bainbridge, William Sims (eds.). (2002). *Converging Technologies for Improving Human Performance*. Nanotechnology, Biotechnology, Information Technology and Cognitive Science.

STFDO 2005 = *Toward Understanding Science and Technology Convergence (in nano, bio, information and cognitive sciences and their emerging intersectional and innovative technology domains)*. Science & Technology Foresight Directorate Office of the National Science Advisor Privy Council Office, Government of Canada, 2005.

Stieglitz N. (2002). *Industry dynamics and types of market convergence*, Copenhagen, DK: DRUID summer conference 2002, www.druid.dk.

Uotila, T. & Ahlqvist, T. (2008). Linking technology foresight and regional innovation activities: network facilitating innovation policy in Lahti region, Finland. *European Planning Studies* 16:10, 1423–1443.

Valovirta, V., Pesonen, P., Halonen, M., van der Have, R. Rilla, N. Ahlqvist, T. & Loikkanen, T. (2009). *Suomalaisten innovaatioiden maantiede. (Geography of Finnish Innovations)*. Ministry of Employment and Economy Publications, Innovation 26/2009. Edita Publishing Ltd.



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