

Regional economic change, entrepreneurship and regional path dependency in Non-Metropolitan Region

By Thomas Brekke, Assistant professor Vestfold University College, Norway

Key words: Path dependency, entrepreneurship, regional development, evolutionary economic geography, University-Industry collaboration

Abstract:

This paper examines the evolution of industry development in Non-Metropolitan Region characterised by an international oriented R&D industry. Recent theory of regional path dependent industrial development departs from characteristics of well-developed metropolitan regions or peripheral areas. A non-metropolitan region is often characterized as regions holding a dynamic cluster of specialized and innovative companies that benefit from complex interaction and relations between firms, higher education and regional development bodies, both within the region and across geographical scale. This paper argues that non-metropolitan regions experience other types of path dependency than in metropolitan and peripheral regions. The paper provides theoretical justification for why non-metropolitan regions might end in a situation of lock-in where individual R&D intensive companies are innovative but the production system as a whole is becoming more fragmented, despite success in constructing regional advantages. The paper focuses attention on entrepreneurial activity and path dependency. More in particular, the paper explore the extent to which growth and formation of new industry is related to path extension, path renewal and path creation. The paper contends that a non-metropolitan region need regional branching mechanism, such as entrepreneurship and regional knowledge bodies, to avoid “locked into” path extension.

Introduction

The evolutionary turn in economic geography (Boschma and Martin, 2010) has encourage greater interests of regional industrial development. This has brought about the propositions that formation of new industry are place dependent (Martin and Sunley, 2003) tend to have better growth condition where the region hold some place-specific-factors and conditions (Martin and Sunley, 2010). The notion of related variety and place dependent points to the importance of regional branching process wherein existing technology, skills and resources are recombined to form the basis of entrepreneurial activity into new development paths (Asheim et al., 2011, Frenken et al., 2007).

Entrepreneurial activity is seen as a fundamental driver for economic evolution. It is also a distinctly spatially uneven process, reflecting path dependence in industry structure, institutions and culture (Saxenian, 1994) that vary widely across regions and countries (Stam, 2010). Regional condition for entrepreneurship points to the importance of entrepreneurial activity as both as individual, social and organizational product, the characteristic of the industrial structure, the entrepreneurial culture that dominate the region and the size of the region (Stam, 2010). To the extent that new industries emerge from related industries, the sectorial composition of a regional economy affects the diversification opportunities of regions in the long run. This process of sectorial branching occurs primarily at the regional level, because it becomes manifest through a number of knowledge transfer mechanisms (i.e. spinoff activity, firm diversification, labour mobility, networking and research collaboration) that tend to be geographically bounded. Growth in regions is thereby triggered by some extent of diversity of the region's industry, local pool of specialised labour, local supporting institutions, local knowledge spillovers, and various forms of traded and untraded interdependencies (Storper, 1993, Boschma et al., 2010, Neffke and Henning, 2011).

Well-developed core regions such as metropolitan areas are assumed to hold a number of such knowledge transfer mechanisms and a diversified industrial structure supported by several research

and educational bodies that stimulate to both incremental and radical innovation. In the other end of the scale is peripheral region which is characterized as less innovative comparison to agglomerations, they have less R&D intensity and lower shares of product innovations, they have less organizational thinness and innovation is most focused on incremental and process innovation (Tödtling and Trippl, 2005). A non-metropolitan region will differ from metropolitan and peripheral areas in a certain extent. Non-metropolitan regions are often characterized as regions holding a dynamic cluster or a regional production system (Storper and Harrison, 1991) of specialized and innovative companies that benefit from complex interaction and relations between firms, higher education and regional development bodies, both within the region and across geographical scale. By that, path development of non-metropolitan area is based on other preconditions and follows most likely different development paths than metropolitan and/or peripheral regions.

This paper argues that non-metropolitan regions with a specialized production system well integrated in global economy might likely follow a path dependency of stagnation and negative 'lock-ins' than positive 'lock ins'. Thus, breaking a negative locking-position can be done by constructing regional advantages (Asheim et al., 2011) and by connecting the regional production system to external knowledge network (Boschma and Frenken, 2011). In the first part of the paper I will present the conceptual framework and literature used with regard to path dependency and entrepreneurial activity. In the next section a presentation of the context and method used will be given. The third part interprets the industrial development in Horten/Tønsberg in light of the conceptual framework of path dependency and entrepreneurship. Part four concludes by discussion some general lessons relating to path dependent in non-metropolitan region.

Conceptual framework – path dependency and entrepreneurship

The main theoretical framework of this study departs from the notion that structural changes is not random (accident of history), but takes the form of path dependent process whose evolution is

governed by its own history (Boschma et al., 2010) or by purposive behaviour and directed decision making by economic agents (Martin and Sunley, 2006). The concept of path dependency points to the fact that future development of a system (region) depends on its current characteristic and past events that influence development today. This means that past decisions, events, circumstances, knowledge and skills affect the probability of future events to occur (Boschma et al., 2010). It also holds that historical trajectory and its associated path dependence processes may co-evolve. In this way, according to Martin and Sunley (2010), path dependency is continuous and endogenous change process where the inherited local knowledge base of an industry can form the basis of new emerging and related industry.

The concept of related industry (Frenken et al., 2007, Asheim et al., 2011, Boschma et al., 2010) emphasis that to the extent of new industry grow out of existing and related industry might determines (not necessary) diversification opportunities of regions future economic development. According to Boshman and Frenken (2011) the relatedness between the technologies used among firms in a region is thought to affect the nature and scope of knowledge transfer when proximity (cognitive, geographical and social) among firms is present in such an extent that interactive learning occur. Cohen and Levinthal (Cohen and Levinthal, 1990) argues, that firm can understand, absorb and implement external knowledge when it is close to their own knowledge base. In other words, knowledge creation and innovation is driven by interaction and feedback between firms, but only when they are related (but not too much) in terms of shared competence. By that, the existing industrial structure of a region is determining the nature and scope of knowledge transfer following from regional branching mechanism that foster new firm formation and specific path development. Regional branching describes how regional industries diversify into new industry through some knowledge transfer mechanism; such as spinoff activity, labour mobility, network collaboration, and firm diversification.

Path dependency regional industrial development holds that regions can suffer from negative lock-in or positive-locking (Martin and Sunley, 2006). The former indicate that innovation potential is severely reduced and where innovation takes place at a restricted technology path, ending in uncompetitive and a declining situation. According to Boschman and Frenken (2011) lock-in occurs when a region lacks boundary spanning function (function), a common mindset (cognitive) that might confuse secular trends with cyclical downturns, and political (political) initiatives aiming at preserving existing traditional industrial structure is interrelated in such way that they manifest themselves at the regional level (Hassink, 2010). The latter form, positive-lock-ins, addresses a situation where the regional industry holds the capacity to grow, mainly through utilizing external and regional resources in their innovation processes and where knowledge transfer is well within the regional production system. Isaksen (forthcoming in Journal of Economic Geography) distinguishes four possible development paths of regional economics which can form an analytical concept in order to categorize key elements in regional economic development; (1) path exhaustion, (2) path extension, (3) path renewal, and (4) path creation (table 1). The paths may occur simultaneously in the same regions, e. g. in different sectors, which means that both continuity and change may take place in a regional economy. These models are ideal and analytical concepts which are difficult to identify. They may occur simultaneously in the same region and in different sectors, showing both continuity and change in a region.

Path exhaustion characterises a condition where the region is finding itself in a situation of negative lock-in where the innovation potential is reduced and the industry is uncompetitive and then declines as the market diminishes. A regional industry might emerge into a situation of path exhaustion when existing industry may be unable or slow to respond to emerging technologies and increasing competitions due to low resilience and adaptability (Martin and Sunley, 2010) and where regional lock-in in terms of function, cognitive and political is preserving the old industrial structure. The break-up and dissolution of an industrial trajectory might be brought about by an 'external shock' of some sort, which destabilises the system and opens up for a new path to emerge, or through intentional action by change agents.

The second characteristic, *path extension*, holds a positive lock-in where incremental innovation and more of the same (continuity) keeps the industry going. Innovations are distinguished as user-driven and occur ad-hoc as customers demand new solutions to existing products/services. Innovation is mainly characterised as incremental product or process innovation in existing industry and technology paths which is often based on doing using mode of innovation (Jensen et al., 2007).

The third path, *path renewal*, refers to changes which takes place within old industries or clusters which have already existed for a long time in the region (Tödtling and Trippel, 2013). Development takes place through restructuring of existing firms and firm formation through regional branching. Existing knowledge and resources shape to some degree the type of renewal that occurs often within related sectors or industries. Related variety stimulates knowledge transfer when the region holds a diverse industrial structures and larger and more diverse knowledge infrastructure. Related knowledge may be found outside a region and reinforce the industry with new knowledge, this demand absorptive capacity of the industry to identify and acquire external knowledge for commercial ends. According to Tödtling and Trippel (2013) path renewal is linked to change in the region's knowledge infrastructure often through creation of research and educational bodies that support firms to introduce new technologies, offering highly qualified labour and stimulating to increase entrepreneurial activities. Governance structures such as network formation or clustering/RIS is often used as a policy tools to stimulate local learning and knowledge sharing processes (Etzkowitz, 2002, Asheim, 2007).

The fourth path is *path creation*. Path creation is a process where industrial change in a region implies a major shift in the development trajectories of regions. Change is brought by the emergence and growth of new industries based on new scientific knowledge and organisational trajectories, but in context of existing structures, technologies, industry and institutional arrangements. Evolution of new path creation requires the existence of assets, competence and resources embedded and rooted in the

region. However, external investment may also influence regional development through transplantation of external firms into the region. In this way new path creation often emerge out of previous and existing regional paths (Martin and Sunley, 2006) and where the relatedness among industries affects regional development by build-up of a local resource base that fits the requirements of the regions industries (Frenken et al., 2007).

The success of path renewable and path creation is a result of companies absorptive capacity to react on fast changes, to absorb new ideas and knowledge coming from R&D activities, and network collaboration where proximity based knowledge embedded in nearby firms and R&D institutions may play a significant role of enhancing innovativeness and competitiveness (Boschma and Frenken, 2011). As path renewal and path creation indicates, a well-developed regional knowledge infrastructure with modernized educational and research organisations and support structures seem to be key factors that contribute to develop and sustain new regional industrial development through knowledge creation and sharing (Asheim et al., 2011). An important distinction between path renewable and path creation made in this paper is related to the entrepreneurial outcome. While path creation is often linked to a Schumpeterian interpretation of innovation as a technology shift or by creative destruction outcompeting former technology domen, path renewable is likely to stimulate disruptive or incremental innovation which builds on existing knowledge and resources embedded at the regional level.

The process of creative destruction (Schumpeter, 1934) by introducing new variations (new products, processes, business models) in the economy, forces firms to improve or change in order to survive, or they will be outcompeted. Entrepreneurial activity that creates new methods of production, services, new organisational solutions and new markets, plays an important role as change agent that destroy existing economic structure within. In this way entrepreneurship play a significant role in regional economic development as entrepreneurship create variations and diffuse new technologies in society.

Variation and diffusion also feed each other by creating further opportunities so that new entrepreneurs can enter the market (Nooteboom and Stam, 2008). However, entrepreneurs usually start their firm in the region they live and by that they gain experience from related industries (Boschma and Frenken, 2011). Entrepreneurship may also deepen established industrial structures due to social conformity (proximity) and imitation of exciting practice and technologies, and introvert social networks, by that act contra productive as change agents in regional industrial development (Neffke and Henning, 2011). Not all new start-ups survives for a long time in the market or they grow to some extent. Next to variation, diffusion and selection, proximity plays an important role in entrepreneurship and regional economic development. Proximity, is seen as important condition for interactive learning and innovation to take place as proximity between actors contribute to development of mutual trust, allowing complex knowledge to travel well and building trustful relationship or network (Gausdal, 2008, Larson, 1992).

Entrepreneurship has, historically, been explained as either the product of the environment (market) or individual behaviour (Spilling and Alsos, 2006, Shane, 2000). In this paper, opportunity for entrepreneurship is seen as the result of interaction between the entrepreneur prior knowledge that allows him/her to recognize certain opportunities (Shane, 2000) and capabilities opportunities embedded in the local network (Martin and Sunley, 2010). This means that entrepreneurship is both a result of reproduced structural or regional condition, as well as that entrepreneurial activity transforms these structural conditions (Stam, 2010). Entrepreneurship is thereby dependent on entrepreneurial opportunities embedded in the institutional context (market and proximity), knowledge transfer mechanism (networks, research and educational bodies and other institutional arrangement) and individuals that identify and exploit these entrepreneurial opportunities based on their prior knowledge (skills, competence, experiences) (Shane, 2000:452).

The problem of regional economic stagnation or path development resulting in negative “lock-ins” has been in policy focus for the last decades. Present innovation policy tools are usually based on past policy experiences combined with new innovation theories that emphasize innovation as an interactive and social process and where learning and knowledge are key to economic development and path evolution. Influential theoretical models such as triple helix (Leydesdorff and Etzkowitz, 2001), the regional innovation system concepts (RIS, Cluster and learning networks) (Asheim and Isaksen, 1996, Cooke et al., 1998) have emphasized interorganisational arrangement, R&D collaboration, firm start-up, university–industry collaboration as promising way to enhance positive lock-ins. Often these models are based on best practice from well performing regions. The concept by Asheim et. al. (2011) ‘Constructing Regional Advantages’ take account of these differences and suggest an innovation policy approach that incorporate ideas found in the triple helix model (Etzkowitz, 2002, Leydesdorff and Meyer, 2006), with the concept of related variety which attaches great importance to knowledge spillovers or regional branching mechanisms that works across complementary sectors and different knowledge base. Boschman and Frenken (Boschma and Frenken, 2011) suggest that the regions should increase their knowledge flow and entrepreneurial opportunities by “cognitive widening” realised through the establishment of networks outside the region which can feed the region with new ideas and knowledge not available in the region.

The theoretical framework of the paper departs from the notion of path dependent regional industrial development which is characterized by lock-in effect that push technology, industry, or regional economy along one path rather than another. According to Storper (2011, p. 343) “the ‘dark matter’ of regional development is context” in terms of microeconomic ways that behaviours of agents are structured through institutionalized, spatially-differentiated forces. Furthermore, that is still lacking, is a more thorough understanding of path dependency focusing on contextual factors concerning regional development process related to firm growth and entrepreneurial activity. The theoretical framework of path dependency in this paper should not to be miss interpreted as a deterministic approach, as the idea highly emphasise relationship between past economic development and future possibilities (Martin

and Sunley, 2006). Following Storper's (Storper, 2011, p. 338) argument that "studying cities and regions as forward-moving development process", path dependency in this paper is interpreted as non-equilibrium concept of path dependency (Martin and Sunley, 2010, p. 74) formed through historical and context specific factors or conditions which will form the basis of this analyses. The paper has three main research questions. The empirical question is what characterise industrial development processes in a medium-sized specialized region as Horten/Tønsberg, what type of mechanisms evolves and how do they work in path evolution process, while a theoretical question revolves around how do new industries grow out of existing and related industries and knowledge bases within the border of regions? The last question addresses what is to be learned from the case of Horten/Tønsberg.

Table 1. Path dependency and regional development

	Development process	
Continuity	<p>Path exhaustion</p> <p>Innovation potential is several reduced, innovation take place at a restricted technology path often ending in uncompetitive and then decline. Imply negative in-locking as firm may be unable or slow to respond to emerging technologies and increasing competition. External sock or purposive decisions might create new path development</p>	<p>Path extension</p> <p>Development of existing industries based on existing technologies and knowledge bases. Lead to more of the same (continuity) in regional economy. Imply positive lock-in, where externalities reinforce local industrial dynamism. Stimulate to networking and build-up of a regional knowledge infrastructure that enhance research collaboration</p>
Change	<p>Path renewal</p> <p>Development takes place through restructuring of existing firms and firm formation (regional branching) switch to different, but related sectors or industries. Existing knowledge and resources shape to some degree the type of renewal that occurs. Related variety stimulates knowledge spillover when the region holds a diverse industrial structures and larger and more divers knowledge infrastructure. Related knowledge may be found outside a region and reinforce the industry with new knowledge. This demand absorptive capacity of the industry to identify and acquire external knowledge for commercial ends.</p>	<p>Path creation</p> <p>Development based on new technologies and new organisation in new industries. Establishment of new firms in new sectors, new way of organize, productions, new technology/knowledge what hitherto dominate in the region. May still build on existing regional skills and competence as new paths may be latent in old ones or spinout from existing ones. Parts of the knowledge are often scientific as it is often difficult to create entirely new, which can come from external sources. Innovation activity demands often proximity based relationship and mutual trust.</p>

Context and method

The paper analyses aspects of industrial development in a medium-size city in Norway, namely

Tønsberg/Horten with just over 90 000 inhabitants. Tønsberg/Horten is located on the Western shores

of Oslofjorden, just 1 hour by car from the capital city of Oslo. The region is housing a set of specialized micro- and electronic firms (Isaksen, 2003, Asheim et al., 1999, Isaksen, 2007), caused by R&D activities within semiconductors in the 1950s, 60s and 70s which laid the fundament for rapid growth and starts-ups, in particular spin-outs, in the 1970s and 1980s. The growth was strengthened by four pioneer firms as part of a national strategy for developing a more high-tech manufacturing industry in Norway (Isaksen, 1997). Based on technology and product idea in important national R&D institutions, research became industrialised through establishment of new firms and through cooperation with firms in Horten/Tønsberg (Isaksen, 2007). It is seemingly the most well-known electronic cluster in Norway, appointed by the Government as a Centre of Expertise in microelectronics in 2003. The location quotient of the region is 7, and the region holds 20% of total amount of employment within high technology in Norway.

However, in the last two decades the industrial environment is characterized by few new starts-ups and spin-outs and where much of the industrial growth have been done outside the region (Nilsson, 2006). The region is also characterised by decline of work intensive manufacturing which have been moved to low cost countries (Isaksen, 2007). Despite of increasing globalizations and international recession, there has been few closure or bankruptcies which indicate that the companies are highly adaptable to marked changes and new demands. Throughout this process of growth and diversification, the industry continue to draw on research communities located outside the region, while contributed to build-up a specialized knowledge based within it. These have included various regional network initiatives and institutional arrangement, transformation of a regional University College with updated educational programs and R&D competence adapted towards industrial need, construction of entrepreneurial infrastructures including research laboratories, research centre and a commercialisation company (Herstad and Brekke, 2012). In sum, the composition of the region fits well for designation as an organisationally specialised medium-size region; due to its size and distance from metropolitan areas, compositions of the industrial structure, access to knowledge resources and attractiveness of global companies (Tödting and Tripl, 2005).

The main empirical data source is interviews by CEOs, research and development directors in 11 companies in Tønsberg/Horten. The interviews are conducted in connection with investigation carried out in the period of 2006 – 2010, which have made it possible to closely follow important developments in innovation activity, local collaboration and start-ups in the cluster over a number of years. The interviews was written down and then sent to interviewees for a quality check which raise further comments. The interview focused on the firms' history, their way of organizing innovation and learning process, their external innovation partners and knowledge flow, spin-off activities and use of input factors.

The empirical study focusses on three types of industries; large electronic- and microelectronic companies with more than 150 employees each (3 companies), business and technology consultancy (3 companies) and 6 start-ups/spin-out companies. The electronic- and microelectronic industry is selected due to its size and that it holds significant knowledge base for the region. Business and technology consultancy companies are selected because of its rapid growth and the role they play in the regional knowledge infrastructure as change agents. Start-ups are selected as indicators for new emerging business opportunities that may led to path creation, path renewal and regional branching.

Type of firms	Number of firms	Aggregated numbers of employees 2012	Location owners	Year of establishment
Electronic- and microelectronic companies	3	548	International and local owners	2003, 1965, 1946
Business and technology consultancy	4	67	Local owners	2005, 2001, 1997
Start-up/spin-out	6	39	International and local owners	2011,2011, 2011, 2008, 2006, 2005,
Sum	13	654		

Evolution of a specialized medium-size region, path creation and path exhaustion

The process of path development of the region Horten/Tønsberg goes back to the early 1800s when the National Government of Norway decided to relocate the Royal Navy and establishing a new naval shipyard at Horten, in 1818. The place were selected due to its favourable good entry and departure port for sailboat. During the 1800s, sailboat-based technology was gradually replaced by steam engines which made it necessary to formalize technical education based on scientific methods. In 1855 the Norwegian Government established the first public technical school in Horten. Establishment of a technological school based on scientific methods indicated a shift of the knowledge base of the region. A new layer in the regional economy emerged involving new organizations that exploited new forms of knowledge which often involved exploitation of scientific methods (traditional knowledge of sailing was replaced by scientific knowledge with specialized expertise, engine technology, which was located outside the region and the country) and social groups (engineers, scientist, managers etc) which became important for local learning and innovation processes (Wicken, 2009). Another important institutional setup happened in 1947, when the Norwegian Defence Research Establishment became located in Horten. The main objectives was to commercial military research done during the Second World War (Ørstavik, 1989). In the following decades the growth of the region in terms of regional branching was characterised by innovation activity driven through close collaboration between the naval shipyard, the technological school, NDRE and firm growth based on specialised labour force holding technological competence within modern steel ships (Velvin, 2002). In particular, the role of the naval shipyard as a large and demanding customer played an important role as a regional branching mechanism until the shipyard closed down in the 1980s. An informant from Sense Technology AS described how the shipyard influenced path development of the regional economy: *“the shipyard produced large and complicated products which challenged local suppliers to become more innovative and to work in pack to find new solutions. By that the shipyard acted as a hug locomotive for the local industry where we as suppliers needed to collaborate closely to find new innovative solutions”*. The complexity of building entirely ships at one place seemed to favour

industrial collaboration and local entrepreneurship in order to collectively respond to the needs and demands for the local shipyard.

The development path of the regions also holds a number of economic lows or path exhaustion, which should be understood in a national institutional context. In 1960s the Norwegian Government decided to relocate the Royal Navy to the Western Coast of Norway. In 1984 the shipyard closed down as a result of national reduced financial subsidies aimed at the Norwegian shipbuilding industry. However institutional setups such as the technical school and NDRE remained in the community acting as local capabilities and regional branching mechanism that foster new industrial path development. A second wave of industrial path emerged in the 1960s partly emerged as a result from spin-off from the naval shipyard in the 1940s and as completely new types of industry entering the region in the 1960s. The new path creation that started in the 1960s was shaped by a national innovation strategy aimed at constructing a high tech industry in Horten/Tønsberg (Isaksen, 1997, Ørstavik, 1989). The region was selected because of favourable local condition; such as a skilled workforce, a welcoming municipality, necessary institutional setups (technical school and NDRE) and local commercialise competence which have shown its capacity to commercialise advanced technology into end products. These companies were Vestfold Radio (1946), Simensen & Mustad (1947), Akers Electronics (1964), and Norcontrol (1965). In the 1970s and 1980s these four companies gave birth to more than 20 companies (to mention some; SensoNor AS, Jotron AS, Vingtor AS, Vingmed AS) which formed the basis of a local production system and specialized companies that became more integrated in national and internal knowledge network (Isaksen, 2007). These companies can be characterised as R&D intensive, where R&D was incorporated in the production process of the company and where problem solving activities was done in collaboration with other actors (Wicken, 2009). The development path of the industry was pushed forward by increasing product and company specialization, risk reduction, and evolution of a skilled labour force combined with an entrepreneurial culture. An interview with a company owner explained it in this way “*It was like a war, where it was important to start new business before other competitors identified the same new opportunity. Often these competitors did not*

like each other very well either, which sometimes evolved into a personal thing". This quote illustrates how path evolution of the region of Horten/Tønsberg was formed by both personal motives, entrepreneurial skills and opportunities embedded in an emerging new technology – miniaturizations of semiconductor devices (Balconi and Laboranti, 2006). The growth of the electronic industry in Horten/Tønsberg should be understood in context of an emerging global electronic and semiconductor business where the technology became more complex and advanced as new area of use emerged (Balconi and Centuori, 2004).

Path renewal and path extension

The path creating process gradually changed from path extension to path renewal in the 1970s and 1980s, as a sort of “positive locking” in which the regional industries experienced increasing returns and positive externalities that reinforce local dynamism and innovativeness. The new emerging path was characterised by small and medium size companies that blurred the distinction between R&D and production as knowledge pervaded all aspects of the company in terms of organizing work, flexibility and continuous change. These companies close relationship with the research system feed the local production system with new spin-out or product improvement which also challenged these companies to collaborate close with one another. In the 1980s and 1990s several companies went through acquisitions and became foreign owned which tied them closer in the global economy. Interpreted as companies competing on a global market and which is dependent on highly specialized global and national knowledge resources in order to stay innovative and competitive. These companies are world champions within their niche, indicating that they hold high competence and they are continuously improving their organizations and product/services in order to stay competitive.

One example is GE Vingmed Ultrasound, (200 employees) which produce medical ultrasound equipment target for the international health equipment market. GE Vingmed Ultrasound has its historical roots from Vestfold Radio, producing telecom equipment for the maritime market. In 1968 the company (Vingmed AS) started to test and explore Doppler ultrasound technology based on patent

from Norwegian University of Technology and Science in Trondheim (NTNU). Further research collaboration with NTNU in the 1980s and 1990s, partly financed by the research council of Norway, resulted in several new inventions. In 1985 the company was divided into two; Vingtor Marine AS and Vingmed Sound AS. The company went through several acquisitions in the 1980s and 1990s and in 1998 General Electric bought the company. By that, the company got access to General Electric global pool of knowledge resources and market channels. Example of the importance of in-house R&D capacity drawing national and global knowledge resources is the evolution of the Vscan. In 2008, the company developed new compact ultrasound equipment, the Vscan. The Vscan have received high international attention, as the new disruptive technology made advanced ultrasound treatment cheaper and more accessible for a larger customer group in emerging economic such as China. The company holds a research department, located in Horten, consisting of 72 people who either holds a PhD or master degree within mathematic, physic and cybernetic. According to the R&D director, the company innovative success depends on a mixture between highly skilled experienced workforce and graduate's curiosity to find new solutions. In sum this composition between skilled experience, graduates and utilizing resources from parent company (General Electric) makes GE Vingmed Ultrasound capable to identify gap in the marked and internalize external knowledge resources for commercial purposes. The company is heavy dependent on access to high skilled workers which they recruit from larger national Universities located in Trondheim and Oslo. This type of science based mode of innovation (Jensen et al., 2007) have made it necessary for the company to established local departments close to these Universities.

The role GE Vingmed plays in the regional production system is changing as a consequence of becoming part of a global international company (General Electric). According to the R&D director *“collaborating with local companies is mainly within small-scale and test production, where time is a critical factor”*. High Norwegian wages, production in low cost countries in combination with own capacities within GE have made it less obvious to make use of local manufacturing capacities and technical support. The company have some collaborate with the regional University College, Institute

for Microsystem. *“Although it is not the core technology for our company as they are focusing on nano-technology and packaging of MEMS sensors”*, she says. It seems that the company is reluctant to the selected area of MEMS and Nano technology as they interpret this type of technology as periphery to their core competence. However, it seems that local collaboration has some neighbouring effect. *“It makes it easier for us when we recruit skilled workforce, as we can brand that we are part of a cluster of high tech companies in this region”*. At the end of the conversation she summarize the interview by pointing at *“local knowledge collaboration does not necessary have any significant impact on our capability to innovate, as we are more tied and dependent to our parent company, costumer and research resources outside the region”*. The case of GE Vingmed indicates that industrial path development of the region can be characterised as a fragmentation of the innovation system, where local knowledge collaboration is less likely to occur (Tödtling and Trippel, 2005). This perspective was supported by company managers from Norspace AS and SensoNor AS in an interview, where they express that the regional production system is about to lose its importance as they are becoming even more than before more dependent on research collaboration with large research institute (SINTEF) and universities located in Oslo and Trondheim. Most of production or product development is done in-house resulting in less outsourcing of large scale production to local sub-suppliers.

Another international oriented company and which also depend on in-house R&D, is Jotron AS. Jotron AS (250 employees) is producing communication system for the domestic and international market of safety equipment. The company was established in 1965 and located in the region due to specialized workforce and local commercialisation expertise. In the 1970s, the company became involved in developing a national alarm system for ships in distress, based on radio communication. Since then the company have widen its product portfolio from sea to land and air. This has been possible through utilizing on their long experience of producing communication systems and through several company acquisitions which have feed the company with new necessary skills. The company is utilizing global organization of work. Production and development is made in company sites in Norway and production and assembly is made in Lithuanian. They have agents and sales offices in UK, Singapore

and USA. The innovation process is characterized as doing-using innovation (Jensen et al., 2007), where most of the development is done in-house by test engineers or development personnel holding bachelor or master degree. Most of the engineers are recruited from regional educational institutions. To a less extent they use the local production system or suppliers. If they use local suppliers, they usually do small-scale or test production. According to the technical manager, technology improvement is often a consequence of ideas generated from participation in international standardizations organizations, as this is the area where they meet customer and other suppliers. In 2010 the company launched a new product for integration of the ship's office with the land base office, based on broadband and internet communication. A new company was established in 2010, Nera SatCom AS, with a mixture of external expertise and competence from Jotron AS. In 2012 Jotron Satcom AS merged with Jotron and became part of the company second division of maritime energy & communication division.

To-day, the medium-size city of Tønsberg/Horten, can be characteristic as a mixture between specialised and diversified region (Malmberg and Maskell, 1997), holding a set of companies which are, as mentioned, well integrated in their particular national and global knowledge network. The overall picture is that there have been few new spin-offs or new firm formation in the last two decades that can lead to regional branching and new path development. Following the line of arguments of the life-cycle model (Boschma and Frenken, 2011), it seems that the regional industry are following the cycle of high growth of new firm in the first phase (1960s, 70s and 80s), then falls rapidly again in the 1990s, and eventually stabilize (2000s) into an oligopolistic market structure dominated by few leaders. Furthermore, the firms are largely self-contained with competence; they have most of what they need for in-house production, and where local knowledge collaboration is considered to be of less important for their competitiveness as they are more dependent to external knowledge resources. In sum it seems that the local production system has evolved into a path development characterised as a fragmentation (Tödting and Trippel, 2005) of the local production system where "R&D" intensive companies remains small-scale enterprises that continuously changed their products and often

developed tailor-made solutions for other companies, resulting in weak cluster and innovation related networking (Tödttling and Trippel, 2005, Benneworth et al., 2009, Wicken, 2009).

Although that some companies such as Jotron and GE Vingmed Ultrasound is highly capable to stay innovative and competitive through incremental innovation within their branches, it is more difficult to identify the potential for the path renewal or path creation concerning the production system as a whole. A company manager from 7 Sense Technologies AS expressed this worries in this way “*after the closure of the shipyard in the 1980s, there are none big demanding customer left in the region. Today's products are small in scale, they are complex but they are also heavily exposed to competition from competitors located outside the region which in sum does not favour the blossom of local innovative subcontractors*”. In order to survive, these regional suppliers, such as Techni AS and 7 Sense Technology, are now forced to focus more on developing their own products and to concentrate their scarce resources in in-house development. In particular these companies claim that small-scale and test production combined with lack of larger regional industrial collaboration does not give them sufficient power to grow and to realize their innovation potential. Instead they stay small in scale which further push the regional production system into direction of negative ‘lock-ins’, where potential for firm growth and start-ups are been reduced.

Emergence of a new path development

Warning signs in the late 1990s indicated that economic growth of the regional industry occurred more outside the region as manufacturing were moved to low-cost countries, there were few new start-ups in the region, and formalized research collaboration was rare among localized companies (Nilsson, 2006, Uhlin and Johansen, 2001). In the beginning of the millennium these issues were discussed among a group of industrial representatives, the county council and the local community of Horten. The outcome of the meeting ended in a joint agreement of renewing the regional production system. The idea was based on ideas found in the triple helix and regional innovation system concept which is

summarized in the CRA-concept (Asheim et al., 2011). The idea was to develop a set off specific regional branching mechanism that enhances learning and knowledge between companies and R&D collaboration with the university college within an already existing industrial specialisation (Asheim and Coenen, 2005, Asheim et al., 2011, Isaksen, 2007).

In particular, the regional University College became challenged to modernize its education and research profile (Herstad and Brekke, 2012). The new role of the University College needs to be understood in light of rapid technology and institutional changes. Since the invention in 1959 of the integrated circuit (IC), the evolution of the microelectronic industry is characterized by rapid growth of a global business, which has led to increased functionalities following from the trajectory of minitaurization. These outcomes are associated with increasing levels of knowledge complexities and global competition which has been increasingly demanding even for large companies to handle (Balconi and Centuori, 2004). A director from SensorNor AS (spin out from Akers Electronic, in 1984) expressed his concern in a meeting in the beginning of 2000, between industrial representatives, the county council, the local municipality and Vestfold University College, in this way: *“in order to stay competitive we need to build a research facility located within the region, as we are each of us too small in size to build advance research facilities alone”*. Furthermore, he pointed out that; *“It should not be necessary to travel out of the region, when there are so many advanced electronic- and microelectronic companies located within this region.* The director also addressed the University College to become more proactive towards the needs of the industry: *We need a University College which is capable to respond to industrial needs and feed the industry with high-end research”*. A consensus was made among the participants that it was time to act and secure that the region became capable to handle its own history and become partly self-sufficient with research and educational facilities.

The University College responded to these ambitions plans by invite the industry to joint them in the effort of modernizing their research and educational structure, as they had no experience or competence to build a world class research and educational environment within electronic and microelectronic. To achieve these goals the industry and the University College decided to focus their effort to become world class leader within the niche of minitaurization and packaging of multimems (MEMS). The new institute, Institute of Microsystem Technology (IMST), was staffed by researchers and engineers recruited mostly from local companies and by that drawing on local knowledge. In the following years, from 2003 to 2005, IMST manage to build a bachelor and a master program within microelectronic and in 2009 the institute could offer its first PhD-program. In 2005, the collaborative effort became appointed as the selected area of housing a national centre of expertise in Nano- and Microelectronic, by the Norwegian Government.

The new institutional setup of the region was also supported by three other branching mechanisms, designed to promote entrepreneurship and new path development. A hybrid corporate business incubator (Branstad, 2012), Microtech Innovation AS (MTI AS) emerged in 2001. In 2005 a private initiated and owned business incubator (Becker and Gassmann, 2006), Visonair Consult AS, was established in the region. a Research and Innovation Park was established in 2010 which was located within the area of the campus.

Microtech Innovation AS (MTI) was established as a hybrid corporate incubator in joint partnership between some selected microelectronic companies, County Council, Horten Community and Vestfold University College (Branstad, 2012). The main aim was stimulate to new firm formation by utilizing ideas and knowledge embedded in the local production system or through external attractiveness by offering necessary resources, support and funding. According to the company manager “*our advantages is that we are located in a cluster of advanced electronic and microelectronic companies, which has shown their capability to commercial advanced technology*”. However, according to a

manager of MTI, there have been few cases coming from the local industry. *“It seems that they are more reluctant to collaborate with us as they have either in-house competence or they do not focus on spin-out ideas at all”*. Instead of relying on local ideas, MTI attract ideas and business start-ups coming outside the region. A recently example is SensoCure AS. SensoCure AS was established in Oslo by a founder working at Rikshospitalet. Due to several weaknesses related to the selected technology, the company soon ran out of funding. MTI AS became a selected partner as the founder had previously working experience with a local company in Horten/Tønsberg. SensoCure AS was re-established in 2011 and is now located at the Innovation and Research Park at the campus, utilizing research capacity from IMST, particular within miniaturizations of microsystem and biosensor. This is made possible by engaging professors and PhD students who do testing and do advanced research. MTI provide the company with new management, they secure the company with funding and they involve other companies through the research process. MTI is acting as a branching mechanism that stimulate to knowledge spillovers between local companies, IMST, and new start-ups. A manager at MTI explain it in this way *“such form for collaboration generates further research collaboration between companies and the University Colleges and by that feed the local production system with new ideas”*.

Similar exploitation of the entrepreneurial know how of the region is also used by Visionair Consult AS. Visionair Consult AS was established in 2005 by a group of former industrial managers. Today the company are now employing 10 former industrial managers or CEOs. The company main idea is to develop patents and technology solutions to a state where it can be licensed for system suppliers and/or take forward their own end products. The company, Visionair Consult AS, usually relocate start-ups located outside the region and replace them at the campus area. They got access of such start-ups through their national and international relationships. According to the company manager, *“we design a company development process where we staff the company with our own managers, and then we use researchers and phd students at the University College to further improve the technology. By that we got access to research funding from the Norwegian Research Consul as we include research*

effort with user driven business development. Questioning why these external entrepreneurs ask for help, he explains. *“We are located in a business cluster known to hold several advanced electronic- and micro technology companies and which have shown its capability to industrialize advanced technology to end product. This is our advantages”.* Organisations such as MTI AS and Visonair Consult AS act as branching mechanism through implementation of external start-ups that draws on the regions related knowledge and research facilities and at the same time introduce new technology and knowledge in the region.

There are also some new start-ups based on research done at IMST, which also take advantages of the regional knowledge base. One example is Trilobite AS. Trilobite AS holds a patent that separate cancer cells from other cells using counter-flow microfilter technology. This has been possible by utilizing knowledge from IMST within miniaturizations of microprocessors and biotechnology, commercial competence from the Research Park and engineering skills from an external company. This early entrepreneur's emphasis the easy access and the way unique high technological competence, research facilities, commercial skills and access to technology companies are organized as important key element for why he started the new firm.

So far in this part of the analyses the focusing have been on early start-ups, either initiated by commercial agents (MTI and Visonair Consulting) or as a result of research activity at the University College. The question which still remains to be answered is, are there any examples of new start-up spinning-out from existing industry which holds the potential to stimulate regional branching in such a way that stagnation or in-locking is a less potential development trajectory for the region?

One, example of international oriented industry who utilizes knowledge from existing industry is Norspace. Norspace started in 2003, by a management buy-up from Alcatel Space, as Alcatel needed

to restructure their business due to the collapse of the dot.com market in the beginning of 2000. The new management of Norspace manage to make a lucrative arrangement with Alcatel, allowing them to be the main supplier of Alcatel customers within satellite communication worldwide and to draw on Alcatel's technological expertise concerning product development for the next four years. Norspace started up with approximate 30 employees in 2003, which in 2012 have grew to approximate 95 employees. In 2006 Norspace started to develop their own product portfolio based on licences and expertise from Alcatel. Most of the company research is done in-house but in close relationship with external research institutions supported by national research programs. The company is integrated in the global economy as most of its customers and suppliers are located outside Norway. Local collaboration is mostly done at small-scale production or test production. However in the last years the company have started participated in joint research project with the University College. In 2011, the company owners sold the company to the Kongsberg Group.

Another example of a new international spin-out is poLight. poLight became established in 2006 by four inventors, who decided to start a new company when their employee Ignis closed down in 2005. Based on technological and commercial competence from Ignis (controlling the polarization of an optical signal) and the research institute SINTEF they patented a new solution of producing camera for the mobile phone market. The nationality of the company core competence is from France, Russia and Germany. This is explained on the basis of company's customer is international and where international experience is seen as absolute necessarily to succeed with the commercial process. Researchers and engineers have been recruited from NTNU, Vestfold University College and from local companies. Where local collaboration is at present, it is mostly through borrowing specific research instruments and facilities.

These examples, Norspace and poLight, illustrate that previous work form related to in-house development and international relationship is the dominating logic of business development. Local

collaboration occurs in part of the business process where easy access to knowledge and facilities is best achieved through personal relationship which they have previous working experience from. Large scale knowledge collaboration is still absent. However, both companies have some initiatives with the University College of developing joint research projects and recruiting engineers.

Another spin-out company based on existing related knowledge is Fimreite AS (2008). Fimreite was established by a former engineer at GE Vingmed. He identified a gap in the market concerning new digital software solutions of transferring secured ultrasound picture which he identified when he worked at GE Vingmed. Today the company have grown to 4 people. Most of product and services innovation is costumer driven. According to the company manager and the R&D director at GE, the relationship between GE and Fimreite have been important for both actors, as GE get access to new knowledge and new ways of doing things and Fimreite draws on a large company network of resources in the start-up phase. To-day, Fimreite and GE Vingmed Ultrasound are offering several joint PhD-positions within common technology areas in relationship with the university in Trondheim (NTNU).

Discussion and conclusion

This paper addresses three main research questions concerning the above arguments. The empirical question is what characterise industrial development processes in a medium-sized specialized region as Horten/Tønsberg, what type of mechanisms evolves and how do they work in path evolution process, while a theoretical question revolves around how do new industries grow out of existing and related industries and knowledge bases within the border of regions? The last question addresses what is to be learned from the case of Horten/Tønsberg.

In answering these questions we first have to keep in mind that path dependency may effect economic development in a variety of ways. It might bring about continuous negative lock-in where existing industry decline or diminish as a result of low adaptability or resilience by the industry to new technology or competitiveness. This could have been the situation for Horten/Tønsberg when the shipyard closed down in the 1980s. On the other hand, path dependency might also give birth to new path development resulting from past history and events. The case of Horten/Tønsberg illustrates how decades with build-up of organisational layers, a knowledge base and the growth of a specialized production system combined with purposive decision making have formed the basis of the present industrial structure of the region. The current dominating electronic and microelectronic industry in Horten/Tønsberg departs to a large extent from a path creation process by the establishment of four pioneer companies in the 1960s, which gave birth to several new companies. The regional factors have to do with fact that the region holds a favourable skilled work force combined with historical build-up of organisational setups (branching mechanism) which made it possible to utilize on an emerging technology, following from global expansion of the semiconductor industry. The global evolutions of the electronic industry and the complexity of the technology following expanding area of use (Balconi and Laboranti, 2006) resulted in incremental product development which was mostly done in-house, as R&D became integrated in the production process of the company (Wicken, 2009). At the same time, larger companies became more integrated in national and global knowledge networks. Following from these historical trajectories in-house development and integration in national and global knowledge network, the industry became more fragmented and less related as sectorial specializations drifted the industry away from each other. The region reacted to these negative 'lock-ins' path development by constructing regional advantages, based existing industrial structure, focusing on scientific development and stimulate to entrepreneurial behaviour. However, despite the effort of designing regional branching mechanism that stimulate to learning and knowledge spillovers and modernizations of the knowledge infrastructures, the existing industry seem to be reluctant to this initiates when it comes to the relevance of their innovation process.

A theoretical issue in this paper is what can be drawn with regard to industrial development paths in non-metropolitan areas. The major finding is that, despite of decades with systematic build-up of regional institutional arrangements, there have been few new start-ups/spin-out leading to new sustainable firm formation coming from the industry. Only exiting R&D intensive firms seem to do well by introducing novel product/services to the market. One important reason for this is that the success of the knowledge-based industry and its capability to utilize from external knowledge network, has limited the opportunity for regional branching to occur. However, drawing on the main knowledge base in the region (industrialisation of applied micro technology research) and a build-up of a new regional knowledge infrastructure, the potential for path creation or renewal is at present. A final finding is that a non-metropolitan regions which holds an international technology oriented industry need a third part actor, such as a regional University College and support organisations, to boost regional branching and entrepreneurship in order to avoid being in 'locked into' path extension. The paper concludes that the framework of path dependency opens for analysing regional development and the role institutional arrangement play in regional development in a new way. Thus, the framework still needs to be further elaborated in order to increase the understanding of development changes following regions which is partly global dependent and locally embedded. The framework may provide new insights regarding how innovation policy is working. Present innovation policy focusing on stimulating growth of already existing industrial specialisation should be replaced by a much more explorative innovation policy.

Acknowledgements

This work was supported by the Research Council of Norway, development Program, "DEMOSREG".

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