Paper no. 2013/07

Renewal of Mature Industry in an Old Industrial Region: Regional Innovation Policy and the Co-evolution of Institutions and Technology

Lars Coenen (lars.coenen@circle.lu.se)
CIRCLE, Lund University, Sweden, NIFU, Norway

Jerker Moodysson (jerker.moodysson@circle.lu.se)
CIRCLE, Lund University, Sweden

Hanna Martin (hanna.martin@circle.lu.se)
CIRCLE, Lund University, Sweden

This is a pre-print version of a paper that has been submitted for publication to a journal

This version: March 2013

Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
Lund University
P.O. Box 117, Sölvegatan 16, S-221 00 Lund, SWEDEN
http://www.circle.lu.se/publications

WP 2013/07

Renewal of mature industry in an old industrial region: regional innovation policy and the co-evolution of institutions and technology

Lars Coenen, Jerker Moodysson and Hanna Martin

ABSTRACT

The objective of this paper is to further insights on the potentials and barriers for industrial renewal in locked-in regions and industries. To do so, the paper analyzes the Swedish policy program ‘Biorefinery of the Future’ (BioF). This initiative is geared to develop a strong regional innovation environment for forestry-based biorefinery development in the area of Örnköldsvik and Umeå in Northern Sweden. Theoretically, the paper draws on concepts from evolutionary economic geography regarding path-dependence, related variety and lock-in, and combines these with institutional approaches found in science and technology studies to explain disruptive shifts or transitions in socio-technical systems.

JEL Codes: R58, R5, R, O38, 03, O, Q23, Q2, Q

Keywords: Regional Innovation Policy, Old Industrial Regions, Evolutionary Economic Geography, Socio-technical Transitions

Renewal of mature industry in an old industrial region: regional innovation policy and the coevolution of institutions and technology

Abstract

The objective of this paper is to further insights on the potentials and barriers for industrial renewal in lockedin regions and industries. To do so, the paper analyzes the Swedish policy program 'Biorefinery of the Future' (BioF). This initiative is geared to develop a strong regional innovation environment for forestrybased biorefinery development in the area of Örnsköldsvik and Umeå in Northern Sweden. Theoretically, the paper draws on concepts from evolutionary economic geography regarding pathdependence, related variety and lockin, and combines these with institutional approaches found in science and technology studies to explain disruptive shifts or transitions in sociotechnical systems.

Introduction

Following an evolutionary turn in economic geography (BOSCHMA AND FRENKEN, 2006; BOSCHMA AND MARTIN, 2010; ESSLETZBICHLER AND RIGBY, 2007; MARTIN AND SUNLEY, 2007) there is an increased interest in industrial renewal in the context of regional development (STORPER, 2011; HASSINK, 2010). Since the early 1990s there has been an ongoing engagement in the subdiscipline with the particular problems, challenges and strategies of old industries and old industrial regions (HASSINK AND SHIN, 2005; HUDSON, 1989, 2005). In this significant body of work there has been a particular focus on how such industries and regions may, or may not, be able to break out of lockedin paths of development by pursuing innovation and new technological pathways. More recently this debate has gained further momentum through the introduction of the concept of related variety (FRENKEN et al., 2007). Instead of juxtaposing regional specialization versus regional diversity as guiding principles for economic development, it draws attention to the economic importance of bringing different but complementary pieces of knowledge together. More specifically, it offers a new way to consider opportunities of regions to diversify into new industries and, thus, to contribute to dynamic processes of economic renewal (ASHEIM et al., 2011).

At the same time, various scholars have articulated the critique that an overriding focus has been attributed to microlevel firm routines in evolutionary economic geography at the expense of other actors and institutions (such as the state) (MORGAN, 2012). This reflects a more fundamental concern about how to combine and relate overlapping economic, institutional and political approaches in the context of evolutionary economic geography. Departing from institutional economic geography, GERTLER (2010) asserts that there is a need to better understand processes of institutional evolution and change over time in light of regional economic change. This requires a multilevel perspective, paying close attention to both agents (firms, individuals, organizations, consortia etc) and structural factors (institutions, sectoral, national and regional conditions).

The objective of this paper is to further insights on the potentials and barriers for industrial renewal in lockedin regions and industries by building on a combined institutionalevolutionary approach. To do so, the paper analyzes the Swedish VINNVÄXT program 'Biorefinery of the Future' (BioF). VINNVÄXT is one of VINNOVAs (the Swedish Agency for Innovation Systems) regional support programs with the aim to promote sustainable regional growth by developing internationally competitive research and innovation environments in specific growth fields. More specifically, the BioF initiative is geared to develop a strong innovation environment for biorefinery development from raw materials provided by forests in the area of Örnsköldsvik and Umeå in Northern Sweden. The forest industry is a traditionally important and sizeable industry in this region in terms of employment opportunities. However, due to shrinking global demand for paper products and tightening global competition, scarcity and increased prices of forest raw materials, and increased requirements on more sustainable production methods, the industry is facing challenges to remain competitive. Therefore, the industry is seeking alternative ways to extract greater value from biomass, while at the same time reducing its waste and pollution. A biorefinery can be seen as a platform technology that integrates biomass conversion processes and equipment to produce environmentally friendly fuels, power, heat, and valueadded chemicals from biomass within one single facility. Instead of primarily using the forest biomass (i.e. lignocellulose) for the production of paper pulp, biorefinery technologies allow its conversion into high value fuels such as ethanol, green chemicals, feedstuff, substances for the building industry, viscose for clothing, or ingredients for the food and pharmaceutical industry; being heat a sideproduct in the production process. As such, the biorefinery concept offers a possibility for forest related industries to increase its efficiency and diversify into different markets by also establishing linkages to other industries and, in doing so, to potentially contribute to their renewal. The BioF initiative can therefore be seen both as an attempt to address regional lockin but also, and more importantly, as a way to promote renewal of industries which, if successful, would have far reaching (environmental and economic) positive impact also beyond the region in which it is set up.

From an evolutionary economic geography perspective, the BioF initiative thus makes a relevant and interesting case to study the emergence of novelty in the context of a mature industry as well as renewal of an old industrial, peripherally located, region. The initiative pertains to a large extent to the introduction and bridging of new scientific and technological knowledge into what is considered by many as a conservative and riskaverse industry, located in an area where traditional forest related industries such as pulp & paper to a large extent have defined the economic identity of the region. Previous studies have shown that there has been a fair deal of resistance in the forest industry against what is considered to be a radical and disruptive technological pathway (LAESTADIUS, 2000; OTTOSSON, 2011). As such, it makes an interesting case to question:

How can a regional innovation support program (i.e. VINNVÄXT), and its efforts to foster the adoption of sciencebased knowledge creation and exploitation, contribute to the renewal of mature industries? How is such ability conditioned by territorial and industry specific socioeconomic factors (i.e. the regional and industrial context)?

The active engagement and involvement of policy and public authorities in BioF opens up for both an evolutionary and institutional perspective on industrial and regional renewal. To cater for a joint evolutionary and institutional perspective, the paper draws on a theoretical framework that borrows concepts from evolutionary economic geography regarding pathdependence, related variety and lockin, and combines these with insights from institutional approaches to science and technology studies concerning the coevolution of technologies and institutions in light of disruptive shifts or transitions in sociotechnical systems (GEELS, 2002, 2004; TRUFFER and COENEN, 2012).

The remainder of the paper is organized as follows. The next section presents the theoretical framework of the study, drawing on literature on industrial and regional path dependence, knowledge complementarities, and sociotechnical transitions. Section three provides a short outline to the research design and methods applied in the study, followed by the empirical case study and analysis in section four. The paper ends with conclusions and suggestions for future research.

Theoretical framework: pathdependence, knowledge complementarities and sociotechnical transitions in old industrial regions

As the focus of this paper concerns deals with mature industries in a region facing severe challenges for future economic prosperity and growth, the theoretical discussion departs from the existing literature on old industrial regions and the debate concerning pathdependence and technological lockin. Three related but different dimensions of lockin are usually highlighted in the literature: functional, cognitive and political (GRABHER, 1993). While the first dimension primarily addresses problems related to value chain organization and network formation, the second and third take a broader societal focus by addressing challenges not directly under control of single actors or groups of firms. Cognitive lockin, as well as strategies to address its possible resolution, has been dealt with extensively in the field of economic geography the past halfdecade, giving rise to concepts like skill relatedness and related variety (FRENKEN et al, 2007). The framework of this study draws partly on that literature. However, to address other dimensions of lockin, including political, the framework includes a cognate evolutionary field of research, namely that of transition in sociotechnical systems (GEELS, 2002). Through its socalled multilevel perspective, this body of work has provided compelling narratives on the obduracy of incumbent technologies and institutions and the related challenges for novel, pathbreaking technologies to break through.

Regional challenges to industrial renewal

In economic geography, industrial renewal has been discussed intensively in light of the challenges faced by old industrial regions. These types of regions are typically overspecialized in mature industries experiencing decline. TÖDTLING and TRIPPL (2005) provide a stylized ‘problem description’ of the regional innovation system found in these regions. Innovation activities in old industrial areas often follow mature technological trajectories mainly of an incremental character. Efforts to introduce radically new products into the market tend to be limited compared to process optimization and other efficiencyoriented activities. Even though, as TÖDTLING and TRIPPL (2005) observe, the region may have a highly developed and specialized knowledge generation and diffusion system, this is usually oriented towards the traditional industries and technology fields. Moreover, small firm innovation and entrepreneurial activity tends to be low given the dominance of larger firms, incumbent to the established and mature industrial and technological specialization. Examples of old industrial regions are frequently found in regions specialized in heavy industries like the Ruhr area in Germany (GRABHER, 1993), the North East of England (HUDSON, 1994; COENEN, 2007) or Wales (MORGAN, 2012). It is interesting to note in the context of this paper, that these regions are also wellknown for being sites with severe difficulties dealing with waste and pollution (such as e.g. carbon emissions). On a general level, the problems of old industrial regions can be characterized as suffering from lockin (HASSINK, 2010).

The notion of lockin is defined by MARTIN (2010, p. 3) as “the idea that the combination of historical contingency and the emergence of selfreinforcing effects steers a technology, industry or regional economy along one ‘path’ rather than another”. Here, it is important to note that lockin does not by default need to have a negative impact on the regional economy. Strong specialization in specific industries is a classic feature of clusters and regional competitive advantage (PORTER, 2000). Lockin becomes problematic when its direction steers to (over)specialization in longestablished technologies and industries with little scope for further economic exploration of knowledge while, often simultaneously, curtailing efforts by novel industries or technologies to emerge and develop.

As TÖDTLING and TRIPPL (2005) acknowledge, actual regions may face a mix of regional innovation systems deficiencies (failures) as suggested in their typology. While the notion of lockin provides an important concept to analyze (barriers to) renewal of industry in a region, we therefore also draw partly on a second type of ‘problem description’ related to regional innovation systems, namely that of ‘peripheral regions’. Given the location of the BioF initiative in the Northern, thinly populated part of Sweden, it is reasonable to assume that the region also faces challenges related to peripheral regions. A main characteristic of many peripheral regions is that important regional innovation system conditions are poorly developed due to ‘organizational and institutional thinness’. Similar to the old industrial region typology, the emphasis is on incremental innovation and on process innovations. But now, the main explanation for a lower level of innovation activity is tied to a low level of clustering and agglomeration as well as a ‘thin’ and less specialized structure of knowledge suppliers, technology transfer organizations and educational institutions.

Knowledge complementarities and strategies to address lockin

Previous studies of the forest related industry in Sweden provide ample evidence of cognitive lockin. The work by LAESTADIUS (2000) draws on concepts from evolutionary economics, i.e. technological pathways and discontinuities, to analyze the adoption of scientific knowledge and technology in the pulp & paper industry. The study concludes that, in contrast to information and communication technology, biology and biotechnology is the exception rather than the rule in wood transforming activities all over the world. The industry is dominated by large plants and large machinery systems which have a low flexibility to face demand for new products and processes. On the one hand, this has facilitated a relatively quick adoption of information technology, arguably a preceding general purpose technology that has the potential to fundamentally transform industry, through advanced process automation allowing for an enormous increase in speed, precision, paper quality and environmental performance during recent decades. On the other hand, LAESTADIUS (2000) argues that this has created institutionalized rigidities in agreed or de facto standards and qualities that form the cognitive context for engineers working in the industry. As a result, biotechnology was to a much lesser extent considered compatible with existing technologies and production processes.

More specifically, LAESTADIUS (2000) explains the discrepancy between the adoption of ICT and biotechnology on the basis of cognitive traditions. He notes that the pulp & paper industry is characterized by a synthetic mode of knowledge production (see also MOODYSSON et al., 2008). Whereas ICT builds on a more or less similar engineering rationale, biotechnology is fundamentally different in that it draws on an analytic (or sciencebased) mode of knowledge production. Whereas previous studies have emphasized the importance of absorptive capacity in (mainly quantitative) terms of R&D activity and level of education at the receiving end, the above findings also point to the qualitative nature of absorptive capacity. Due to cognitive differences with their prevailing worldview on what constitutes valuable knowledge, biotechnology has simply been ignored by the majority of paper and pulp engineers for many years. It should of course be noted that the empirical data that fed into the study by Laestadius is somewhat dated, but it helps to qualify what is meant by cognitive path-dependency and lockin in the context of the forest industry.

This account puts a more nuanced perspective on the possibilities for knowledge spillovers between firms with complementary knowledge bases and competences. According to ASHEIM et al's (2011) constructing regional advantage perspective, economic renewal of regions depends on their ability to diversify into new applications and new sectors yet building on their current knowledge base and competences. Drawing on NOOTEBOOM'S (2000) concept of optimal cognitive distance, they argue that regional specialization in technologically related sectors is more prone to induce regional innovativeness rather than regional diversity or regional specialization per se. While the combination of different knowledge bases between firms and industries of related variety may indeed give rise to regional branching processes, and thus to regional diversification, there may also be considerable barriers to such processes due to existing lockins to prevailing knowledge bases. The case in focus in this study, BioF, displays potential for exploiting such related variety through combining the knowledge bases of forestry, energy and specialty chemicals industries with each other, with scientific knowledge bases of biotechnology, and with new forms of engineering based skills. While the forest and energy industries have been related for a long time, the specialty chemicals industry and biotechnology have (re)entered the scene during the last decades when new enzyme based technologies made it possible to degrade forest raw material into finer components and extract more value instead of just burning the waste. Examples of products (innovations) based on such processes are new environmentally friendly plastic materials and textiles based on cellulose instead of oil.

Sociotechnical challenges to industrial and regional renewal

In the past decade, the literature on sociotechnical transitions has made a considerable contribution in understanding the complex technologyrelated shifts considered necessary to prepare and adapt societies in terms of (primarily ecological) sustainability imperatives (ELZEN et al., 2004; SMITH et al., 2005). Transition is here understood as transformative changes or 'system innovations' in distinctive sociotechnical systems that consist of technological artefacts and their organizational, institutional, infrastructural and userelated aspects (RIP and KEMP, 1998; GEELS, 2002). The main focus of transitions of sociotechnical systems is to analyze formation and transformation processes in relation to disruptive, pathbreaking technological change. This body of research has its roots partly in evolutionary economics and partly in constructivist approaches to technology. In its conceptual vocabulary it draws considerably on processes of variation, selection and retention to explain technological change (NELSON and WINTER, 1982) while it at the same time emphasizes the social construction of technology and technological systems (PINCH and BIJKER, 1987). This literature has made a significant contribution in both academic and policy circles concerning a carbon lockin to present fossil fuel-based energy and transport systems due to persistent market and policy failures that inhibit the diffusion of low-carbon technologies despite their apparent environmental and economic benefits (UNRUH, 2000). It suggests that incumbent sociotechnical configurations exhibit strong path dependencies beyond increasing economies of scale due to aligned and lockedin use patterns (DAVID, 1985), standards, infrastructures and institutional structures (GRANOVETTER and MACGUIRE, 1998). At the same time, the sociotechnical configuration around emergent technologies is regarded as more fluid and less aligned: technologies need to improve in performance and costs, use patterns and user preferences have not taken definitive form and institutions governing the use and impact of the technology are not yet fully developed (see also CALLON, 1998 and DOSI, 1982).

Proponents of sociotechnical systems have in fact criticized the innovation systems approach for over-emphasizing the producerside of technologies and putting an analytical premium on firms and successful technologies at the expense of the adoption and usesides as well as the potentially transformative impact on society well beyond the economic sphere (GEELS, 2004; STIRLING, 2011). The main strength of the socio-technical system framework lies in its ability to conceptualize transformative technological change based on detailed historical accounts of technological (trans)formation processes in e.g. hygienic reform of waste water disposal in late 19th century Netherlands (GEELS, 2006), the transition from horsedrawn carriages to automobiles in the US 18701930 (GEELS, 2005) and the recent emergence of renewable energy in the Netherlands (VERBONG et al., 2008). Long periods of relative stability and technology optimization are followed by relatively short periods of structural change and technological upheaval (ANDERSEN and TUSHMAN, 1990). One can identify strong parallels between these historical examples and the current shift taking place in the intersection of the forest related, energy and specialty chemicals industries dealt with in this paper. A shift, or transition, takes place where existing structures are changed and/or broken down and new ones emerge. Even if oil probably will continue to be the dominant raw material for energy and chemicals productions for decades to come, there is not much doubt that a radical shift will come sooner or later, neither that more incremental transitions already are taking place, the BioF being one illustrative case. Such a shift will have far reaching implications for the entire industrial structure, not only regionally but also on a global scale.

Framework for analysis: a multilevel perspective to renewal

Within the literature on sociotechnical systems, the socalled multilevel perspective has been highly resourceful in explaining this dynamic process of change in a way that does justice not only to the structural inertia of technological change but also to the sudden discontinuities when radical novelty emerges. The multilevel perspective differentiates between landscapes, regimes and niches as three different levels through which transitions evolve. A central tenet in the framework concerns the stabilizing influence of a sociotechnical regime on innovation dynamics and technological change. Here, a regime is defined as "the coherent complex of scientific knowledge, engineering practices, production process technologies, product characteristics, skills and procedures, established user needs, regulatory requirements, institutions and infrastructures"' (RIP and KEMP, 1998, p. 338). The 'structuration' of this complex is high, providing stable rules and coordinating effects on the actors that are implied by the regime. By its very nature a regime seeks to retain its configuration, allowing only for incremental, pathfollowing innovation that 'resists' the broad, transformative and structural change implied by a transition. Regime pressure or selection provides an explanatory framework for technological lockin (UNRUH, 2000) or the prevalence of sustaining innovation. Conversely it can be used to identify barriers to disruptive innovation.

For the purpose of identifying a number of concrete regimebased barriers to emergent disruptive technologies, KEMP et al. (1998) have singled out the following factors: (1) technology and infrastructure factors, (2) government policy and regulatory framework,
(3) demand factors, (4) production factors, and (5) undesirable societal and environmental effects of new technology. One of the hallmarks of the regime notion is that it emphasizes how different factors are interrelated and mutually reinforcing, thus strengthening its stabilization effects. But for explanatory purposes it makes sense to first disentangle the different factors and discuss their effects respectively.

Technological and infrastructure barriers concern the relatively suboptimal performance of new technology in terms of user functionality as well as the need for facilitative, complementary technology or supporting infrastructure that perhaps is not available yet or expensive to use (UTTERBACK, 1994). Often new technology does not diffuse into large scale application until a dominant design is established, allowing for economies of scale. Government policy and regulatory frameworks may be a barrier in case they provides unclear or contradictory signals concerning the need for specific new technology. When there is no clear future vision that helps guide technology developers, entrepreneurs and investors this creates disincentives for further investment. In terms of demand factors, KEMP et al. (1998) refer to persistent values and attitudes among manufacturers and consumers that reinforce the familiar and eschew unfamiliar alternatives. This relates also to economic barriers on the demand side visàvis prospective users' preferences, risk aversion and willingness to pay for new technologies that have not proven what they are worth (KEMP et al., 1998). On the production side, potential barriers exist in the form of sunk investments and existing competences in established production facilities which may constitute an important impediment for firms to invest in setting up a technical and organizational production structure for a new technology from scratch. Finally, it is possible that new technology may solve certain problems (e.g. in terms of environmental performance) but at the same time give rise to new ones. Such backlash problems may frustrate the introduction of a new technology or in the worst case annihilate its chances for commercial success. The recent food for fuel discussion serves as an example of this.

The second level in the multilevel perspective, i.e. ‘niches’, acts as ‘incubation spaces’ for radical pathbreaking innovation yet immersed in uncertainty and experimental disorder. These are “protected spaces in which actors learn about novel technologies and their uses” (GEELS, 2002, p. 365) and that nurture novelty creation and protect radical innovations against mainstream market selection. RAVEN (2005) makes a distinction between market and technological niches. Market niches can be seen as new application domains, understood as selection environments that employ different selection criteria or have substantially different resources to deploy compared to mainstream markets (LEVINTHAL, 1998). These differences may in turn give rise to the development of a new technology trajectory. RAVEN (2005) remains critical of the dominant focus on the demand side and, instead, conceptualizes niches as being situated between variation and selection environments, thus stressing the interplay between technology generation(s) and its application(s). The approach by which niches are purposefully nurtured to induce regime shift is called strategic niche management. KEMP et al. (1998, p. 186) define it as “the creation, development and controlled phaseout of protected spaces for the development and use of promising technologies by means of experimentation”, with the aim of both learning about the desirability of the new technology and enhancing the further development and the rate of application of the new technology. RAVEN (2005) mentions three key processes in such experiments for successful niche formation: (1) network formation, (2) alignment of expectations and (3) collective learning.

Network formation refers to the development of a heterogeneous but stable network of actors in the experiment (producers, users, regulators, societal groups, etc). Social networks are considered important because they provide necessary resources, sustain development, carry expectations, articulate new requirements and demands and enable learning and diffusion of lessons and experiences between actors. HOOGMA et al. (2002) argues that two network characteristics are of crucial importance for niche formation, membership and alignment. The membership of the network requires a careful balance between the interests of various stakeholders. Dominance of established firms may lead to prevalence for incremental, pathfollowing innovation because their activities are structured by the dominant regime. On the other hand, established firms have the resources needed to maintain niche development even when shortterm market value is absent. Alignment of expectations entails the development of similar, or at least converging expectations about the experiment in order to provide the legitimacy for actors to invest time and effort in a new technology that does not yet have any market value. In the beginning, expectations around a technology may diverge considerably among different stakeholders. Through experimentation, these expectations may start to align which further reinforces the development path of a technological trajectory. Learning processes take place that align the technical features of the niche experiment with its social dimensions (e.g. regulation, user preferences) and that induce the actors to reflect about their underlying norms and values about the niche experiment. HOOGMA et al. (2002) distinguish various aspects of collective learning, such as technical learning, policy learning, learning about user characteristics and demand, learning about production aspects and maintenance to facilitate largescale diffusion, and learning with regard to safety, energy and environmental aspects of the technology.

Finally the landscape level represents the exogenous environment that influences both regimes and niches. In the literature, the landscape has been defined as a “. . . set of heterogeneous factors, such as oil prices, economic growth, wars, emigration, broad political coalitions, cultural and normative values, environmental problems.” (GEELS, 2002, p. 1260). Even if seen as exogenous, i.e. largely beyond the influence and control of single actors or groups, the landscape thus strongly influences the preconditions for success or failure of regime transformation (or conservation) and strategic niche management. As will become evident in the remainder of this paper, one can hardly study transformation of the forest related energy and specialty chemicals industries without paying close attention to some of these, oil prices and environmental problems being two of the most obvious. Thus, to sum up, the multilevelperspective, as adopted in the present study, should be seen as an attempt to embrace the interplay of stabilizing and conditioning mechanisms at the regime and landscape levels combined with the emergence of new routines and modes of organisation at the niche level. While the approach has received critique for being largely aspatial, this paper follows TRUFFER and COENEN’S (2012) suggestion to embed the geographic context in the analysis.

Research design and methods

The following sections of this paper will use the BioF initiative in northern Sweden as an illustrative example of strategic niche management in a regional context, identifying a range of factors that serve as barriers and enablers for the adoption of biorefinery technologies for the renewal of the forest related industries in the region as well as in more general terms. Not only factors internal to the initiative itself are addressed, but also specific characteristics of the regional context (its location, industrial composition and history) and characteristics of its target industries (knowledge complementarities, geographic distribution of actors and activities, and the current and historical situation with regard to institutional aspects such as regulations, norms and conventions related to innovation and renewal). The analysis is based on a combination of qualitative research methods; document studies and personal indepth interviews with key stakeholders being the two dominant data sources. Previous research on these and similar industries are used as reference cases, while primary data collection has been focused on publicly available documents such as websites, annual reports, strategy documents and publicly commissioned evaluations. A total number of 20 semistructured interviews with representatives of the initiative and its target industries were conducted. The group of respondents includes representatives from the public sector (policy makers) as well as universities and industry. Eight interviews were conducted in October 2008 when the initiative in its current form was recently launched. Six more interviews were conducted in January 2012. While the first interviews primarily aimed at collecting information on the industries, the initiative and the various challenges that served as main rationale for the initiative, the second round of interviews focused more explicitly on activities, outcomes, and remaining problems/deficiencies. In addition to those interviews, which explicitly dealt with the initiative and its target industries another six interviews were made with actors doing research on or representing the industries but with no specific stake in the initiative as such. These interviews, carried out in the period MarchJuly 2009, are used primarily for reference and crosscheck purposes. The interviews revealed broad agreement between the interviewees’ views with regard to the research questions studied in this paper.

Analysis

History of the regional forest industry

Forest related industries have been important for the northern part of Sweden and the Örnsköldsvik area in particular, since the late 19th century. Its main products have been paper and pulp, with energy production from less refined parts of the raw material being an important sideproduct. The production of chemicals, chlorine and ethanol entered the scene in the 1930s when the region's leading pulp & paper company established what can be seen as an early version of what today would be described as a biorefinery. This was part of a strategy of self-sufficiency as a response to trade blockades during the Second World War, which led to a shortage of chemicals in Sweden. In the post war years chemical production relocated to the west coast of Sweden, due to its proximity to major international ports, which was of strategic importance for the petrochemical industry. The forest industry in the north returned to, and further strengthened, it's specialization in pulp & paper production, with less emphasis on taking care of residual chemicals in its production. While the regional forest industry invested a lot of resources in R&D since the 1940s, the vast majority of these resources followed the dominant technological paradigm focusing on incremental quality improvements and process efficiency. Until the 1980s production was almost entirely based on traditional (and environmentally polluting) techniques for dissolving cellulose using hightemperature and highpressure processes technologies drawing on (sulphite or sulphate) chemicals. Technological challenges, particularly in connection to dissolving lignocellulose, combined with a conservative culture in the industry and little openness to renewal in general, served as one of the main lockin mechanisms for the industry during the 1990s (LAESTADIUS, 2000). However, new scientific and technological breakthroughs in life science made it possible to start experiments with dissolving cellulose applying alternative technology
(i.e. enzyme based biotechnology processes) in the mid1990s, and one of the paper mills of the region was among the few actors worldwide entering into this field. At this time, however, other factors than technological breakthroughs and an awakening openness to renewal served as major drivers for change in the regional industry. These are outlined in the remainder of this section.

Reorganization and industrial transformation

In the mid1990s, the regional forestrelated industry experienced encompassing transformation, primarily due to new international competition following globalization processes. Not only did high volume production functions leave the region as a result of rationalizations following mergers with multinationals, but also, and more importantly, knowledge intensive research and development were relocated from the region. The situation became severe in 2000 when one of the large paper producers in the region, which already had restructured a large part of its R&D due to a merger with another large Swedish firm in the mid1990s, was acquired by a Finnish multinational company. A substantial decrease of R&D investments and activities in the area was expected, as the mother company gave priority to units located in Finland and abroad. As a response to this threat, an independent research unit was spun off. The rationale was to retain regional demand for qualified labor and cutting edge R&D competences in light of increased offshoring of research activities. This spinoff proved to be a key factor for the future development of the forestrelated industry in the region, not the least since its founders already from the start made sure to establish a 'neutral' ownership structure, allowing for multiple companies to use the facility on equal terms (PETERSON, 2011). This spinoff R&D firm is today one of the core actors of the BioF initiative.

In parallel to this development towards reorganization and relocation of production and R&D activities, four other, more industry specific, interrelated processes contributed as drivers of industrial transformation, and for the site in Örnsköldsvik in particular. Firstly, there was an overall absolute decrease in global demand for paper and a shift in demand patterns towards more fine quality products at the expense of high volumes. Secondly, there was a scarcity and increasing prize of forest raw materials. Despite the fact that large parts of Scandinavia and neighboring regions are covered by forest, there is insufficient supply of raw materials with suitable characteristics for these processes. Thirdly, environmental regulations increased taxes on disposal which forced the industry to make efforts to refine its waste into products. Fourthly, the development towards what is sometimes referred to as 'peak oil' accentuated (i.e. the point in time when the maximum rate of global petroleum extraction is reached, after which the rate of production enters terminal decline). These external, landscape processes trigged two main reactions in the industry and region. Firstly, it became obvious to the companies (i.e. pulp & paper producers) that they could not continue with their current technologies, only using approximately 40 percent of the raw material for value creation while burning the remainder as waste. Also the deposit of waste, in particular sludge, became too expensive and was a driving force for the industry to extend its value chain. Secondly, and strongly related, they realized that they had to diversify their product portfolios even more to get higher value out of their processes. This was manifested in attempts to reintroducing the diversification of the 1930s, but now with modern technologies. In addition to bioethanol and specialty chemicals (e.g. various plastic products), high quality viscose became a new important market area. The actors at the site also joined forces to create a shared system of energy, water and waste management, which contributed both to environmental and economic efficiency. These adoptions can be seen as new routines and modes of organization at a niche level, triggered by exogenous forces on the industry. Moreover, they were clearly conditioned by the collocation of actors in one historically and geographically bounded area, and on the local presence of a related variety of industry competences (e.g. energy, chemicals, forestry, agriculture and clean technologies).

The BioF initiative

The BioF initiative was materialized in 2003, by that time in the shape of a technology park, located at the site of the pulp & paper industry in Örnsköldsvik. Twelve SMEs related to research and development in pulp & paper technologies, chemicals and energy production started collaborating with two large companies specialized in various applications of forest and chemistryrelated production. The municipality, the county administration, a regional technology transfer agency and a privately owned funding foundation with its roots in the region's forestbased industry provided financial support. Over time, linkages to the nearby universities in Luleå and Umeå were established and increasingly formalized. The technologypark evolved to a network of related firms and organizations (i.e. an innovation system) distributed over a territory much wider than the boundaries of the city in which it was initiated. A large grant from the Swedish Energy Agency was used to set up a pilot plant for alternative ethanol production, which gradually developed into a platform for several products based on forest- and agriculturebased lignocellulose. This pilot plant, now probably more appropriately referred to as a demonstration facility, has during the first decade of the 2000s been one of the most visible expressions of the niche experiment. A central firm in this pilot plant is a regional producer and developer of ethanol, today considered to be a world leading actor in the field of bioethanol and green chemicals. The pilot plant, the ethanol firm, a small firm specialized in pulp & paper related R&D, a large forestry company, a sector specific industry support initiative, and the regional universities can today be seen as composing the nexus around which the biorefinery initiative evolves.

A decisive moment for BioF came 2008 when VINNOVA (the Swedish Agency for Innovation Systems) launched a second call for regional industry development initiatives called VINNVÄXT. The consortium with representatives from industry, academia and the regional public sector (i.e. the group of actors referred to above as the nexus of the initiative) made a successful application and received a ten year grant. The aim with the project was to become a leading initiative for developing biorefineries based on forest raw material and energy crops by combining historical and current strengths in traditional forestry with new cutting edge knowledge in science based technologies. Active promotion of the interplay between researchers, companies and the political public sector
(i.e. triple helix) was set centre stage in the initiative. The grant allowed for expansion in scope as well as scale. One immediate consequence was that the universities became more central actors; one of the regional universities established new professorships located at the industry site. An R&D board with the aim of supporting new development projects in the region was established, with two university professors, the head of R&D at the aforementioned ethanol firm, and the CEO of the pilot plant being responsible for evaluating applications, giving advice to entrepreneurs, and distributing resources for new R&D experiments. The first two years of its existence, the board supported 74 projects with approximately 18 million SEK.

Challenges to new development paths

However, despite this publicprivate partnership and their efforts to support industry related R&D in the region, there are some major challenges to further development, particularly when it comes to upscaling, i.e. bringing inventions from the R&D lab to commercial production. One such factor can be interpreted as industry related regime factor and has to do with sunk investments in conventional technology and production facilities. Forest-related industries are very capital intensive, and massive resources have already been invested in facilities world-wide drawing on the old technological paradigm. These investments and the competences built up around them implies a structural resistance to alternative technologies since those may create a paradigm shift making the existing facilities less profitable in the long run.

> “The fact that the investments are so huge leads automatically to an inertia in the system.”

Also the petrochemical industry (today dominant in both energy and specialty chemicals production worldwide) strongly opposes further development of cellulose based biorefineries for the same reason.

Furthermore, other, more policy related factors can be identified. To achieve profitability, it is expected that a commercial biorefinery (e.g. a full scale version of the pilot plant/demonstration facility referred to above) requires new investments of approximately 3 billion SEK. Combined with the current lack of possibilities to employ premium pricing strategies for green chemicals and energy (i.e. an insufficiently developed market) this raises an urgent need for subsidies from the public sector. While respective subsidies exist in Sweden today, they lack a long term horizon which makes them uncertain and create critical financial liabilities for investors.

> “The problem with these systems and regulatory frameworks is that they are almost on oneyear basis, and this is what limits us. (…) First they subsidize and then they take it away. Ethanol was in for a while, then it was biogas and now it is electric cars. It is impossible to see what is coming as consumer or producer.”

This is a striking illustration of political lockin and a regimebased barrier to new technologies; government policies providing unclear and contradictory signals concerning the needs for carbon reductions and a shift to renewable energy and at what costs such needs should be supported. As a result of this lack of clear future vision investors hesitate and entrepreneurs are reluctant to take the necessary risks. Another, strongly related, barrier to the fulfillment of the aims of BioF has to do with perceived undesirable societal effects of the new technology. In the public opinion, the forest based biorefinery technology is hardly separated from agro based ditto, which implies resistance with reference to the crops for food or fuel debate.

Also within the initiative itself, and in the regional context in which it takes place, there are mechanisms acting as barriers to radical renewal. The place bound historical legacy and current industrial structure is one example. Even if the experiment (materialized in the consortium of BioF) is composed by a fairly large number of independent and relatively young knowledge intensive small and medium sized firms, most of them have their roots in the dominant forest industry or chemical producer in the region. The same is true for a large share of the capital channelized through the private foundation, as well as the large forestry company acting as 'anchor firm' in the region. During the period from the late 19th century until the 1970s, they were all part of the same organization. This joint history and alliance with the established industry on the one hand provides stability and alignment of expectations, as well as high degree of cognitive proximity even though they over time have diverged into different fields of specialization. The social networks built up over generations thus provide important conditions enabling knowledge spillovers and interactive learning (within and across sectoral boundaries), and it contributes to giving the actors a unified voice articulating needs and demand. But on the other hand it also contributes to retained pathdependence since the activities carried out by actors in this network, though striving for renewal, are ultimately structured by the dominant regime.

The location as such, a peripheral region in the north with, by Swedish standards, less developed transport infrastructure and, up till the last decade, negative migration trends and aging population, implies both benefits and drawbacks to the possibilities for industrial renewal. On the one hand the location is seen as an important (positive) factor behind the development of social networks of firms and individuals. The regional identity is considered strong. This means that knowledge exchange both within and across sectoral boundaries in the region are facilitated by regionally bound social capital and interpersonal trust. On the other hand, this also leads to less integration in national and international networks since the regional actors are strongly focused on intraregional networking and have less access to the outer world. This problem of intraregional lockin however tends to diminish, partly due to the changed ownership structure referred to above and partly as a result of the BioF initiative. Today, the dominant forestry company
(i.e. the anchor firm) has been acquired by an Indian MNF, and R&D collaborations have been established between BioF members and universities in other parts of Sweden (Chalmers in Gothenburg, Royal Institute of Technology in Stockholm, The University for Agricultural Sciences in Uppsala, and Lund University). Another problem with the location which persists though has to do with the relatively weakly developed general knowledge infrastructure (except the strongholds previously referred). One concrete example is the lack of qualified engineers and scientists, as well as staff with management skills. While more centrally located regions can attract such human capital from neighboring regions, this region has to rely largely on own mobilization of resources. While this strategy so far seems to work for handling the current needs of the regional industry, the low degree of inmigration obviously leads to challenges with regard to dealing with path dependence and lockin.

Discussion and conclusions

The above analysis conceptualized the BioF initiative as niche strategies aiming to transform the region's forest related industries into becoming more competitive, resourceefficient and environmentally sustainable through combinatory efforts within the frame of biorefinery technologies. Despite considerable success in terms of developing and implementing novel technologies, process improvements and new product portfolio's, the initiative's location in a peripheral 'old industrial' region, suffering from organizational and institutional thinness, constitutes, however, potentially important challenges to break path dependence and enter into new path creation.

Endogenous aspects influencing the niche strategies to result in success or failure were identified and addressed. Drawing on privatepublic partnerships (triple helix), the initiative has contributed to the development of a heterogeneous but stable network of actors (especially in terms of including actors outside the traditional forest-related paper and pulp value chain). An overlap of social and business relations in the network adds (positively) to the alignment (or at least convergence) of expectations and ambitions among the actors around a core set of activities (R&D, pilottesting new technologies, developing new products from sidestreams), and it contributes to lending the actors a collective voice to raise needs and demands e.g. on institutional transformation. Sector-transcending combinations of knowledge within the network contribute to collective learning processes, both with regard to technology and market. The historically more or less separated cognitive domains of the forest industry on the one hand and the energy and chemicals industries on the other have started to merge, giving rise to new but related knowledge specifically adapted to the emerging field of biorefineries.

In parallel, a range of industry related regime factors were identified. One of those, working both as enabler and outcome of the sectortranscending network development, is the current situation with regard to knowledge complementarities (e.g. related variety) in these industries and in the region. Presence of compatible competences in different but related industrial fields (i.e. forestry, chemicals, energy) made such network formation possible, and the network formation as such further influenced the complementarity. Yet, the situation with regard to functional, cognitive and political lockin can be seen as regimebased mechanisms retaining path dependence. While the technological challenges which held back renewal in the 1990s in essence have been solved, there are still both functional and political lockin mechanisms in place. A concrete example is the unclear signals from the public sector with regard to support of transformation processes to sustainability in those sectors. Shortterm time horizons in subsidies and regulations, as well as shifting (political) priorities from one year to the next, create major barriers and uncertainty for private investment. Also the persistent attitudes among both manufacturers and consumers, partly related to sunk investments in traditional technology, and partly to a lack of perceived premium value of green technology (thus resulting in less or no willingness to pay more for such products), contributes to lockin to the traditional value chains of respective industry.

The niche and regime levels must, obviously, be constantly read in the light of the landscape level, which very much determines the conditions of the regime and niche. Concrete examples of such landscapebased enablers and barriers are the oil paradigm in the chemicals industry, the chemistry based paradigm in the forest industry (both working as conserving forces), and the increasingly urgent, globally spread, environmental challenges facing almost all sectors and regions (working as drivers for renewal). Also processes of globalization, strongly influencing both this specific niche experiment and the region in general, should be seen as part of the landscape. Structured in such a stylized way, the case of BioF clearly illustrates the benefits of adopting a multilevel perspective to studies of industrial and regional renewal. It shows that regional niche initiatives clearly have potential in advancing pathbreaking technological and industrial renewal but, at the same time, that important pathreinforcing tendencies persist which often transcend the regional scale. The development and diffusion of biorefinery technologies should be seen as an international process, as it is triggered by different landscape forces of largely global character. Örnsköldsvik with its regional initiative can be seen as fulfilling a pioneering role with regard to this development; however, important barriers to renewal remain present in a wider industry context. Moreover, crucial institutional barriers have been identified within the sphere of supraregional (national, international) jurisdictions.

By way of concluding, we argue that biorefinery represents a very promising new technology for environmentally sustainable and economically efficient production of a range of products, but that institutional conditions are not yet sufficiently developed to allow making use of this potential on a wider level. Institutions are thus bottlenecks, not yet aligned to this new technology. The multilevel perspective to sociotechnical transitions, as adopted in this paper, illustrates this institutional mismatch and helps us specify these system deficiencies in a more precise way. It shows that there is still a lot of insecurity with regard to how new institutions more suitable for biorefery technologies should look, not to mention how they should be achieved and who could/should influence them. As opposed to a onedimensional focus on technological relatedness, mainly addressing supplyside aspects to production and development, the multilevel perspective pays careful attention also to the demand and adoption side. Technology, while often being a necessary condition for industrial and regional renewal, is not sufficient. Institutions remain crucial, and the regional level only embraces a small fragment of the institutional framework that conditions such technological and social renewal and adoption.

There is thus a complex interplay of territorial and nonterritorial, industry specific and general socioeconomic factors that defines the potential of technological and economic path renewal. Given this complexity and the multitude of challenges to be dealt with, policy support initiatives as the one dealt with in this paper (VINNVÄXT, BioF) ought to employ a broad scope and scale, both functionally and geographically. Industry-wise the scope should transcend traditional sector boundaries allowing for true exploitation of related variety without predefined limitations in terms of skills and markets. To achieve this, it might be useful to focus on the knowledge base of activities rather than the outcome in terms of products or processes. Geographywise, such regional initiatives must be aligned with policy agendas also on a national and international scale, not only with regard to focus but also with regard to time horizons.

References

ANDERSON, P. and TUSHMAN, M.L. (1990) Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change, Administrative Science Quarterly 35 (4).

ASHEIM, B., BOSCHMA, R. COOKE, P. (2011) Constructing regional advantage: Platform policies based on related variety and differentiated knowledge bases, Regional Studies.

BOSCHMA, R., and FRENKEN, K. (2006) Why is economic geography not an evolutionary science? Towards an evolutionary economic geography, Journal of Economic Geography, 6, 273302.

BOSCHMA, R., and MARTIN, R. (2010) Handbook of Evolutionary Economic Geography, Cheltenham: Edward Elgar.

CALLON, M. (1998) Society in the Making. The Study of Technology as a Tool for Sociological Analysis, in BIJKER, M. et al. (eds) The Social Construction of Technological Systems. Cambridge, MA: MIT Press.

COENEN, L. (2007): The Role of Universities in the Regional Innovation Systems of the North East of England and Scania, Sweden: Providing Missing Links? Environment and Planning C: Government and Policy, 25(6), 803821.

DAVID, P. (1985) Clio and the Economics of QWERTY, The American economic review, 75 (2), 332—337

DOSI, G, (1982) Technological paradigms and technological trajectories, Research Policy, 11(3), 147162.

ELZEN B., GEELS F. and GREEN K. (2004) System Innovation and the Transition to Sustainability: Theory, Evidence and Policy. Edgar Elgar, Cheltenham

ESSLETZBICHLER, J. and RIGBY, D. (2007) Exploring evolutionary economic geographies, Journal of Economic Geography, 7(5), 549571.

FRENKEN, K., VAN OORT, F., and VERBURG, T. (2007) Related variety, unrelated variety and regional economic growth. Regional Studies, 41(5), 685697.

GEELS, F. W. (2002) Technological transitions as evolutionary reconfiguration processes: a multilevel perspective and a casestudy, Research Policy, 31, 12571274.

GEELS, F.W., 2004 From sectoral systems of innovation to sociotechnical systems: Insights about dynamics and change from sociology and institutional theory, Research Policy, 2004. 33(67):897920.

GEELS, F. (2005) Coevolution of technology and society: The transition in water supply and personal hygiene in the Netherlands (18501930)a case study in multilevel perspective, Technology in Society, 27(3), 363397.

GEELS, F. (2006) The hygienic transition from cesspools to sewer systems (18401930): The dynamics of regime transformation, Research Policy, 35 (7), pp. 10691082

GEELS, F., HEKKERT, M., JACOBSSON, S. (2008) The Dynamics Of Sustainable Innovation Journeys, Technology Analysis and Strategic Management 29 (5)

GERTLER, M. (2010) Rules of the game: the place of institutions in regional economic change, Regional Studies, 44(1), 115.

GRABHER, G. (1993) The weakness of strong ties: the lockin of regional development in the Ruhr area, in GRABHER, G. (ed) The embedded firm, London: Routledge.

GRANOVETTER, M., and Mcguire, P. (1998) The Making of an Industry: Electricity in the United States in M. CALLON (ed) The Laws of the Markets. Oxford: Blackwell.

HASSINK, R. (2010) Locked in decline? On the role of regional lockins in old industrial areas, in BOSCHMA, R., and MARTIN, R. (eds) Handbook of Evolutionary Economic Geography, Cheltenham: Edward Elgar.

HASSINK, R. and SHIN, DH. (2005) The restructuring of old industrial areas in Europe and Asia, Environment and Planning A, 37(4), 571580.

HOOGMA, R, KEMP, R, SCHOT, JW, TRUFFER, B. (2002) Experimenting for sustainable transport: the approach of strategic niche management. London: Spon Press.

HUDSON, R. (1989) Labour market changes and new forms of work in old industrial regions: maybe flexibility for some but not flexible accumulation, Environment and Planning D: Society and Space 7 (1), pp. 530

HUDSON, R. (1994) New production concepts, new production geographies? Reflections on changes in the automobile industry, Transactions of the Institute of British Geographers 19 (3), pp. 331345 HUDSON, R. (2005) Rethinking change in old industrial regions: reflecting on the experiences of North East England, Environment and planning A. 37 (4), pp. 581596

KEMP, R. SCHOT, JW, HOOGMA, R. (1998) Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management. Technology Analysis & Strategic Management, 10 (2), 175195.

LAESTADIUS, S. (2000) Biotechnology and the potential for a radical shift of technology in forest industry, Technology Analysis and Strategic Management, 12, 193
212.

LEVINTHAL, D.A (1998) The slow pace of rapid technological change: gradualism and punctuation in technological change, Industrial and corporate change, 7 (2), 217247.

MARTIN, R., and SUNLEY, P. (2007) Complexity thinking and evolutionary economic geography, Journal of Economic Geography, 7(5), 573601.

MOODYSSON, J., COENEN, L., and ASHEIM, B. (2008) Explaining spatial patterns of innovation: analytical and synthetic modes of knowledge creation in the Medicon Valley life science cluster, Environment and Plannin A, 40(5), 10401056.

MORGAN, K. 2012. Path dependence and the State: the politics of novelty in old industrial regions. In: COOKE, P. ed. Reframing regional development: evolution, innovation, transition. Regions and Cities Abingdon: Routledge

NELSON, R., and WINTER, S. (1982) An evolutionary theory of economic change, Cambridge MA and London: The Belknap Press.

NOOTEBOOM, B. (2000) Learning and innovation in organizations and economies, Oxford: Oxford University Press.

OTTOSSON, M. (2011) Opposition and adjustment to industrial ‘greening’: The Swedish forest industry’s (re)actions regarding energy transition, 19892009, Linköping: Linköping University.

PETERSON, C. (2011) Sweden: from large corporations towards a knowledgeintensive economy, in HULL KRISTENSEN, P. and LILJA, K. (eds) Nordic capitalisms and globalization: new forms of economic organization and welfare institutions, Oxford: Oxford University Press.

PINCH, T. and BIJKER, W. (1987) The social construction of facts and artifacts: Or how the sociology of science and the sociology of technology might benefit each other, in BIJKER, W., HUGHES, T. and PINCH, T. (eds) The social construction of technological systems: New directions in the sociology and history of technology, 1750. Cambridge, MA: MIT Press.

PORTER, M. (2000) Location, clusters and company strategy, in CLARK, G., FELDMAN, M. and GERTLER, M. (eds) The Oxford Handbook of Economic Geography, Oxford: Oxford University Press.

RAVEN, R. (2005) Strategic niche management for biomass. PhD thesis, Technical University Eindhoven, The Netherlands.

RIP, A., and KEMP, R. (1998) Technological change, in RAYNER, S., and MALONE, E.L. (eds) Human choice and climate change, vol 1, Columbus OH: Batelle Press.

SMITH, A.G., STIRLING, A.C., BERKHOUT, F.G.H. (2005) The governance of sustainable sociotechnical transitions, Research Policy, 34(10), 14911510.

STIRLING, A (2011) Pluralising Progress: from integrative transitions to transformative diversity. Environmental Innovation and Societal Transitions 1 (1)

TÖDTLING, F., and TRIPPL, M. (2005) One size fits all? Towards a differentiated regional innovation policy approach, Research Policy, 34, 12031219.

TRUFFER, B., and COENEN, L. (2012) Environmental innovation and sustainability transitions in regional studies, Regional Studies, 46(1), 121.

UNRUH G. C. (2000) Understanding carbon lock in. Energy Policy 28, 817–830.

UTTERBACK, J. (1994) Mastering the Dynamics of Innovation. Boston: Harvard Business School Press.

CIRCLE ELECTRONIC WORKING PAPERS SERIES (EWP)

CIRCLE (Centre for Innovation, Research and Competence in the Learning Economy) is a multidisciplinary research centre set off by several faculties at Lund University and Blekinge Institute of Technology. CIRCLE has a mandate to conduct multidisciplinary research and education on the following issues: Long-term perspectives on innovation, structural change and economic growth, Entrepreneurship and venture capital formation with a special focus on new ventures, The dynamics of R&D systems and technological systems, including their impact on entrepreneurship and growth, Regional innovation systems in different national and international contexts and International comparative analyses of national innovation systems. Special emphasis is done on innovation policies and research policies. 10 nationalities and 14 disciplines are represented among the CIRCLE staff.

The CIRCLE Electronic Working Paper Series are intended to be an instrument for early dissemination of the research undertaken by CIRCLE researchers, associates and visiting scholars and stimulate discussion and critical comment.

The working papers present research results that in whole or in part are suitable for submission to a refereed journal or to the editor of a book or have already been submitted and/or accepted for publication.

CIRCLE EWPs are available on-line at: http://www.circle.lu.se/publications

Available papers:

2013

WP 2013/01
Start-up rates, Entrepreneurship Culture and the Business Cycle
Swedish patterns from national and regional data
Martin Andersson

WP 2013/02
Market Thickness and the Early Labor Market Career of University Graduates
-An urban advantage?
Lina Ahlin, Martin Andersson and Per Thulin

WP 2013/03
Implementing an R&D Strategy without Prior R&D-Experience
Recruitment as a Source of R&D-related Routines and Capabilities?
Lina Ahlin, Martin Andersson and Thorben Schubert

WP 2013/04
The Choice of Innovation Policy Instruments
Susana Borrás, Charles Edquist

WP 2013/05

What Does Evolutionary Economic Geography Bring To The Policy Table?
Reconceptualising regional innovation systems

Bjørn Asheim, Markus M. Bugge, Lars Coenen, Sverre Herstad

WP 2013/06
Commercializing clean technology innovations – the emergence of new business in an agency-structure perspective
Sofia Avdeitchikova, Lars Coenen

WP 2013/07
Renewal of mature industry in an old industrial region: regional innovation policy and the co-evolution of institutions and technology
Lars Coenen, Jerker Moodysson and Hanna Martin

2012

WP 2012/01
Is the University Model an Organizational Necessity? Scale and Agglomeration Effects in Science
Tasso Brandt and Torben Schubert

WP 2012/02
Do regions make a difference? Exploring the role of different regional innovation systems in global innovation networks in the ICT industry
Cristina Chaminade and Monica Plechero

WP 2012/03
Measuring the knowledge base of regional innovation systems in Sweden
Roman Martin

WP 2012/04
Characteristics and Performance of New Firms and Spinoffs in Sweden
Martin Andersson and Steven Klepper

WP 2012/05
Demographic patterns and trends in patenting: Gender, age, and education of inventors
Olof Ejermo and Taehyun Jung

WP 2012/06
Competences as drivers and enablers of globalization of innovation: Swedish ICT industry and emerging economies
Cristina Chaminade and Claudia de Fuentes
WP 2012/07
The Dynamics and Evolution of Local Industries – The case of Linköping
Sabrina Fredin

WP2012/08
Towards a Richer Specification of the Exploration/Exploitation Trade-off: Hidden Knowledge-based Aspects and Empirical Results for a Set of Large R&D-Performing Firms
Torben Schubert and Peter Neuhaeusler

WP 2012/09

The European Spallation Source (ESS) and the geography of innovation

Josephine V. Rekers

WP 2012/10

How Local are Spatial Density Externalities? - evidence from square grid data

Martin Andersson, Johan Klaesson, Johan P Larsson

WP 2012/11

Why Pre-Commercial Procurement is not Innovation Procurement

Charles Edquist, Jon Mikel Zabala-Iturriagagoitia

2011

WP 2011/01
SMEs' absorptive capacities and large firms' knowledge spillovers: Micro evidence from Mexico
Claudia de Fuentes and Gabriela Dutrénit

WP 2011/02
Comparing knowledge bases: on the organisation and geography of knowledge flows in the regional innovation system of Scania, southern Sweden
Roman Martin and Jerker Moodysson

WP 2011/03
Organizational paths of commercializing patented inventions: The effects of transaction costs, firm capabilities, and collaborative ties
Taehyun Jung and John P. Walsh

WP 2011/04
Global Innovation Networks: towards a taxonomy
Helena Barnard and Cristina Chaminade

WP 2011/05
Swedish Business R&D and its Export Dependence
Karin Bergman and Olof Ejermo

WP 2011/06
Innovation Policy Design: Identification of Systemic Problems
Charles Edquist

WP 2011/07
Regional Institutional Environment and Its Impact on Intra-firm and Interorganisational
Innovation Networks: A Comparative Case Study in China and Switzerland
Ju LIU

WP 2011/08
Entrepreneurship: Exploring the Knowledge Base
Hans Landström, Gouya Harirchi and Fredrik Åström

WP 2011/09
Policy coordination in systems of innovation: A structural-functional analysis of regional industry support in Sweden

Magnus Nilsson and Jerker Moodysson

WP 2011/10
Urban Design in Neighbourhood Commodification
Ana Mafalda Madureira

WP 2011/11
Technological Dynamics and Social Capability: Comparing U.S. States and European Nations
Jan Fagerberg, Maryan Feldman and Martin Srhoelec

WP 2011/12
Linking scientific and practical knowledge in innovation systems
Arne Isaksen and Magnus Nilsson

WP 2011/13
Institutional conditions and innovation systems: on the impact of regional policy on firms in different sectors
Jerker Moodysson and Elena Zukauskaite

WP 2011/14
Considering adoption: Towards a consumption-oriented approach to innovation
Josephine V. Rekers

WP2011/15
Exploring the role of regional innovation systems and institutions in global innovation networks
Cristina Chaminade

2010

WP 2010/01
Innovation policies for development: towards a systemic experimentation based approach
Cristina Chaminade, Bengt-Ake Lundvall, Jan Vang-Lauridsen and KJ Joseph

WP 2010/02
From Basic Research to Innovation: Entrepreneurial Intermediaries for Research Commercialization at Swedish 'Strong Research Environments'
Fumi Kitagawa and Caroline Wigren

WP 2010/03 Different competences, different modes in the globalization of innovation?
A comparative study of the Pune and Beijing regions
Monica Plechero and Cristina Chaminade

WP 2010/04 Technological Capability Building in Informal Firms in the Agricultural
Subsistence Sector In Tanzania: Assessing the Role of Gatsby Clubs
Astrid Szogs and Kelefa Mwantima

WP 2010/05

The Swedish Paradox – Unexploited Opportunities!
Charles Edquist

WP 2010/06
A three-stage model of the Academy-Industry linking process: the perspective of both agents
Claudia De Fuentes and Gabriela Dutrénit

WP 2010/07
Innovation in symbolic industries: the geography and organisation of knowledge sourcing
Roman Martin and Jerker Moodysson

WP 2010/08
Towards a spatial perspective on sustainability transitions
Lars Coenen, Paul Benneworth and Bernhard Truffer

WP 2010/09
The Swedish national innovation system and its relevance for the emergence of global innovation networks
Cristina Chaminade, Jon Mikel Zabala and Adele Treccani

WP 2010/10
Who leads Research Productivity Change? Guidelines for R&D policy makers
Fernando Jiménez-Sáez, Jon Mikel Zabala and José L- Zofío

WP 2010/11
Research councils facing new science and technology
Frank van der Most and Barend van der Meulen

WP 2010/12
Effect of geographical proximity and technological capabilities on the degree of novelty in emerging economies
Monica Plechero

WP 2010/13
Are knowledge-bases enough? A comparative study of the geography of knowledge sources in China (Great Beijing) and India (Pune)
Cristina Chaminade

WP 2010/14
Regional Innovation Policy beyond 'Best Practice': Lessons from Sweden
Roman Martin, Jerker Moodysson and Elena Zukauskaite

WP 2010/15
Innovation in cultural industries: The role of university links
Elena Zukauskaite

WP 2010/16
Use and non-use of research evaluation. A literature review
Frank van der Most

WP 2010/17

Upscaling emerging niche technologies in sustainable energy: an international comparison of policy approaches
Lars Coenen, Roald Suurs and Emma van Sandick

2009

WP 2009/01
Building systems of innovation in less developed countries: The role of intermediate organizations.
Szogs, Astrid; Cummings, Andrew and Chaminade, Cristina

WP 2009/02
The Widening and Deepening of Innovation Policy: What Conditions Provide for Effective Governance?
Borrás, Susana

WP 2009/03
Managerial learning and development in small firms: implications based on observations of managerial work
Gabrielsson, Jonas and Tell, Joakim

WP 2009/04
University professors and research commercialization: An empirical test of the "knowledge corridor" thesis
Gabrielsson, Jonas, Politis, Diamanto and Tell, Joakim

WP 2009/05
On the concept of global innovation networks
Chaminade, Cristina

WP 2009/06
Technological Waves and Economic Growth - Sweden in an International Perspective 1850-2005
Schön, Lennart

WP 2009/07
Public Procurement of Innovation Diffusion: Exploring the Role of Institutions and Institutional Coordination
Rolfstam, Max; Phillips, Wendy and Bakker, Elmer

WP 2009/08
Local niche experimentation in energy transitions: a theoretical and empirical exploration of proximity advantages and disadvantages
Lars Coenen, Rob Raven, Geert Verbong

WP 2009/9
Product Development Decisions: An empirical approach to Krishnan and Ulrich
Jon Mikel Zabala, Tina Hannemann

WP 2009/10
Dynamics of a Technological Innovator Network and its impact on technological performance

Ju Liu, Cristina Chaminade

WP 2009/11
The Role of Local Universities in Improving Traditional SMEs Innovative Performances: The Veneto Region Case
Monica Plechero

WP 2009/12
Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities
Coenen, Lars and Díaz López, Fernando J.

WP 2009/13
Public Procurement for Innovation (PPI) – a Pilot Study
Charles Edquist

WP 2009/14
Outputs of innovation systems: a European perspective
Charles Edquist and Jon Mikel Zabala

2008

WP 2008/01
R&D and financial systems: the determinants of R&D expenditures in the Swedish pharmaceutical industry
Malmberg, Claes

WP 2008/02
The Development of a New Swedish Innovation Policy. A Historical Institutional Approach
Persson, Bo

WP 2008/03
The Effects of R&D on Regional Invention and Innovation
Olof Ejermo and Urban Gråsjö

WP 2008/04
Clusters in Time and Space: Understanding the Growth and Transformation of Life Science in Scania
Moodysson, Jerker; Nilsson, Magnus; Svensson Henning, Martin

WP 2008/05
Building absorptive capacity in less developed countries
The case of Tanzania
Szogs, Astrid; Chaminade, Cristina and Azatyan, Ruzana

WP 2008/06
Design of Innovation Policy through Diagnostic Analysis:
Identification of Systemic Problems (or Failures)
Edquist, Charles

WP 2008/07

The Swedish Paradox arises in Fast-Growing Sectors
Ejermo, Olof; Kander, Astrid and Svensson Henning, Martin

WP 2008/08
Policy Reforms, New University-Industry Links and Implications for Regional Development in Japan
Kitagawa, Fumi

WP 2008/09
The Challenges of Globalisation: Strategic Choices for Innovation Policy
Borrás, Susana; Chaminade, Cristina and Edquist, Charles

WP 2008/10
Comparing national systems of innovation in Asia and Europe: theory and comparative framework
Edquist, Charles and Hommen, Leif

WP 2008/11
Putting Constructed Regional Advantage into Swedish Practice? The case of the VINNVÄXT initiative 'Food Innovation at Interfaces'
Coenen, Lars; Moodysson, Jerker

WP 2008/12
Energy transitions in Europe: 1600-2000
Kander, Astrid; Malanima, Paolo and Warde, Paul

WP 2008/13
RIS and Developing Countries: Linking firm technological capabilities to regional systems of innovation
Padilla, Ramon; Vang, Jan and Chaminade, Cristina

WP 2008/14
The paradox of high R&D input and low innovation output: Sweden
Bitarre, Pierre; Edquist, Charles; Hommen, Leif and Ricke, Annika

WP 2008/15
Two Sides of the Same Coin? Local and Global Knowledge Flows in Medicon Valley
Moodysson, Jerker; Coenen, Lars and Asheim, Bjørn

WP 2008/16
Electrification and energy productivity
Enflo, Kerstin; Kander, Astrid and Schön, Lennart

WP 2008/17
Concluding Chapter: Globalisation and Innovation Policy
Hommen, Leif and Edquist, Charles

WP 2008/18
Regional innovation systems and the global location of innovation activities: Lessons from China
Yun-Chung, Chen; Vang, Jan and Chaminade, Cristina

WP 2008/19
The Role of mediator organisations in the making of innovation systems in least developed countries. Evidence from Tanzania
Szogs, Astrid

WP 2008/20
Globalisation of Knowledge Production and Regional Innovation Policy: Supporting Specialized Hubs in the Bangalore Software Industry
Chaminade, Cristina and Vang, Jan

WP 2008/21
Upgrading in Asian clusters: Rethinking the importance of interactive-learning
Chaminade, Cristina and Vang, Jan

2007

WP 2007/01

Path-following or Leapfrogging in Catching-up: the Case of Chinese Telecommunication Equipment Industry
Liu, Xielin

WP 2007/02
The effects of institutional change on innovation and productivity growth in the Swedish pharmaceutical industry
Malmberg, Claes

WP 2007/03
Global-local linkages, Spillovers and Cultural Clusters: Theoretical and Empirical insights from an exploratory study of Toronto's Film Cluster
Vang, Jan; Chaminade, Cristina

WP 2007/04
Learning from the Bangalore Experience: The Role of Universities in an Emerging Regional Innovation System
Vang, Jan; Chaminade, Cristina.; Coenen, Lars.

WP 2007/05
Industrial dynamics and innovative pressure on energy -Sweden with European and Global outlooks
Schön, Lennart; Kander, Astrid.

WP 2007/06
In defence of electricity as a general purpose technology
Kander, Astrid; Enflo, Kerstin; Schön, Lennart

WP 2007/07
Swedish business research productivity – improvements against international trends
Ejermo, Olof; Kander, Astrid

WP 2007/08
Regional innovation measured by patent data – does quality matter?

Ejermo, Olof

WP 2007/09
Innovation System Policies in Less Successful Developing countries: The case of Thailand
Intarakumnerd, Patarapong; Chaminade, Cristina

2006

WP 2006/01
The Swedish Paradox
Ejermo, Olof; Kander, Astrid

WP 2006/02
Building RIS in Developing Countries: Policy Lessons from Bangalore, India
Vang, Jan; Chaminade, Cristina

WP 2006/03
Innovation Policy for Asian SMEs: Exploring cluster differences
Chaminade, Cristina; Vang, Jan.

WP 2006/04
Rationales for public intervention from a system of innovation approach: the case of VINNOVA.
Chaminade, Cristina; Edquist, Charles

WP 2006/05
Technology and Trade: an analysis of technology specialization and export flows
Andersson, Martin; Ejermo, Olof

WP 2006/06
A Knowledge-based Categorization of Research-based Spin-off Creation
Gabrielsson, Jonas; Landström, Hans; Brunsnes, E. Thomas

WP 2006/07
Board control and corporate innovation: an empirical study of small technology-based firms
Gabrielsson, Jonas; Politis, Diamanto

WP 2006/08
On and Off the Beaten Path:
Transferring Knowledge through Formal and Informal Networks
Rick Aalbers; Otto Koppius; Wilfred Dolfsma

WP 2006/09
Trends in R&D, innovation and productivity in Sweden 1985-2002
Ejermo, Olof; Kander, Astrid

WP 2006/10
Development Blocks and the Second Industrial Revolution, Sweden 1900-1974
Enflo, Kerstin; Kander, Astrid; Schön, Lennart

WP 2006/11

The uneven and selective nature of cluster knowledge networks: evidence from the wine industry
Giuliani, Elisa

WP 2006/12
Informal investors and value added: The contribution of investors' experientially acquired resources in the entrepreneurial process
Politis, Diamanto; Gabrielsson, Jonas

WP 2006/13
Informal investors and value added: What do we know and where do we go?
Politis, Diamanto; Gabrielsson, Jonas

WP 2006/14
Inventive and innovative activity over time and geographical space: the case of Sweden
Ejermo, Olof

2005

WP 2005/1
Constructing Regional Advantage at the Northern Edge
Coenen, Lars; Asheim, Bjørn

WP 2005/02
From Theory to Practice: The Use of the Systems of Innovation Approach for Innovation Policy
Chaminade, Cristina; Edquist, Charles

WP 2005/03
The Role of Regional Innovation Systems in a Globalising Economy: Comparing Knowledge Bases and Institutional Frameworks in Nordic Clusters
Asheim, Bjørn; Coenen, Lars

WP 2005/04
How does Accessibility to Knowledge Sources Affect the Innovativeness of Corporations? Evidence from Sweden
Andersson, Martin; Ejermo, Olof

WP 2005/05
Contextualizing Regional Innovation Systems in a Globalizing Learning Economy: On Knowledge Bases and Institutional Frameworks
Asheim, Bjørn; Coenen, Lars

WP 2005/06
Innovation Policies for Asian SMEs: An Innovation Systems Perspective
Chaminade, Cristina; Vang, Jan

WP 2005/07
Re-norming the Science-Society Relation
Jacob, Merle

WP 2005/08
Corporate innovation and competitive environment

Huse, Morten; Neubaum, Donald O.; Gabrielsson, Jonas

WP 2005/09
Knowledge and accountability: Outside directors' contribution in the corporate value chain
Huse, Morten, Gabrielsson, Jonas; Minichilli, Alessandro

WP 2005/10
Rethinking the Spatial Organization of Creative Industries
Vang, Jan

WP 2005/11
Interregional Inventor Networks as Studied by Patent Co-inventorships
Ejermo, Olof; Karlsson, Charlie

WP 2005/12
Knowledge Bases and Spatial Patterns of Collaboration: Comparing the Pharma and Agro-Food Bioregions Scania and Saskatoon
Coenen, Lars; Moodysson, Jerker; Ryan, Camille; Asheim, Bjørn; Phillips, Peter

WP 2005/13
Regional Innovation System Policy: a Knowledge-based Approach
Asheim, Bjørn; Coenen, Lars; Moodysson, Jerker; Vang, Jan

WP 2005/14
Face-to-Face, Buzz and Knowledge Bases: Socio-spatial implications for learning and innovation policy
Asheim, Bjørn; Coenen, Lars, Vang, Jan

WP 2005/15
The Creative Class and Regional Growth: Towards a Knowledge Based Approach
Kalsø Hansen, Høgni; Vang, Jan; Bjørn T. Asheim

WP 2005/16
Emergence and Growth of Mjärdevi Science Park in Linköping, Sweden
Hommen, Leif; Doloreux, David; Larsson, Emma

WP 2005/17
Trademark Statistics as Innovation Indicators? – A Micro Study
Malmberg, Claes