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Combined Innovation Policy: Linking Scientific and Practical Knowledge in Innovation Systems[1]

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Abstract

New research indicates that firms combining the science-based STI (Science, Technology, Innovation) and the experience-based DUI (Doing, Using, Interacting) modes of innovation are more efficient when it comes to improving innovation capacity and competitiveness. With regard to innovation policy, the STI mode calls for a supply driven policy, typically aimed to commercialise research results. The DUI mode suggests a demand driven policy approach, such as supporting the development of new products or services to specific markets. This paper analyses how the two types of innovation policy and the two innovation modes can be combined in regional innovation systems. The analysis builds on studies of the food industry and related knowledge organisations in two counties, Rogaland County (Norway) and Skåne County (Sweden), and two policy initiatives (NCE Culinology and Skåne Food Innovation Network) aimed at strengthening the innovative capability of the regional innovation systems. The analysis indicates that policies aimed to link science and user driven innovation activity should focus on building absorptive capacity of DUI firms (e.g. through increased scientific competence) and implementation capacity of STI firms (e.g. through increased market and process competence).

Keywords: *Innovation policy; Regional system of innovation; Modes of innovation, Food industry*

1 Introduction

New studies point to the fact that firms combining different types of knowledge and different ways of innovating perform best. Jensen et al. (2007) maintain that firms that combine science driven STI (Science, Technology, Innovation) and user driven DUI (Doing, Using, Interacting) modes of innovation are more product innovative than firms relying on only one mode. Likewise, Laursen and Salter (2006) demonstrate that firms that source knowledge from a diversity of external sources are the most innovative ones.

This has implications for the design and implementation of innovation policy. By this logic, policy should stimulate the linking of R&D-activities and on-the-job learning, as well as stimulating the sourcing and adoption of different types of external knowledge. Experiences indicate that a bias towards only one type of knowledge and learning activities may hamper firms' innovation activities. A one-sided focus on scientific learning may, for example, make it difficult to commercialise (or otherwise implement) research results. A central issue for policy is thus how policy makers can contribute to linking science and user driven innovation activities in systems of innovation rather than merely supporting R&D-activities or user driven innovation processes.

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This paper contributes to the literature on regional innovation policy by conceptual an empirical analyses on how science and user driven policy approaches can be combined. The empirical cases include policy programs in one Swedish and one Norwegian regional innovation system (RIS) within the food sector. The Norwegian case is the NCE Culinology project to support the food industry in Rogaland County. The aim of the project is to strengthen the knowledge platform and the innovation capability within industrial gastronomy and culinary differentiation in Rogaland in order to increase value added and profitability for actors along the food value chain. The Swedish case is the VINNVÄXT program organized within Skåne Food Innovation Network (SFIN). SFIN is an established network aimed at supporting the food industry in Skåne and it comprises basically all major actors within food in Skåne. While both cases comprise strong R&D environments (providing potential for STI innovation) they are situated within the traditionally low-technology industry of food (OECD 2007:220) where the DUI mode of innovation is dominant.

The paper analyses two research questions. The first is descriptive while the second is a more analytical question and relates to general theoretical lessons from the cases.

1. What characterises the food innovation systems in Skåne and Rogaland and the two main policy tools aimed to strengthen these innovation systems
2. To what extent and how can the two innovation system initiatives, and regional innovation policy in general, contribute to increase the linking of the STI and DUI innovation modes?

The paper consists of four parts. The next part discusses characteristics of science driven and user driven innovation policies and the benefits of combining these two types. After this, the data collection and methodology is discussed. Then follow empirical analyses of the food innovation systems in Skåne and Rogaland and the strategies and activities of NCE Culinology and Skåne Food Innovation Network. The last part sums up the answers to the research questions posted above.

2 Regional innovation policy: Combining science and user driven approaches

Innovation has become a focal area for policy in many countries and regions in order to foster long-term economic development. Innovation policy can be defined broadly as policy that explicitly aims to promote the development, diffusion and efficient use of new products, services and processes (Lundvall and Borrás 1997). A main objective is to foster and speed up learning and innovation processes within organizations and between organizations and their environment.

Towards a regionalized policy building on the system-of-innovation school

The approach to innovation policy has changed since its start as an explicit policy area in the 1980s. Initially policy was dominated by a *technology push* approach inspired by the linear innovation model. This type of first generation innovation policy (Jakobsen and Onsager 2008) viewed innovations as direct results of R&D-activities. The rationale for this is found in the neoclassical economics concept of market failure (Niosi 2010). The idea is that if markets are left to themselves it will lead to under-investment in science and technology due to externalities, i.e. that knowledge flows freely and without cost between organizations

(Clarysse et al. 2009). The focus of policy is then to support R&D-activities in firms and R&D-organizations.
The second generation innovation policy developed in the 1990s with a quite different understanding of the innovation process. Rather than seeing innovation as an output of R&D, greater emphasis was now put on interactive learning among a multitude of actors. This approach views innovation processes as triggered by many events. New scientific knowledge is one such event; however the second generation policy emphasises market signals and customer requirements as vital triggering factors. Policy is thus characterized by market pull and also by its focus on stimulating interaction and knowledge exchange between varieties of organizations.
The last point refers to the fact that an important rationale for the second generation policy is *systemic failure*. This concept is inspired by evolutionary and institutional economics, especially the system-of-innovation school (Niosi 2010). The system-of-innovation school regards innovation processes as taking place in cooperation between various actors supported by an institutional infrastructure (Liu and White 2001). Institutions refer to the sets of common norms, practices, rules or laws that guide and constrain the behaviour of the actors (Edquist 2005), or as put by North (1992 p.10) "[i]f institutions are the rules of the game, organizations are the players". From this follows that innovation processes are hampered if the system functions poorly. The failures can be classified as problems related either to the components of the innovation system (such as the universities), or to the functioning of the system, for example barriers for efficient knowledge exchange between firms and universities (Chaminade et al. 2009; Nilsson & Moodysson 2011).

The development from the first to the second generation innovation policy has also involved a *regionalization* of policy (Borrás and Tsagdis 2008). The strengthening of the regional level in performing innovation policies builds on two main arguments. First, innovation activity is seen as a partly territorially embedded phenomenon. Innovation processes are stimulated by location-specific resources, i.e. resources that are found in some locations, and which cannot quickly and cheaply be copied or reproduced elsewhere (Gertler 2007). The second argument points to the heterogeneity of regions. There is no one set of policy instruments that suits all types of regions (Isaksen and Remøe 2001; Tödtling and Trippl 2005). Rather, policy tools have to be adapted to different regional circumstances, and the argument is that this can best be achieved at the regional level.

Narrow and broad regional innovation systems

To illustrate how policy tools can be adapted to regional circumstances the following discussion distinguishes between two main views on regional innovation systems. RISs can be defined in a narrow and a broad way (cf. Lundvall 2007; Lundvall 1992). The narrow definition mainly includes organizations occupied with R&D-activities, such as universities, research institutes, and firms' R&D departments. The broad definition of an RIS includes all actors and activities that affect learning, knowledge creation, and innovation in a region. In both the broad and narrow definition, the RIS can be conceptualized in terms of three subsystems: [1] the production structure i.e. the firms in the main industries or clusters in a region; [2] the knowledge infrastructure, i.e. universities, and training organisations; and [3] the support structure, comprising various organisations, often publicly funded, tasked with supporting the economy and the system in various ways (Nilsson and Moodysson 2011).

The narrow definition focuses primarily on 'big science' and radical innovations, while the broad definition places equal emphasis on the diffusion of innovation and incremental changes. Furthermore, there is a geographical dimension inherent in these definitions. The narrow type of RIS is often linked to the national level because many organizations that perform basic research are national and represent core organizations in national innovation systems (Isaksen 2009). The broad type of RIS is more oriented towards the diffusion of innovations that is often handled by regional universities, technology transfer organizations, regional innovation system initiatives, and local firms.

The broad and narrow conceptualisations of regional innovation systems can be further elaborated by considering two main ways to organise learning and innovation processes in firms; that is the STI and the DUI modes of innovation (cf. Lundvall et al. 2009). The STI mode has a strong focus on science-based learning and R&D-activities aimed at developing more radical innovations (Jensen et al. 2007). Much of the innovation activity thus takes place at in-house R&D departments, in research intensive small firms, and at universities and research institutes. The knowledge creation process is in large part based on the development and testing of formal, scientific models, and includes elements of basic research. This mode includes the formalisation and codification of new knowledge (Lundvall et al. 2009) and the exploitation of such knowledge in innovations. This emphasis on the centrality of the explicit dimension of knowledge in the STI mode should however not be taken to imply an insignificant role for locally embedded tacit knowledge (Jensen et al. 2007). The main rationale of the STI mode is however to immediately codify tacit knowledge and thus making it explicit. The primary actors in the STI mode are thus firms' R&D departments, universities and research centres.

The STI mode only represents one type of learning and innovation. In practice, much learning takes place through doing, using and interacting within and between organisations. This first of all includes learning from experiences and competences acquired by employees on-the-job as they face new challenges and problems that need to be addressed (Jensen et al. 2007). Such challenges may come from the firms' own activities but they often relate to requirements and needs of customers and users and thus the DUI mode often involves a degree of interaction within and between organisations and functions (Lundvall 2007). The DUI mode pivots on know-how (how to perform tasks) and know-who (about who knows what) (Johnson et al. 2002). This entails that the knowledge and learning focused on in the DUI mode is often found outside R&D departments and universities.

The combination of science driven and user driven innovation policy

A consequence of the above distinction between STI and DUI modes of innovation is that policies to support innovation activities arguably differ between the two modes. Table 1 illustrates main differences between STI and DUI policy. Policy aimed at strengthening the STI innovation mode primarily focuses on supporting the knowledge infrastructure of the system (e.g. R&D activities in firms and research institutes) as well as facilitating cooperation between firms and R&D organisations. This is done through supporting formal education, R&D infrastructure, and knowledge exchange between knowledge organizations and industry, including stimulating academic spin-offs.

Innovation policy targeting the DUI mode will, on the other hand, focus more on developing learning organizations and interactive learning between organisations. Learning organizations are characterized 'by decentralized responsibility, teamwork, circulation of employees between departments, and investment in training' (Lam and Lundvall 2006: 113-114), which stimulate on-the-job learning and continuous problem-solving by employees. Policies to support the DUI innovation mode also involve facilitating interactions between actors in the value chain, notably users and producers. More indirect ways to stimulate DUI-innovation is through active labour market policies, and policies aiming at broad-based education systems and life-long learning (Chaminade et al. 2009: 376).

Table 1.
STI and DUI policies for regional innovation systems.

Innovation mode supported	
STI mode (science driven)	**DUI mode (user driven)**
Aim: Increase the R&D capacity of the actors in the system and increase cooperation between firms and R&D organisations *Typical innovation policy*: - Increase the R&D capacity of organisations - Support joint R&D-projects between firms and universities. - Support higher education programs - Subsidies for R&D infrastructure (laboratories, research and technology centres, research groups etc.) - Support (financial) for increasing mobility between academia and industry - Support for commercialization of research results	*Aim*: Foster organizational and inter-organisational learning and increase cooperation between in particular producers and users *Typical innovation policy*: - Support on-the-job learning and organisational innovations - Matchmaking activities and building and sustaining existing networks - Stimulate trust building and joint innovation projects between actors in the value chain (producers-suppliers-users-consumers). - Stimulate joint projects between competing and auxiliary businesses (e.g. food-health)

Many of these policy activities are aimed at increasing the ability to utilize the existing competencies and assets within the system. In terms of STI policy, this takes the form of improving the absorptive capacity of firms, i.e. their ability to "recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1990 p.128). This ability is primarily dependent on the level of prior related knowledge. In the case of DUI policy, on the other hand, the emphasis is to a lesser extent on the capacity to absorb scientific knowledge. Instead it concerns the ability to exploit external non-scientific, often tacit, knowledge resources and implement improvements and new ideas for incremental innovation.

Table 1 shows some "pure" types of policy actions to support either the STI or the DUI mode of innovation. We know however that innovation processes often combine the two, for example so that specific modes dominate in different phases of the process (Moodysson 2008). Jensen et al. (2007) maintain that firms combing the STI and DUI mode are more product-innovative. This means that policy that combines elements from the STI and the DUI may be more efficient and better equipped to contribute to innovation activities inside and across firms as compared to policy aimed at stimulating either STI- or DUI-innovation.

A "combined" approach to innovation policy has at least two benefits that the "pure" types do not have. Firstly it can trigger innovation activities beyond R&D. That makes the policy

relevant for a broader set of industries and innovation actors, i.e. not only for research intensive sectors and R&D-organizations. Secondly, it can support the building of technology platforms in less research intensive firms beyond the focus in the user driven DUI policy. Many DUI-firms innovate ad hoc which means that the firms more or less start from scratch in every new innovation project. More elements of STI policy may result in firms engaging in applied research, possibly in cooperation with a knowledge organization. A key aspect of such a move from strict DUI logic to a combined approach is that the absorptive capacity of the firms often needs to be increased. For traditional low-tech industries such as food, policies based on STI logic may fit poorly with the innovation mode of the industry. However, policies combining STI and DUI logics can potentially encourage firms to go beyond their traditional modes of innovation and also become involved in research-driven innovation.

3 Research design and method

The empirical study was conducted based on two main types of empirical data. First, documents (physical and electronic) dealing with the two food innovation systems and the two support programs were collected. Examples of such documents are applications for regional support, for example the original VINNVÄXT applications; evaluations of the two policy programs compiled by the policy actors (NCE and VINNOVA) and researchers; and strategy document and reports from the two initiatives. These documents were complemented with current electronic documents and web pages that describe the policy activities by analysis of firm level innovation data, such as the community innovation study (which is not presented in detail here)

Second, document studies were supplemented with in-depth interviews with main stakeholders within the two systems. The respondents represent actors in the production structure (firms), the knowledge infrastructure (universities and research institutes), and the support structure (e.g. regional and national policy actors and innovation intermediaries). The interviews were designed as semi-structured interviews focusing on the topic of innovation and policy, allowing room for open-ended answers and elaborations. In the case of Skåne, interviews, document studies and statistical analysis relating to the regional system, the food industry and innovation policy has been conducted over a 10-year period (previously reported in Henning et al. 2010; Nilsson 2008; Nilsson and Moodysson 2011; Nilsson et al. 2002). The Rogaland case benefitted from and followed up a detailed study of the region's food innovation system from the end of the 1990s (Onsager 1999).

Based on these sources of information the researchers compiled a data set enabling analyses and comparisons of the evolution and structure of the two cases, both in terms of the innovation system as such and of the policy support initiatives in the Rogaland and Skåne food systems. The cases include the same mature and low tech sector, while the Skåne food industry has traditionally been more science based than corresponding industry in Rogaland.

4 The food innovation systems in Skåne and Rogaland

Characterizing the food innovation system in Skåne

Skåne is the southernmost region in Sweden and, with its 1.25 million inhabitants; it represents the third largest region in Sweden in terms of population. While the region, partly as a consequence of its size, has an industry structure quite similar to Sweden as a whole

(according to Henning et al. 2010 .98 correlation). However, of the 17 sectors which *are* overspecialized in the region nine falls within food production, processing, and auxiliary sectors (ibid). In total, close to 30 000 people are fully or partly employed in food production and processing in Skåne (see Table 2 for an overview). The regional innovation system within food in Skåne thus holds a dominant position within the Swedish food sector.

Table 2.
Number of employees in the different parts of the food production system in Skåne.*

Primary production		Processing	
Farmers	13945	Processing of agricultural and fish products	15768
Total	29713		

* Source: Statistics Sweden. Numbers for 2009. Aggregates from individual data. Includes [i] individuals employed November 2009 and individuals that has been employed previously in 2009 (excluding migrant workers).

The reason for Skåne's strong position in food and agriculture is to a large extent historical. The availability of fertile farm land and a favourable geographical position in terms of trade produced a strong food sector that significantly influenced the industrialisation of the region (Borg 2005). Today, Skåne comprises a mix of large national and international corporations and small and medium sized firms. In contrast to other food districts in Europe, many of the SMEs are however not the traditional low-tech and low-innovation firms that are normally associated with the industry. This is illustrated by the fact that labour productivity is high in comparison to the food industry nationally (Henning et al. 2010).

In addition to the sectoral over-specialization and strong auxiliary industries – within for example food machinery, packaging, and logistics – the region also houses a number of prominent educational and research organizations within food, primarily located at Lund University, the Swedish University of Agricultural Sciences, and Kristianstad University.[2] The strength of the knowledge infrastructure in Skåne is illustrated by the fact that the region houses approximately half of Swedish research within food (Kempinsky et al. 2011). There are also several research organisations engaged in related subject areas such as consumer behaviour and international marketing, packaging and logistics, nanotechnology in food processing, and food safety. Several of the innovative food SMEs has evolved in close connection to the universities. Apart from the academic research and training institutions there are also some public actors such as the Swedish Institute for Food and Biotechnology with offices in the region, and several science parks wholly or partly devoted to food and food development. The food RIS in Skåne is thus organizationally thick when it comes to both the production structure and the knowledge infrastructure.

The Skåne Food Innovation Network initiative and the VINNVÄXT program

With 70 member and partner organizations, the main policy initiative for developing the food sector in Skåne is the Skåne Food Innovation Network (SFIN). In 1994 when SFIN was

[2] At Lund University e.g. Food Science; Food Technology and Food engineering; Functional Food Science Centre; Biomedical Nutrition; Food Service Management; AgriFood Economics Centre. At the Swedish University of Agricultural Sciences e.g. Horticultural Genetics and Crop Sciences; Plant Breeding and Biotechnology; Agriculture and Farming Systems; Center for Innovative Drinks. At Kristianstad University: e.g. Culinary Arts and Food Sciences.

formed the Swedish food industry was characterized by bulk production and a low degree of innovation activity. Few companies had in-house R&D resources and there were little industry-university interaction (Kempinsky et al. 2011). The driving force behind SFIN's formation was Sweden's pending EU membership and the expected increased competition within low value added sectors. The initiative for setting up SFIN was taken by the C.E.O. of Nestlé Sweden together with the governor. SFIN was implemented in a triple helix collaboration including the major universities, several of the largest food companies, and the regional authorities. At the time, there was a strong belief that academic research and industry-academia linkages were the best ways to address increased price competition. Focus was thus on achieving a move from DUI to STI mode of innovation in the industry. This policy focus continued throughout the 1990s and into the early 2000s, partly reinforced by the Swedish national food strategy in 1997 and VINNOVA's strategic plan in 2002 (VINNOVA 2002).

In 2003 SFIN received a 10 year funding of approximately 1+1 million Euros annually within the VINNVÄXT program, making it the single largest funder of SFIN. The program is organized by the Swedish Governmental Agency for Innovation Systems (VINNOVA) with the aim to "advance the functionality, dynamics and efficiency of the regional innovation system" within a chosen area of strength (Andersson et al. 2010 foreword). The selection was made based on a national competition where regional innovation systems from all of Sweden applied and were evaluated. Both the call and evaluation, and the original application from SFIN (SkånesLivsmedelsakademi 2003) reflect the emphasis on science-driven innovation in the Skåne RIS. Strong knowledge infrastructure and links to academic research was stressed as important for all three winning applicants (VINNOVA 2003).

Illustrating this science-driven approach, in the initial phase of the VINNVÄXT program (2003-2005) SFIN focused heavily on knowledge development within the four specific areas of Food and health - functional foods; International consumer marketing; Large scale food and eating; and Innovation in theory and practice. In practice this meant that considerable funds were allocated to finance university research groups and projects, often in collaboration with industry but with a clear scientific orientation. For example, the single largest activity in the first three-year period was the creation of a PhD program within functional foods at Lund University.

In 2005 SFIN began re-evaluating their view on the innovation process. This was fuelled by internal discussions as well as external pressure to produce tangible results. At that time focus started to shift from research to implementation; from early-stage development and basic research to more direct support related to the innovation process. The main shift in mind-set was that academic research was no longer seen as the main *source* and first necessary step of innovation. This can be seen as a "step back", revitalizing the status of DUI modes of innovation. While maintaining close ties to academia, science was now increasingly being seen as one facilitator of innovation, typically by supplying specific expertise and highly skilled people. SFIN's role changed from that of funder of, and active partner in, R&D to that of broker or intermediary with the role to identify and evaluate ideas and provide targeted support for parts of the innovation process. The view on innovation and innovation policy has thus moved from a first-generation to a second-generation perspective (cf. Jacobsen and Onsager, 2008). However, as compared to the situation in the 1990s an

important difference was that many firms in Skåne saw the benefits of working with universities to increase their innovativeness.

Today SFIN is organized in five focus areas. Within *Cooperation and strategies* the rationale is to identify future growth areas. This is largely done through formation of networks (e.g. with C.E.O.s and Food Researchers) and knowledge exchange activities inside the region. This area also organizes foresight guilds, i.e. seminars to address future issues for the industry. While most activities target actors in the region, SFIN also maintain contacts with other food systems in Europe, Asia and South America for the purpose of benchmarking. These activities primarily focus on the long-term innovation capacity of the sector rather than on providing hands-on innovation support.

As a contrast to this, *Tomorrow's meal service* is focused on a specific sub-sector (food service) that has been identified as important for the future growth of the industry. Policy activities provide networks where relevant actors (e.g. hospitals, public bodies, scientists, food service firms etc.) can collaborate to identify potential future problems, needs, and opportunities and discuss how these can be addressed. Over the long run, such knowledge-sharing activities may lead to the development of new products, services, and ways to organize the supply chain. In addition to coordinating networks, SFIN (partly through regional universities) also produce reports and analyses about the meal service sector and market.

The area with most clear focus on direct support for innovation processes is *Innovation and entrepreneurship*. The aim is to assist firms' innovation and product development processes. An example is the Entrepreneur Council which is a group of successful entrepreneurs and scientist that function as advisors and mentors for new entrepreneurs, often over six to nine months. The focus is not on financial support but on advice and matchmaking. The idea is that this can help shorten the innovation process: to move more quickly from idea to commercial product. In addition to the more user-driven and experience-based Entrepreneur Council, an R&D network was initiated in 2010. The R&D Network comprises established firms' R&D directors and thus represents a more clear-cut science driven approach to innovation. The aim with this network is to create a platform where people responsible for R&D can identify common problem areas and potential collaborative projects.

The fourth focus area, *A taste of Skåne,* is less oriented towards supporting innovation than the three described above. The aim is to promote small scale food production and increase the awareness of Skåne as a culinary region. In this, SFIN acts as advisor to help small businesses in their product and concept development, for example by organizing networks to exchange experiences and discuss shared problems and opportunities. An example is the Retailer Network where local food retailers meet to discuss current topics and get training and education about consumers. There is also an ongoing project to develop store concepts and test-stores for sales of high quality local products.

Lastly, and with little direct focus on innovation, the area of *Jobs and careers* addresses the difficulty to attract highly educated people to the food industry. Within this, trainee

programs and different activities to attract university students to the industry are carried out, which relates to the long-term innovativeness of the industry.

It should be clear that the current policy activities represent a combination of science-driven and user-driven approaches to innovation. The historical focus on science-driven approaches remains through the strong links to university research. However, the current activities are more closely linked to strengthening the absorptive capacity of DUI firms and the ability to implement research results. The STI focus is seen in the high number of academics involved in the networks and activities and in the production of research reports. The role of academia has however changed since the start of VINNVÄXT when a large portion of the budget was directed towards basic research. The increased emphasis on DUI-mode innovation is perhaps most evident in the focus on setting up networks a large number of networks to facilitate interaction between actors.

Characterising the food innovation system in Rogaland

Rogaland County is situated in the south-western part of Norway. It has about 440,000 inhabitants, including the Stavanger labour market region with 264.000 people, which is the 'oil-capital' in Norway. Rogaland also houses a large food industry in Norwegian terms. The food industry in Rogaland has been characterised as a regional innovation system, which however in different ways is linked to and integrated in a national innovation system (Onsager 1999). The regional innovation system is, as in the case of Skåne, organizationally thick as it includes both a comparatively strong industrial component and a well-developed knowledge infrastructure. The integration in a national system reflects the fact that many firms and knowledge organizations are part of national, but also international, corporations, and that firms are using national knowledge organizations outside Rogaland in innovation processes.

The production structure in Rogaland includes several value chains from raw materials to finished products, mainly based on agricultural products and fish from traditional fisheries and aquaculture. Table 3 presents an overview of parts of these value chains, but not including producers of equipment and machines to the primary production and to the manufacturing of food.

Rogaland has a strong position in parts of Norwegian agricultural production, which relates in particular to the Jæren region in the southern part of the county. Sæther and Gjefsen (2011) see this area as unique in Norway with a strong production environment characterised by entrepreneurship and cooperation between farmers, producers of agricultural machineries and to some extent the food processing industry. The county was also a national centre for the canning and herring industry from the end of the 1800s to the 1960s, largely based on rich sardines and herring fisheries off the coast (Onsager 1999). This industry is mainly shut down, but essential knowledge is maintained. Important in that respect is Nofima Norconserv, which was established in 1928 as a competence and control organisation for the canning industry. It has developed into a research and training organization for the food industry in general. The new aquaculture industry has also grown in Rogaland, with a particular stronghold in the production of fish fodder and R&D-activity. The county houses the world's largest salmon producer at the beginning of the 2000s,

Nutreco, which also has located its international centre for fish feed and aquaculture to Stavanger (Skretting Aquaculture Research Centre).

Rogaland has a large number of jobs in the manufacturing of food, more jobs than all other counties except Oslo (Statistics Norway 2010). Rogaland has also seen an increasing number of jobs in the agricultural based food industry since 2000, in contrast to many other parts of Norway (Sæther and Gjefsen 2011). The industry is dominated by large farmer-owned cooperative organizations, but includes increasingly more independent, private firms (Onsager 1999).

Table 3.
Number of employees in the different parts of the food production system in Rogaland

Primary production*		Processing**	
Agriculture***	1504	Processing of agriculture products	4337
Fishing (main occupation)	381	Fish processing	497
Aquaculture	356		
Total	2241	Total	4834

*Source: Statistikkbanken, Statistics Norway. Number for 2008 (farmers) and 2009
**Source: Statistics Norway (2010). Numbers for 2007
***With 250,000 NOK (ca. 32,000 Euros) or more in yearly income

Rogaland food IS has a fairly strong knowledge generation and diffusion subsystem. The region comprises three organizations for education and training; five research organisations with elements of basic research; and 11 development organisations with more applied research, for example testing of products, and development projects for specific customers. Some organisations, such as universities, conduct several of these activities (e.g. education and basic research). The organizations have about 500 employees.

The organisations cover a range of scientific subject areas, from animal and fish health to techniques to improve the durability from produce to finished meals. The largest group includes development organizations, while there are fairly few focused research organizations. Onsager (1999) maintains that food production firms in Rogaland also use several national R&D-organisations, such as Nofima Mat (located at Ås near Oslo) and Nofima Aquaculture (Ås and Tromsø). The Nofima Corporation also includes Norconserv in Stanvanger. Other national R&D organisations are the Institute of Marine Research in Bergen and the Norwegian University of Science and Technology (NTNU) in Trondheim and its partner research institute SINTEF, which both have knowledge in food technology.

Rogaland is also characterised by a number of network organizations within the food industry. The Professional Forum for Food and Drink (*Fagforum for mat og drikke*) was established in 1990 to develop and spread competence among actors in the food industry in Rogaland, develop relations and cooperation among the actors, and initiate and lead joint research, development and marketing projects (Onsager 1999). As many as 115 firms and organizations within the food industry in Rogaland have been members of the Professional Forum. The activity is continued by *Måltidets Hus*, which is a network organisation and a building at Innovation Park Stavanger housing laboratories and many of the organizations within the food industry in Rogaland, including the administration in NCE Culinology and five organizations in the knowledge infrastructure. The other organizations in *Måltidets Hus* are

an incubator, private firms in different industrial sectors, and network and interest organizations. One of these network organizations is Blue Planet which is owned by some major aquaculture companies. Blue Planet organizes an important, international business conference on aquaculture, and carries out several other joint projects for the aquaculture industry in Rogaland.

The NCE Culinology project

In the Rogaland food industry, NCE Culinology is the main policy activity. Norwegian Centres of Expertise (NCE) is in many ways similar to the Swedish VINNVÄXT program. NCE is a national program which aims to strengthen on-going development and innovation activities in regional clusters with high capacities for growth and which are the most international competitive ones (NCE 2008). The program intends to provide common visions, networks and cooperation among actors within the 'NCE-clusters', and develop common activities, such as education and training, R&D-services, raising capital, and branding (Asheim and Isaksen 2010).

NCE Culinology became part of the NCE program in 2007, and is at present one of twelve 'NCE clusters' in Norway. As in the Swedish case, regional actors have to apply to become part of the NCE program, and only the internationally most competitive clusters, where some key firms and organizations also agree on common goals and strategies to further develop the cluster, are selected. The successful application from NCE Culinology was the result of several years of institution building in the food industry in Rogaland. A professional forum for food and drink was, as already mentioned, established in 1990 (Furre and Flatnes 2010). The forum was revitalised in 2004 through an Arena project. Arena is a national program run by the same organization as the NCE program, and aimed to develop or strengthen regional clusters or potential regional clusters through increased interaction between regional firms, knowledge organisations and public agencies (Jakobsen and Onsager 2008). The Arena project was eventually extended in the NCE project.

NCE projects are financed 50-50 by the Research Council of Norway and regional stakeholders. The NCE Culinology project is run by an administration counting 3.5 man-labour year and a board with representatives from the partners. NCE Culinology has 22 partners that pay a fee to be part of the project[3]. The partners include 8 firms, 4 private and public R&D-organizations, 3 education institutions, 4 public agencies and one bank. Much of the activity in NCE Culinology is primarily directed towards the partners, while many meetings and seminar and much diffusion of project results are open to others.

Main activities in NCE Culinology include arranging dialog conferences, workshops and thematic meetings, branding the regional food industry, and initiating and coordinating joint innovation projects. In the period 2007-2010, the NCE Culinology project has in particular contributed to strengthening the DUI mode of innovation in firms. Thus, the evaluation of the NCE Culinology project for the period 2007-2010 (Furre and Flatnes 2010) points to the fact that most joint projects are short-term and firm-oriented innovation projects which include R&D-institutes. The focus on applied projects is a result of priorities within the NCE

[3] Source: The homepage of NCE Culinology (www.nceculinology.no) March 2011

Culinology project, and priorities among the firms that have in general little internal R&D-activity.

NCE Culinology has four key areas in which the project should develop basic knowledge: molecular gastronomy, process optimisation, consumer insight and open innovation. The first area (molecular gastronomy) is a scientific discipline occupied with studying the chemical and physical processes of cooking. NCE Culinology uses the approach of cooks, based on experience, experiments and taste, to develop this area. The cooks however cooperate with researchers that apply scientific methods to document the relationship between taste and chemistry. This may take place when cooks prepare different types of tasty foods by use of their primarily experience-based knowledge. Researchers document, among other things using sensors, various chemical processes in the preparation of food as well as chemical characteristics of the food. Several R&D-organisations in Rogaland have experience in this type of scientific documentation and analyses. This example demonstrates a linking of scientific and experience based knowledge.

Competence in molecular gastronomy is further linked with two other key knowledge areas, that of process optimisation and consumer insight. These include quite applied research. Consumer insight includes, for example, developing different methods for testing the taste and look of food among consumers. The linking of the different areas should contribute in developing manufactured quality food products, which represents the core of the NCE Culinology project.

The evaluation of the NCE Culinology project points to the fact that the project is about to become a national network for technology development rather than a regional cluster. An evaluation of the project in 2010 warns against this development as it may hinder the development of cluster upgrading mechanisms (Furre and Flatnes 2010). However, we consider the development of stronger national knowledge links as vital for three main reasons. First, industrial gastronomy is a small competence area, and it is more realistic to develop expertise and international competitiveness within such an area when building on the knowledge bases of relevant Norwegian (and foreign for that matter) research institutes instead of focusing only on regional actors. The regional knowledge infrastructure may be too small to achieve knowledge at a high international level in several fields that are to be linked, while a national network is more realistic.

Second, many partners in NCE Culinology are part of national or international organizations and corporations. Examples are EWOS Innovation and Tine FoU which are research organizations of large corporations; the first with factories in several countries, the second focused on Norway. These two partners in NCE Culinology are thus integrated in internal corporate networks. A strong regional focus of policy tools in which only or mainly cooperation between regional actors are stimulated may not fit this type of organizations. Rather their extended network may be an advantage for the Rogaland food industry in bringing in ideas and knowledge from outside the region. Third, a national focus may strengthen the possibilities of supporting the mainly DUI innovation activities in the firms by more research based knowledge. That is, the national links can strengthen long-term research projects, and in this sense there is no conflict between supporting regional

upgrading mechanisms and national knowledge links, rather the opposite to follow Bathelt et al. (2004) and Isaksen (2009).

5 Conclusions: Linking science and user driven innovation policy in Skåne and Rogaland

This paper takes as its point of departure research results which indicate that firms combining the science-based STI and the experience-based DUI modes of innovation are more product innovative than firms using only one of the two (Jensen et al. 2007). It contributes to the literature by analysing how this insight may lead to a transformed regional innovation policy which combines science and user driven approaches. In doing so it draws on cases from regional innovation systems and policy within food in Skåne and Rogaland.

The first research question relates to characteristics of the two systems. Both cases represent food centres in their respective national contexts. They comprise well-developed knowledge generation and diffusion sub-systems though when compared to Skåne, Rogaland has a greater number of private and public R&D-organisations. Historically, these organisations primarily perform development activities and are less involved in basic research. This has however changed somewhat during the last years. The research organisations that perform most basic research are within niches of the aquaculture and biotechnology sectors. Still however, the NCE Culinology project mostly supports short-term applied projects, but has also introduced some more STI methods in innovation projects. In contrast to Rogaland, the knowledge infrastructure in the Skåne RIS is primarily dominated by university research centres. The emphasis has thus been on basic research taking place at universities that in some cases has been disseminated to (new or established) firms in the system.

The production structure in the two systems is characterised by a relatively high number of innovative firms. In Rogaland a majority of the firms are occupied with experience-based learning and are focused on internal research and innovation activities. While that is true to an extent also for Skåne, the innovation system support structure has been established longer and thus the links between academia and industry are more developed. Skåne experienced a development since the early 1990s until the mid 2000s to increase the level of science-driven innovation in the industry. A reaction to this focus caused a counter movement towards increasing demand-driven innovation, though combined with maintaining the links with research and academia. This is illustrated by the focus areas of the VINNVÄXT program in Skåne in 2011 and 2003. As shown in Table 4, there are considerable similarities between the four initial focus areas within VINNVÄXT and the NCE Culinology project in Rogaland.

Table 4.
Focus areas in NCE Culinology and VINNVÄXT.

NCE Culinology 2011	VINNVÄXT 2003	VINNVÄXT 2011
Molecular gastronomy	Functional food/food and health	Cooperation and strategies
Consumer insight	International consumer marketing	A taste of Skåne
Process optimisation	Large scale food and eating	Tomorrow's meal service
Open innovation	Innovation and theory and practice	Innovation and entrepreneurship
		Jobs and career

The evolution of the innovation policy in the food sector in the two counties can be understood in terms of [i] the nature of the industry and [ii] policy makers' view on the innovation process. Regarding the industry, the fact that the food industry by tradition is dominated by DUI mode firms led to an emphasis on increasing the amount of STI in particular in Skåne. In Rogaland the policy formulation started out as primarily DUI based. An underlying problem in both Skåne and Rogaland that led to the policy initiatives here discussed is that they lack/lacked linkages to the knowledge infrastructure of the system. That is partly because firms that lack internal research capacity will have difficulties in absorbing external, scientific knowledge, and in performing internal research activities. The tools used were traditional STI activities (see Table 1) such as support/subsidies for research infrastructure (e.g. university research groups) and higher education programs (e.g. PhD programs and Trainee programs); support for increasing mobility and joint R&D projects between industry and academia; support for commercialisation of research results. While these activities are well in line with the aim to increase STI, the results have not always been positive. Support for the four focus areas of VINNVÄXT 2003-2005 generated new knowledge and skilled R&D people, but the output in terms of innovation was less evident.

The second and more analytical research question concerns the extent to which and how innovation system initiatives and regional innovation policy more generally, can achieve a better mix between STI and DUI modes of innovation. The food industry is traditionally low tech with entails a focus on incremental innovations and improvements (new flavours, marginally improved or altered packages etc.). Most firms in the industry and especially the SMEs have minimal in-house R&D and this affects not only the ability to produce innovations in-house but also the absorptive capacity of the firms. Therefore it may be difficult for firms to benefit from external knowledge, for example at universities. Increasing the STI mode in an industry traditionally dominated by DUI may thus be difficult. This was illustrated by the first VINNVÄXT period in Skåne where basic research was supported and promoted with limited impact on the level of innovation of the firms.

Conclusion from attempts to combine science and user driven policy is that to simply increase scientific learning may be inefficient as it may make it difficult to commercialise research results since DUI firms often lack the necessary absorptive capacity. This provides a potential explanation for the apparently paradoxical relationship that economies which consistently invest in research and development sometimes score low in terms of innovation output (Bitard et al. 2008). This entails that innovation policy need to be adapted to the industry it aims to develop. In industries dominated by DUI firms, it is often not sufficient for RIS policy to increase the amount of R&D in the knowledge infrastructure. Policy also needs to address the issue of the absorptive capacity of the firms. One important issue in this regard concerns stimulating recruitment of highly educated personnel, which again requires relevant study programs and PhD education at regional universities. Although higher educated personnel can be recruited from anywhere, labour markets are still mainly regional and much recruiting takes place regionally. There is an attempt to address this issue in Skåne through the focus area of Jobs and Careers.

A further way to improve the absorptive capacity of DUI firms is through establishing closer links between industry and academia. That would be a way to enable STI mode innovation in DUI type of firms without necessarily having to recruit researchers. By researchers being

involved in the development and implementation they can ease the process of absorption. That however requires long term commitment from both parties and clear incentives for the researchers to commit. There are several examples of such open innovation processes in Skåne and Rogaland. The entrepreneur or innovating firm then has the market and commercialization competencies, and sometimes also extensive knowledge about the production process. Knowledge is then sources on a more ad hoc basis from external sources, primarily researchers and consultants.

What about STI-firms then? STI firms may have problems to commercialise research results due to a lack of knowledge in setting up a production line, in organising logistics, marketing etc. This relates also to the general question of how STI-firms can draw more on customers and actors in the broad innovation system, and also make more use of experience-based knowledge from different parts of the firms, in innovation projects. Both tasks demand internal capacity building, but aimed to create more learning organizations beyond the R&D-department. In the case of NCE Culinology the few STI-firms can link up to a number of regional applied research organisations with a variety of knowledge. Similarly, there are examples where STI SMEs in Skåne (typically spin-offs from university research teams) have utilized the experiences of the Entrepreneur Council in the development of their products and identification of relevant markets.

A common theme in contributing to make DUI-firms more research-based and STI-firms more able to employ experience-based knowledge is *capability building*. In the first case this includes building more research competence within firms, in the second case to building more competence in industrialisation and commercialisation within firms. This makes it possible for both DUI and STI-firms to utilise both the narrow and the broad regional innovation system. DUI-firms must be able to use the expertise in research institutes, regardless of their location. STI-firms need to cooperate with applied R&D institutes, consulting firms etc. in parts of their innovation projects, which is often most easily achieved in situations of geographical proximity. A conclusion is then that policies of linking science and user driven innovation activity must focus on the building of capabilities in firms and R&D-organizations.

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