Paper no. 2011/02

Comparing knowledge bases: on the organisation and geography of knowledge flows in the regional innovation system of Scania, southern Sweden

Roman Martin (roman.martin@circle.lu.se)
CIRCLE, Lund University, Sweden

Jerker Moodysson (jerker.moodysson@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: February 2011

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
ISSN 1654-3149

WP 2011/02

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Roman Martin and Jerker Moodysson

ABSTRACT

This paper deals with knowledge flows and collaboration between firms in the regional innovation system of southern Sweden. It focuses on industries which draw on different types of knowledge bases. The aim is to analyse how the functional and spatial organisation of knowledge interdependencies among firms and other actors vary between different types of industries which are part of the same regional innovation system. We argue that knowledge sourcing and exchange in geographical proximity is especially important for industries that rely on a synthetic or symbolic knowledge base, since the interpretation of the knowledge they deal with tend to differ between places. This is less the case for industries drawing on an analytical knowledge base, which rely more on scientific knowledge that is codified, abstract and universal, and therefore less sensitive to geographical distance. Thus, geographic clustering of firms in analytical industries builds on other rationale than the need of proximity for knowledge sourcing and exchange. To analyse these assumptions empirically, we draw on data from three case studies of firm clusters in the region of southern Sweden: (1) the life science cluster represents an analytical (science) based industry, (2) the food cluster includes mainly synthetic (engineering) based industries, and (3) the moving media cluster is considered as symbolic (artistic) based. Knowledge sourcing and knowledge exchange in each of the cases are explored and compared using social network analysis in association with a dataset gathered through interviews with firm representatives.

Keywords: knowledge bases, life science, food cluster, moving media, Sweden

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Authors:

Roman Martin and Jerker Moodysson
CIRCLE, Lund University

Abstract:

This paper deals with knowledge flows and collaboration between firms in the regional innovation system of southern Sweden. It focuses on industries which draw on different types of knowledge bases. The aim is to analyse how the functional and spatial organisation of knowledge interdependencies among firms and other actors vary between different types of industries which are part of the same regional innovation system. We argue that knowledge sourcing and exchange in geographical proximity is especially important for industries that rely on a synthetic or symbolic knowledge base, since the interpretation of the knowledge they deal with tend to differ between places. This is less the case for industries drawing on an analytical knowledge base, which rely more on scientific knowledge that is codified, abstract and universal, and therefore less sensitive to geographical distance. Thus, geographic clustering of firms in analytical industries builds on other rationale than the need of proximity for knowledge sourcing and exchange. To analyse these assumptions empirically, we draw on data from three case studies of firm clusters in the region of southern Sweden: (1) the life science cluster represents an analytical (science) based industry, (2) the food cluster includes mainly synthetic (engineering) based industries, and (3) the moving media cluster is considered as symbolic (artistic) based. Knowledge sourcing and knowledge exchange in each of the cases are explored and compared using social network analysis in association with a dataset gathered through interviews with firm representatives.

INTRODUCTION: GEOGRAPHY OF KNOWLEDGE FLOWS

The geography of innovation and knowledge creation is a vital research field in contemporary economic geography. In the last decades, a large body of literature has emerged studying geographical patterns of innovation, building on an long research tradition that ranges from Marshall's (1920) early work on innovation in industrial districts to the more recent work on innovative milieus (Camagni 1991), learning regions (Asheim 1996) and regional innovation systems (Cooke, Uranga, and Etxebarria 1998; Asheim and Gertler 2005). In this stream of literature, innovation is largely understood as outcome of interactive, non-linear processes (Pavitt 2005; Kline and Rosenberg 1986), emanating from interaction among various actors representing industry as well as the university and government sphere (Etzkowitz and Leydesdorff 1997). These interactions do not take place randomly distributed over space, but tend to occur within predominantly, however not exclusively, localised networks of actors (Malmberg and Maskell 2006). Although there is consensus in the literature that proximity matters for knowledge exchange (Gertler and Levitte 2005), there is no agreement under which conditions the local or regional sphere matters most for exchange of knowledge between firms and other organisations. There are however strong arguments on the claim that specific knowledge characteristics contribute strongly to determine the role of space in different industries (Boschma 2005). Whereas some types of knowledge travel easily and can be transferred over large geographical distance, others are spatially sticky and require actors to share the same socio-cultural norms and understandings. The degree at which one or another type of knowledge is prevailing may influence the role of proximity for innovation activities in different industries. Furthermore, it is acknowledged that knowledge exchange and innovation not only occur in industries that traditionally have been referred to as science based and (high-) technology oriented, but from more or less all segments of the economy, whereas increased attention is paid to economic activities transcending established sectorial boundaries (Boschma and Iammarino 2009). There is nevertheless still a gap in the literature as regards how these cross sectorial interactive processes are organised, which actors are involved, where they are located in relation to each other and, not least, how and why these patterns of interaction vary between different types of activities based on different types of knowledge.

The present paper contributes to the existing literature by providing empirical findings on the question how industry specific knowledge characteristics contribute to shaping the geography of innovation. The aim of the paper is to examine how geographical and organisational patterns of knowledge sourcing and exchange vary between industries with different knowledge base, yet located within the same regional innovation system. We address questions on the role of regional versus global knowledge networks in different industries as well as the role of knowledge sources with lower versus higher degree of formalisation. We draw our findings on interviews with firm representatives in three distinct industries located in the regional innovation system of southern Sweden[1]: (1) life science represents an analytical (science) based industry, (2) the food sector includes mainly synthetic (engineering) based industries, and (3) moving media is considered as a symbolic

[1] Interviews have been conducted between 2007 and 2010 in the framework of the European collaborative research project 'Constructing Regional Advantage (CRA)'.

(artistic) based industry. The cases are systematically explored and compared based on descriptive statistics and social network analysis.

THEORY: DIFFERENTIATED KNOWLEDGE BASES

The point of departure in our attempt to understand the geography of knowledge and its industry specific characteristics is a discussion on types of knowledge and forms knowledge creation. At least three knowledge taxonomies can be found in the literature, which build upon each other and have contributed substantially to the discussion.

Probably the most well-known distinction is the one between 'codified' and 'tacit' knowledge. Whereas the first can be written down and easily transferred over time and distance, the latter is embedded into people and organisations and considered as 'spatially sticky'. This classification originates from Polanyi's (1967) work, has been promoted by Nelson and Winter (1982) and receives much attention within the innovation systems literature (Cooke, Heidenreich, and Braczyk 2004). The basic notion is that tacit knowledge is by definition difficult to write down and strongly context-specific, therefore it is difficult to share over distance and most effectively transmitted through directs face-to-face interaction. Consequently, innovating actors who draw on tacit knowledge will tend to locate close to each other in order to access and benefit from these localised knowledge flows. Knowledge sources in geographical proximity will be less important if innovation activities depend more on codified types of knowledge, since these are relatively easy to transfer over distance (Gertler 2008). Despite being rather intelligible, this tacit-codified dichotomy is often criticized for a narrow understanding of knowledge, learning and innovation. The underlying assumption that transfer and coordination of tacit knowledge takes place almost exclusively on a local scale can certainly be criticized: There is no empirical evidence for this claim; in contrast, many studies oriented towards tracing flows of tacit knowledge identify a relatively low degree of local knowledge exchange compared to global flows of knowledge (Hagedoorn 2002; McKelvey, Alm, and Riccaboni 2003; Gertler and Levitte 2005). In some industries such as those based on biotechnology, the most important exchange relations seem to take place in globally configured epistemic communities rather than in locally configured, trust based networks (Moodysson 2008). Besides, it is not reasonable to expect that exchange in the local milieu is limited to tacit forms of knowledge; in fact a large part of the local knowledge exchanged is to a high degree codified. Furthermore, it is obvious that most forms of economically relevant knowledge are mixed in this respect, hence the two types should be seen as complements rather than substitutes to each other (Johnson, Lorenz, and Lundvall 2002). This complementary was in fact also stressed in the original writings by Polanyi (1967), but tend to be forgotten or ignored in the further elaborations and applications of his ideas (Nightingale 1998).

In order to move beyond a binary discussion on the tacitness of some and the codifyability of other types of knowledge, Lundvall and Johnson (1994) promote an alternative distinction between 'know-what', 'know-

why', 'know-how' and 'know-who'[2]. The first, 'know-what', is closely related to what one would associate with the term information; it refers to knowledge about mere facts. It can be acquired by reading books or attending lectures and does not necessarily involve interactive learning or cooperation between actors. Since technological progress has made access to information easier and 'know-what' almost ubiquitous, other types of knowledge have become increasingly relevant. The second type, 'know-why', refers to knowledge about principles and laws in nature and society, which is related to scientific knowledge and particularly important for innovation activities in science based industries such as chemicals or drug development. The third, 'know-how', refers to skills and the capability of doing something, not only in terms of practical or physical work, but of all sorts of activities in the economic sphere. This kind of knowledge is typically generated and preserved within the boundaries of a firm, however the growing complexity of economic activities increases the need for firms to cooperate and to engage into the exchange of 'know-how'. Thus, one important rationale for the formation of networks between firms is their need to share and combine elements of 'know-how'. The forth type of knowledge, 'know-who', is closely linked to the previous by referring to knowledge about possible partners for cooperation and knowledge exchange. In order to acquire competences that are not yet present within the firm, innovating companies need to build up and cultivate relationships with other firms that are willing to share knowledge and related skills. Thus it becomes obvious that 'know-who' is closely related to the formation of knowledge networks between actors. However in the discussion so far, only little can be said about the *geographical* configuration of these networks.

More recently, and referring to Laestadius (2000), Asheim and Gertler (2005) have introduced an alternative conceptualization of knowledge that takes explicitly into account the content of the actual interactions taking place in networks of innovators. To explain the geography of innovation in different industries, a distinction is made between three different types of knowledge bases: (1) analytical, (2) synthetic and (3) symbolic. These knowledge bases differ in various respects such as the dominance of tacit and codified knowledge content, the degree of formalisation and the context specificity of the knowledge. This distinction is intended as ideal-typical.. In practice, most activities comprise more than one knowledge base, and the degree to which a certain knowledge base prevails varies between industries, firms and different types of activities and occupations within those (Asheim and Hansen 2009). The main characteristics of the three knowledge bases are described in the following.

An analytical knowledge base is dominant in economic activities where scientific knowledge is important, and where knowledge creation is mainly based on formal models, codified science and rational processes (Asheim and Gertler 2005). Examples mentioned in the literature are genetics, biotechnology, and information technology, whereas the present study focuses on the life science industry. For those industries, basic and applied research is relevant and new products and processes are developed in a relatively systematic manner. Companies usually run their own research and development (R&D) departments, but rely also on knowledge

[2] 'Know-why' is similar to Episteme and 'know-how' to Techne, a distinction that refers back to Aristoteles and is naturally made in other languages, for instance in French between 'connaissance' and 'savoir-faire' or in German between 'Wissen' and 'Können'.

generated at universities and other research organisations as an input to their innovation activities. Thus linkages and networks between industry and public research organisations are highly important and occur more frequently than in other industries. Analytical industries deal with scientific knowledge stemming from universities and other research organisations; consequently they rely mainly on codified forms of knowledge. However, the role of tacit knowledge should not be ignored since the process of knowledge creation and innovation always involves both kinds of knowledge (Nonaka, Toyama, and Konno 2000; Johnson, Lorenz, and Lundvall 2002).

A synthetic knowledge base prevails in industries that create innovation through use and new combination of existing knowledge, with the intention to solve concrete practical problems (Asheim and Gertler 2005). Examples mentioned in the literature are plant engineering, specialized industrial machinery and shipbuilding, while the present study focuses on innovative food production. In these industries, formal R&D activities are of minor importance; innovation is driven by applied research or more often by incremental product and process development. Linkages between university and industry are relevant but occur more in the field of applied R&D and less in basic research. New knowledge is generated partly through deduction and abstraction, but primarily through induction, encompassing the process of testing, experimentation and practical work. Knowledge that is required for these activities is partially codified, however the dominating form of knowledge is tacit, due to the fact that new knowledge often results from experience gained through learning-by-doing, -using and -interacting. Compared to others, synthetic industries require more know-how, craft and practical skills for designing new products and processes. Those skills are often provided by professional and polytechnics schools or by on-the-job training (Asheim and Coenen 2006).

The symbolic knowledge base is a third category that has been introduced recently to account for the growing importance of cultural production. It is strongly present within a set of cultural industries such as film, television, publishing, music, fashion, and design, in which innovation is dedicated to the generation of aesthetic value and images and less to a physical production process (Asheim, Coenen, and Vang 2007). Symbolic knowledge can be embedded in material goods such as clothing or furniture, but its impact on consumers and its economic value arises from its intangible character, its aesthetic quality. Symbolic knowledge also includes forms of knowledge applied and created in service industries such as advertising. Since these industries often organize their activities in short-term projects, knowledge about possible partners for cooperation and knowledge exchange (know-who) is of considerable importance. Symbolic knowledge is highly context-specific, as the interpretation of symbols, images, designs, stories and cultural artefacts "is strongly tied to a deep understanding of the habits and norms and 'everyday culture' of specific social groupings" (Asheim, Coenen, and Vang 2007)p. 664). As Gertler (2008) points out, "the symbolic knowledge embedded within industries such as advertising has been shown to be very highly shaped by its social and cultural context - witness the infamous accounts of how an advertisement that is highly effective in one cultural setting often meets with a very different reception when it is implemented in another market" (p. 215f.). Therefore, the meaning and the value associated with symbolic knowledge varies considerably between places.

Theory-led expectations

Following the theoretical discussion, it is reasonable to expect that industries with different knowledge bases vary also as regards the geography and organisation of knowledge sourcing and knowledge exchange. We aim at exploring these industry specific differences by focussing on the role of the regional versus the global sphere for knowledge exchange, and the role of more formalised versus less formalised knowledge sources.

Based on the preliminary theoretical considerations, we would expect symbolic industries to rely predominantly on knowledge sources situated in geographical proximity, since the interpretation of the knowledge they deal with tends to vary between places. Formalised knowledge sources related to academia are expected to be less important, since product and process development is driven by creativity rather than application of scientific laws. Since creativity and artistic skills are key to these firms' competitiveness, and since such capacities are hard to transfer from one individual to another, staff recruitment (in the following referred to as mobility) is assumed to be an important strategy for knowledge sourcing among these firms. At the same time, these artistic skills are strongly context dependent, not only with regard to geography but also with regard to type of activity, which would imply that firms in the same type of industry would be the primary source for staff recruitment. Since many of these companies build their image and brand name around their core products, their innovations are usually not kept secret, but distributed in as wide channels as possible. This would imply monitoring of other firms through channels such as fairs, exhibitions and magazines an important strategy for knowledge sourcing among firms in this industry.

Synthetic industries deal to a higher extent with codified knowledge which is less context specific, although the dominating form is still tacit. Therefore, cooperation and knowledge exchange is expected to occur primarily between spatially collocated partners, but also actors on the national and global level to play a considerable role. Staff recruitment between firms in the same industry is expected to be a crucial strategy for knowledge sourcing, while monitoring of other firms innovative activities through indirect channels are expected to be less important, as a consequence of the applied and specialized nature of the knowledge on which these firms build their competitiveness. To the extent that these firms use such indirect channels, these are expected to be less formalized and largely industry-specific.

Analytically based industries rely on scientific knowledge that is codified, abstract and universal, and are therefore less sensitive to geographical distance. In line with this, we would expect analytical industries to rely on formalised knowledge sources and to operate within globally configured epistemic communities rather than locally configured, trust based networks (Moodysson 2008; Gertler 2008). Since a large share of the crucial knowledge for innovation in these types of industries is embodied in key individuals, staff mobility is assumed an important strategy for knowledge sourcing among firms. Universities are assumed to be the main source of human capital, but also other firms with similar profile, whereas the specialized nature of most of these firms makes more generic knowledge available in other types of sectors less important. The strong regulations and reliance on intellectual property rights may serve as a barrier for collaboration, which would

increase the incentives, but also the difficulties, for knowledge sourcing through monitoring competitors using indirect sources of knowledge such as scientific journals, surveys and questionnaires.

These expectations are visualized in Figure 1 and will be empirically addressed in the remainder of this article.

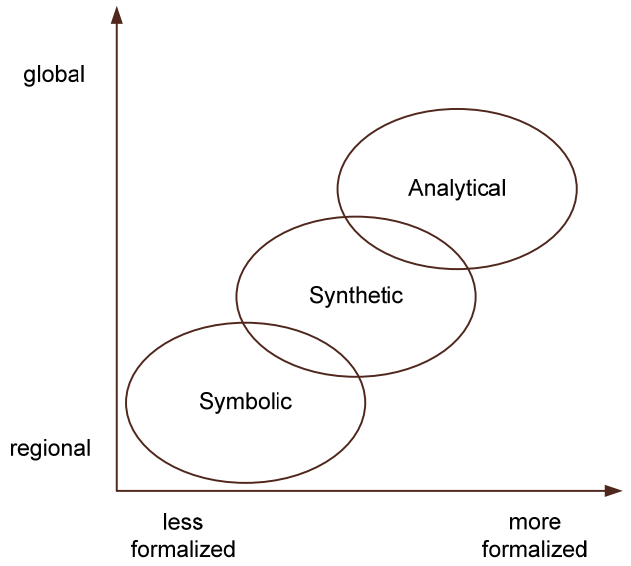

FIGURE 1: EXPECTED PATTERNS OF KNOWLEDGE SOURCING. SOURCE: OWN DRAFT

RESEARCH DESIGN: LIFE SCIENCE, FOOD AND MOVING MEDIA IN SCANIA

While previous studies applying the knowledge base approach, with very few exceptions, have done so without empirics or through in-depth case studies of innovation processes carried out by single firms and/or project groups (Asheim and Gertler 2005; Coenen and Asheim 2005; Moodysson 2008; Moodysson, Coenen and Asheim 2008) or through very indirect measures of knowledge collaboration (Coenen et al 2006) this study draws on data from a collection of cases, with the ambition of further assessing some of the theoretically derived assumptions (specified above). The current analysis should however not be seen as an attempt to verify or falsify the theory, rather as an attempt to better underpin and specify some of its core arguments. For this reason, the initial selection of cases is based on a qualitative assessment of the core activities of companies composing regional clusters, while the assumptions on the geography and organisation of these core activities put forward in previous studies are assessed through a combined survey and interview based study on three industries that are located in the region of Scania, Sweden, namely life science (analytical based), food (synthetic based), and moving media (symbolic based).[3] While some would argue that we hereby apply a circular argument basing the selection of cases on observations what we subsequently set out to

[3] Interviews have been conducted between 2007 and 2010 in the framework of the European collaborative research project 'Constructing Regional Advantage (CRA)'. Eight project teams in different countries have made use of the same jointly developed questionnaire to interview firm representatives.

measure, we argue that this is not the case. The cases are selected based on the type of innovation activities on which the firms ought to base their competitive advantage given the market in which they operate, while the geography and organization of knowledge sourcing are empirical questions not reflected in the selection of cases.

The region of Scania is located in the southernmost part of Sweden. With 1.3 Mio inhabitants representing 13% of the country's total population, it is one of the most populated and urbanized regions in Sweden. Most of the economic activities take place in the agglomeration around Malmö, which is the country's third largest city and has undergone a transformation from heavy manufacturing and shipbuilding to more service oriented activities, and the city of Lund, which hosts the largest university in the Nordic countries and is a major source for scientific knowledge and highly skilled labour with approximately 40,000 students and 5,500 employees. In order to strengthen the position of Scania both nationally and internationally, the regional authorities, represented by the regional council 'Region Skåne', are for more than one decade actively implementing policies that are designed towards innovation based regional development. The existing initiatives are largely influenced by theoretical concepts like clusters (Porter 2003), learning regions (Asheim 1996) and regional innovation systems (Cooke, Heidenreich, and Braczyk 2004; Asheim and Gertler 2005), and geared towards improved cooperation and knowledge exchange between industry, university and government on the regional level. These policies focus on the development of selected industries in which the region is supposed to have a competitive advantage and a future growth potential. Three of these industries are presented and dealt with in the following.

The life science industry in Scania encompasses more than 20 research based biotechnology companies focusing on new pharmaceuticals and about the same number of medical technology oriented companies. The majority of biotechnology companies were established after 1995 and are clustered around Lund University and in the two science parks Ideon (in Lund) and Medeon (in Malmö). Strong research units such as Lund University and Lund Institute of Technology as well as the university hospitals of Lund and Malmö are important organisations that contribute to the development of this industry. Employing about 7,000 people and accounting for around 15% of the country's value added in the sector, the region is today one of the three major locations for the pharmaceutical and biotechnological industry in Sweden, besides the Stockholm-Uppsala Life Science Cluster and Stockholm Science City. The regional industry can also be seen in the larger context of the cross-border cluster Medicon Valley, which covers life science companies in the south of Sweden and the neighbouring part of Denmark, including Copenhagen. Firms in both countries are addressed by a cluster initiative named Medicon Valley Alliance, which was set up with the aim to encourage bi-national cooperation between Swedish and Danish life science companies, to stimulate industry-university linkages and to improve the global visibility of the cluster (Moodysson 2007). With a list of firms provided by this cluster initiative and through a manual selection process, 43 innovating life science companies were identified in the region, most of them independent small and medium sized. No large multinationals, pharmaceutical or medical technology firms with their headquarters located elsewhere were included in the sample. Semi-

standardized and in-depth interviews were conducted with representatives of 30 of these firms (response rate 70%)[4].

The food industry in Scania plays an important role both for the regional economy and for the national food production. This position is rooted in history and links to natural conditions that are favourable for agriculture and food processing, e.g. fertile soils and a relatively mild climate. Today, approximately 45% of the Swedish turnover in the food sector is generated in the region. Nilsson at al. (2002) estimate that a total of 40,000 people are employed in the industry, of which 25,000 are active in the core activities around food production and processing, and another 15,000 in supporting and related industries such as food oriented packaging, agricultural research or manufacturing of food related machinery. There are several larger national or international companies active in food processing, such as Nestlé, Skånemejerier, Findus and Unilever, as well as supporting and auxiliary company such as Tetra Pak, a food packaging company originating from Lund. While these companies have been shaping the cluster for a long time, they do not necessarily have their key activities in the region any more. As a response to an increasing global competition in the agricultural sector, which was partly accelerated by the entry of Sweden to the European Union in 1995, many firms have gone through a sharp process of restructuring and rationalization. The food industry faces a high pressure to innovate and develop towards higher value added niche products such as functional food, e.g. food with health promoting or disease preventing functions. Over the last decades, a number of small knowledge-intensive firms have evolved within food and related sectors, some of which have close contacts to research and development facilities both inside and outside the region (Nilsson 2008). The analysis in this paper is limited to innovative food production and processing companies. Based on an inclusive list of actors whom a regional cluster initiative had identified as being part of the regional food industry, a manual selection process was carried out in which inactive firms and firms that only have sales departments in the region were excluded. After this selection process, the innovative core of the food industry was defined as being composed by 35 firms, of which 28 were interviewed (response rate 80%). As in the case of life science, most of the companies are small and medium sized, based in the region with both head quarter, development and production unit.

The moving media industry represents a new and growing niche in the regional economy of Scania. The growth of the industry took off in the beginning of the 21th century; after a period in which the traditional naval and heavy processing industry located in Malmö went down. In 2002, the large crane of the shipyard, a symbol of Malmö as industrial city, was sold and transported to South Korea for future use in a motor vehicle factory. The regional authorities had the explicit ambition to create a new landmark for the city, and the abandoned shipyard was transformed into a modern office and housing area. In the same period, the local university college experienced rapid growth and extended its facilities into the new neighbourhood. Partly to distinguish themselves from the larger and more established Lund University with core competences in science, engineering and management, the university college in Malmö decided to focus its development and

[4] A desktop-based non-respondent analysis revealed no systematic difference between responding and non-responding companies in terms of size, age and type of activities.

education activities on applied science and 'creative' activities related to arts, design and moving images (Henning, Moodysson and Nilsson 2010). Around the same time, the regional authorities launched a cluster initiative with the aim to bring together and strengthen the media industry in the region. Moving media spans over a range of organisationally distinct, but functionally related, activities. Examples are film and TV production, digital arts and design, development of computer games software and various graphical applications for computers, mobile phones and other hand held devices (Martin and Moodysson 2011). Since the majority of the firms working with moving media represent small and specialised niches of other more generic sectors (like ICT, advertising, software development etc.) it was not possible to use official statistics to identify the entire population of firms. This was instead done through a dialogue with a regional support organisation and a manual selection process, in which inactive firms and firms that only have sales departments as well as independent artists and interest organisations without real commercial activities were excluded. After this selection process, the moving media cluster was defined as being composed by 71 firms, most of them small with less than 10 employees, but also some medium sized. Interviews with representatives of 37 of these companies were conducted (response rate 52%).

Keeping in mind the above mentioned differences and similarities in the evolution and composition of these industries, the remainder of the paper will focus on differences as regards the underlying knowledge structure and will analyse more in detail the organisational and geographical patterns of knowledge sourcing. As touched upon above, all three knowledge bases and the modes of knowledge creation characterizing them are to some extent involved in a concrete innovation process, no matter in which industry it takes place. Nevertheless, there are fundamental differences as regards the degree to which various types of knowledge are present, or, more accurate, as regards the type of knowledge that is crucial and constitutes the competitive core of the industry. Innovation activities in the life science industry are mainly geared toward solving analytical challenges that are most effectively addressed by scientific knowledge and principles. Synthetic challenges related to problem-solving as well as symbolic challenges related to design and aesthetics are present as well, but do not constitute the core competence in this industry. Firms in the food industry in contrast are innovating predominantly through incremental problem-solving processes and by application of engineering skills; their core competence is the dissolving of synthetic challenges. Moving media companies are mostly concerned with symbolic contents involving artistic knowledge and design, often with the aim to improve the user experience and perception of a product. Whereas the analytical and synthetic challenge in principle could be sourced out to advanced suppliers or sub-contractors, the symbolic challenge constitutes the core competence of the moving media industry (Martin and Moodysson 2011).

Empirical Analysis: Organisational and Geographical Patterns of Knowledge Sourcing

Below follows a comparative analysis of organisational and geographical patterns of knowledge flows in the life science, food and moving media industry in Scania. Knowledge sourcing is captured from three different angles, namely *monitoring*, *mobility* and *collaboration*. Monitoring refers to the acquisition of new knowledge

without direct interaction with other actors, but through intermediary carriers of knowledge. Mobility refers to the recruitment of skilled labour from other organisations and is associated with knowledge that is embodied into people. Collaboration refers to the intentional exchange of knowledge through direct interaction with other actors inside or outside the region. In the following, we examine the organisational patterns of various sources for monitoring and mobility, as well as the geographical patterns of collaboration between firms. Firm representatives in the three industries were asked to indicate the importance of each source on a scale from 1 (very low) to 5 (very high); the results thus display *perceived* importance.

Knowledge sourcing through monitoring

As regards *monitoring*, there is a range of possible sources for new knowledge. The most obvious primary sources are other actors in the innovation system such as universities, companies or governmental agencies. However in this section main attention is paid to the acquisition of knowledge without direct interaction, but through intermediaries carrying knowledge from these primary sources. Examples for intermediaries are scientific journals reporting results from basic research, surveys and questionnaires carried out and published by various business and support organisations, specialised magazines focussing on specific industries or technologies, as well as trade fairs and exhibitions targeting these industries. Following the preliminary theoretical consideration, we would expect the life science industry to attribute a relatively high importance to journals and surveys representing scientific knowledge and principles. In contrast, we would expect the food industry and even more the moving media industry to rely primarily on knowledge sources with a lower degree of formalisation, here reflected by business magazines, trade fairs and exhibitions.

TABLE 1: RELATIVE IMPORTANCE OF VARIOUS SOURCES FOR GATHERING MARKET KNOWLEDGE THROUGH MONITORING

		Mean	Std. Deviation	N
Scientific journals	Life Science	3.31	1.31	29
	Food	1.86	1.08	28
	Moving Media	2.31	1.21	36
Surveys, questionnaires	Life Science	3.31	1.51	29
	Food	2.86	1.30	28
	Moving Media	2.44	1.25	36
Specialised magazines	Life Science	2.83	1.34	29
	Food	3.07	1.27	28
	Moving Media	3.19	1.39	36
Fairs, exhibitions	Life Science	2.72	1.39	29
	Food	3.11	1.40	28
	Moving Media	3.00	1.29	36

Source: own survey. Note: importance on a scale from 1 (very low) to 5 (very high)

The results presented in Table 1 reveal clear industry specific differences as regards how different intermediaries for knowledge sourcing are perceived. In the life science industry, the highest importance is

attributed to scientific journals (3.31)[5] and surveys (3.31) representing more formalised sources of knowledge, whereas specialised magazines (2.83) and fairs and exhibitions (2.72) are considered less important. This observation is significantly[6] different from the food and the moving media industry, where fairs and magazines representing knowledge sources with a lower degree of formalisation are perceived as more important. In the food industry, scientific journals are almost unanimously considered as very little important (1.86), whereas main importance is attributes to specialised magazines (3.07) and fairs and exhibitions (3.11). The results for moving media reveal that journals (2.31) and surveys (2.44) are considered less relevant than fairs (3.00) and specialised magazines (3.19). These results go fairly well in line with our theory lead expectations on the organisational patterns of knowledge sourcing. Innovation in life science is based on formal models, codified science and rational processes, thus knowledge and principles stemming from academia are of particular importance. This is less the case for the food industry in which innovation is driven by the use and recombination of existing knowledge rather than by formal basic research. Innovation in the moving media is based on creativity and aesthetics, thus conceptual knowledge stemming from academia is of minor importance compared to context specific knowledge and rumour disseminated in magazines or exchanged at fairs and exhibitions.

Knowledge sourcing through mobility

A second mode to access new knowledge in an even more direct way is the recruitment of skilled labour from other organisations, here referred to as *mobility*. Skilled labour is probably the most important resource for knowledge driven activities, and the recruitment of skilled labour enables firms to internalize knowledge that is highly tacit and embodied into humans[7]. Possible sources for the recruitment of skilled employees are other firms from the same or from a different industry, but also research and education organisations such as universities and technical colleges. Firms in the three industries were asked from where they recruit their skilled labour and how important they perceive these various sources for recruitment. Based on the preliminary theoretical considerations, we would expect firms in the life science industry to draw very much on graduates and experienced academics stemming from universities. Food companies in contrast are expected to rely more on practical skills to solve functional challenges; these competences are best provided by graduates from technical colleges or by workforce with job experience in similar industries. Innovation in the moving media industry requires creativity and a cultural understanding. These competences are expected to develop best by training and experience gained at work in a similar creative context.

The results summarized in Table 2 display the perceived importance of various sources for the recruitment of skilled labour. In line with our expectations, life science companies recruit primarily from universities (3.93) and from other firms in the same industry (3.87). Obviously, these companies deal with highly specialized knowledge content that is most easily acquired and understood at universities involved in research and

[5] Numbers in brackets display mean values.
[6] 'Significance' is meant as statistical significance at 5% level, tested with Scheffé's method.
[7] The explanatory power of labour mobility is also emphasized in the literature on skilled-relatedness, in which industries are defined as related to each other if they share the same or similar skills, measured in terms of labour flows between companies (Neffke and Henning 2010; Boschma, Eriksson, and Lindgren 2009).

education or in other firms active in the same technological field. Consequently, practical education in technical colleges (1.90) and firms in other industries (1.77) play a minor role. For the food industry, the primary source for recruitment of skilled labour is the private sector: other firms in the same industry (3.96) are considered most important, followed by firms in other industries (2.93)[8]. The higher education sector is of little importance, both universities (2.11) and technical colleges (1.89) are considered as hardly relevant. Whereas the first goes well in line with the theory, the latter is surprising, given that the food industry draws on practical education and applied research which is mostly provided by technical colleges. A possible explanation is thematic focus of the local university college, which has set its emphasis on creative activities and does not necessarily provide the specific type of training required by the food sector. In the moving media industry, skilled labour is mostly acquired from other firms in the same industry (4.36), but also universities (2.94) are to some extent considered as relevant. This can be explained by the fact that some universities also operate in creative and artistic fields such as arts, music and theatre, and that some activates in the moving media industry require a good general education provided in classical subjects like languages and humanities. These observations go fairly well in line with our expectations on the organisational patterns of knowledge sourcing. Whereas analytical industries recruit primarily from academia and from other firms in the same technological field, synthetic and symbolic industries recruit primarily from the private sector in general.

TABLE 2: RELATIVE IMPORTANCE OF VARIOUS SOURCES FOR RECRUITMENT OF HIGHLY SKILLED LABOUR.

		Mean	Std. Deviation	N
Universities	Life Science	3.93	1.55	30
	Food	2.11	1.23	28
	Moving Media	2.94	1.45	35
Technical colleges	Life Science	1.90	1.40	30
	Food	1.89	1.20	28
	Moving Media	2.26	1.15	35
Firms in the same industry	Life Science	3.87	1.41	30
	Food	3.96	1.04	28
	Moving Media	4.36	0.93	36
Firms in other industries	Life Science	1.77	1.04	30
	Food	2.93	1.30	28
	Moving Media	2.61	1.13	36

Source: own survey. Note: importance on a scale from 1 (very low) to 5 (very high)

Knowledge sourcing through collaboration

A third fundamental mode for acquisition of new knowledge is *collaboration*, e.g. intentional knowledge exchange through direct interaction with other actors. This interaction can encompass knowledge about new

[8] The observed industry specific differences in the importance of labour flows from other industries partly contradict the literature on skilled relatedness, which builds on the assumption that labour flows occur almost exclusively within related industries. Our observations show that this might be true for some industries (e.g. life science), whereas others (e.g. food) recruit as well from industries that are perceived as very different.

developments or trends on the market as well as knowledge of technological nature that is required as direct input for a concrete innovation process. Based on the theoretical discussion and the insights on the knowledge characteristics of the three case industries, we would expect life science companies to deal above all with knowledge that is universally valid and only little sensitive to geographical distance and therefore to collaborate within globally rather than locally configured networks. Innovation in the food industry is based on practical skills and knowledge that is partly codifiable, but has a strong tacit component. Furthermore, the food industry has a long tradition in the region and a leading position within the national economy (Henning, Moodysson, and Nilsson 2010).Thus, we would expect collaboration to take place predominantly on the regional and the national level. The moving media industry deals with knowledge that is valid within a specific, culturally defined context. Thus, we would expect knowledge exchange to take place in networks between actors that share a similar socio-cultural background and are predominantly located in spatial proximity. In order to test these expectations, the firms were asked with whom they cooperate and exchange various types of knowledge, and where these exchange partners are located. The results are analysed using social network analysis and presented in the following[9].

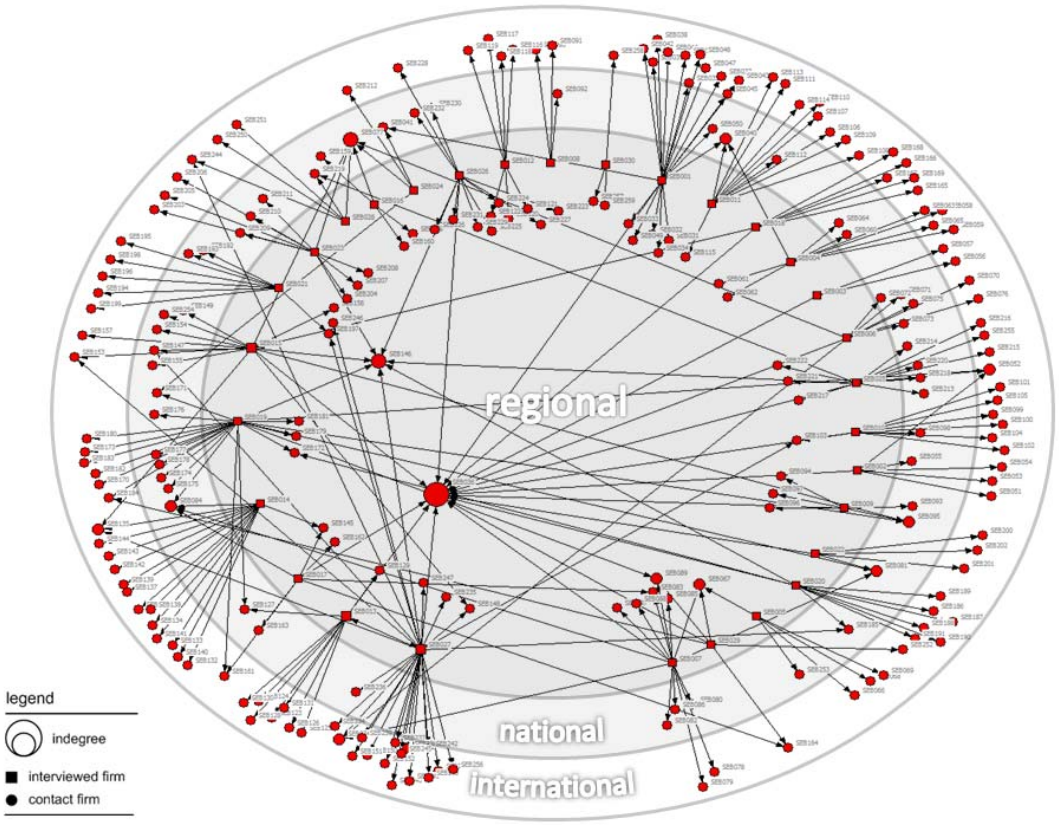

FIGURE 2: KNOWLEDGE SOURCING THROUGH COLLABORATION IN THE LIFE SCIENCE INDUSTRY. SOURCE: OWN DRAFT

[9] Networks are composed of nodes representing actors and links representing knowledge flows. The shape of the node indicates whether the actor is part of the interviewed group and the location of the node reflects the spatial dimension (regional, national, international).

Figure 2 displays the network of collaboration in the life science industry. A view on the structure of the network reveals some basic characteristics of the life science industry in Scania. As regards the number of actors involved in the industry, we count 257 nodes in the network. Regarding the exchange relations between them, we count 293 links representing flows of knowledge. This shows that the network between companies in the regional life since industry is not particularly dense, and only few actors are mentioned several times as important partner for cooperation. The actors that are most often mentioned are Lund University (17)[10], followed by the University Hospital of Malmö (7) and Karolinska Institute (6), a large and renowned medical university placed in Stockholm. As regard the spatial location of actors and exchange relations, it is obvious that contact partners are situated both inside and outside the region, whereas extraregional cooperation is dominating[11]. Of all 257 actors, 31.9% are situated in the region, 19.5% within the country and 48.6% outside the country. Of all 293 exchange relations, 29.4% occur between actors in the region, 23.9% with actors in other parts of the country and 46.8% are international. Thus it appears that, although some collaboration takes place within the region, the largest share of knowledge flows occur on the international level[12].

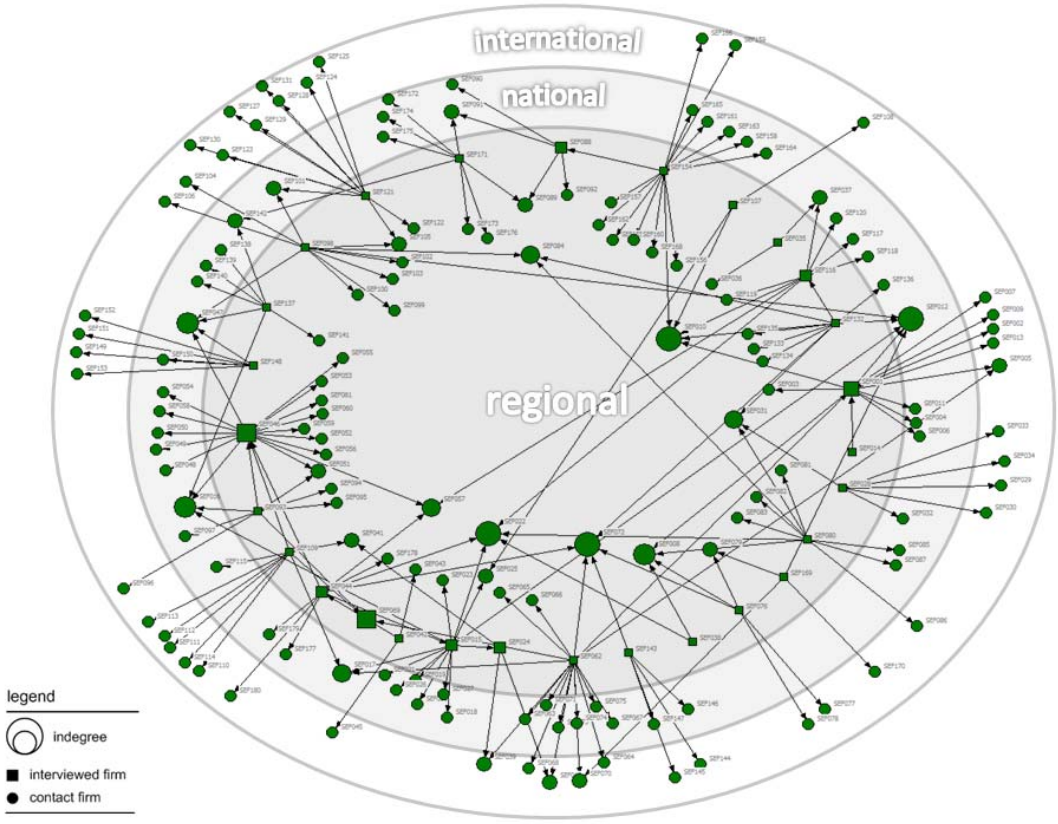

FIGURE 3: KNOWLEDGE SOURCING THROUGH COLLABORATION IN THE FOOD INDUSTRY. SOURCE: OWN DRAFT

[10] Numbers in brackets indicate the number of links directed towards the node (indegree)

[11] The interviews were conducted in the administrative region of Scania, however linkages with firms in Copenhagen are considered as intraregional, in order to account for the close connection and intensive commuting taking place between the two regions.

[12] We found no systematic difference as regards the perceived importance of regional, national and international relations, but a highly significant difference as regards the absolute number of relations.

Figure 3 shows the knowledge network in the food industry. Compared to the life science industry, one can observe a smaller amount of actors involved, but a denser structure of the network. Some actors are frequently mentioned as relevant exchange partners, which are foremost the firms Tetra Pak (5), Skånemejerier (5) and Alfa Laval (5) as well as the Swedish Institute for Food and Biotechnology (5), an applied research institute for foodstuff located in Gothenburg. Overall, we count 178 nodes in the network, of which 44.4% are located in the region, 30.3% within the country and 35.3% in other parts of the world. Of all 204 exchange relations, 42.2% occur within the region, 33.3 % within the country and 24.5% cross national borders. This shows that, compared to the life science industry, a smaller share of the exchange relations occur internationally, whereas national and to some extent also regional exchange relations are increasingly relevant.

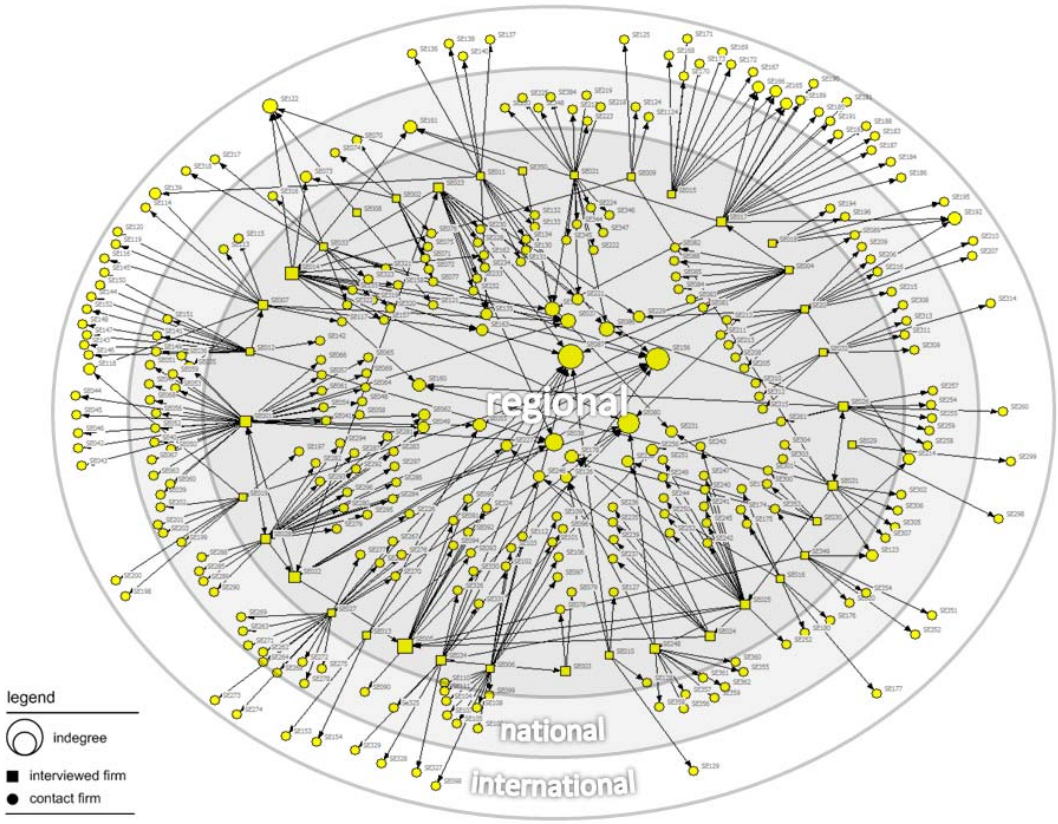

FIGURE 4: KNOWLEDGE SOURCING THROUGH COLLABORATION IN THE MOVING MEDIA INDUSTRY. SOURCE: OWN DRAFT

Figure 4 displays patterns of knowledge sourcing through collaboration in the moving media industry. Actors that are mentioned often as important exchange partners are foremost the Municipality of Malmö (9), the University College of Malmö (7), Media Mötesplats Malmö (8), which is the regional policy initiative targeting the media industry, as well as the local branch of the Swedish television broadcaster SVT (5). Compared to the previous two networks, we observe a larger number of actors and exchange relations. Altogether, we count 349 nodes in the network, of which a majority of 51.9% is located within the region, a smaller share of 28.1%

at other places in the country, and only 20.1% outside the country. Considering the exchange relations between the actors, the dominance of the regional level is even more obvious. Of all 405 links, 54.8% occur within the region, 24.4% within the country and 20.7% cross national boundaries. We thus observe that although national and international knowledge exchange is present, intra-regional knowledge exchange is prevailing by far, which goes well in line with the theory led expectations on the context specificity of knowledge dealt with in symbolic industries.

CONCLUSIONS

In this paper we have studied knowledge flows in the regional innovation system of Scania, southern Sweden. Aim was to examine how the geographical and organisational patterns of knowledge sourcing vary between industries with different knowledge bases, whereas main focus was on the role of regional versus global knowledge networks as well as the role of knowledge sources with a different degree of formalisation. Based on the theoretical discussion, analytical industries were expected to deal with highly formalised knowledge sources and to operate on a global scale. Following the same reasoning, synthetic industries were expected to rely on knowledge sources with a lower degree of formalisation, and global cooperation to play a minor role. Symbolic industries were expected to operate with less formalized sources of knowledge and to be very much locally configured. These theory led expectations have been addressed and tested by case study research on three industries located in the southernmost province of Sweden. Our findings reveal that industries indeed differ considerably with regard to how various sources for knowledge are perceived and acquired. We found that companies in the life science industry rely primarily on knowledge stemming from scientific research and recruitment from the higher education sector, and that knowledge flows occur foremost in globally configured networks. The food industry retrieves new knowledge from less formalised sources and recruits primarily from the private sector. Knowledge exchange takes place in dense, nationally or regionally configured networks. Companies in the moving media industry retrieve knowledge from less formalised sources such as fairs and magazines and recruit primarily from other firms in the same industry. Knowledge exchange takes place in highly localised networks.

These results point in the direction that space and proximity matters for innovation and knowledge exchange, although this is not equally true for all industries. It seems that knowledge exchange in spatial proximity is particularly important for innovation in symbolic and to some extend in synthetic industries, whereas analytical industries operate on a wider geographical scale. The general observation that innovation activities tend to cluster in certain locations is certainly valid and holds for almost all technological fields, however the extent and driving force for co-location seems to differ between industries. What drives co-location in analytical industries is not necessarily the exchange of knowledge with other firms, but first and foremost linkages with public or private research organisations providing education and a skilled labour force. In addition to these localised sources of knowledge, firms maintain vital linkages to specialized knowledge providers situated in other parts of the world. It becomes clear that, despite the importance of the 'local buzz', strong linkages to foreign collaborators and other sources of knowledge remain crucial for enabling innovation

in analytical industries (Bathelt, Malmberg, and Maskell 2004; Gertler and Levitte 2005; Moodysson 2008). In case of synthetic industries, innovation is driven by cooperation and interactive learning within formally established networks between customers and suppliers, often on the national level, whereas local universities play a minor role. In order to bring new products and processes to the market, companies have to apply to norms and regulations that are, at least in the case of food, typically part of the national institutional framework (Coenen et al. 2006). Local knowledge exchange is crucial for symbolic industries, since they build on cultural knowledge that is context specific and most easily understood by actors who share the same socio-cultural background. Due to short-term and project based organisation of innovation activities, symbolic industries require easy access to a pool of possible cooperation partners, which is best provided in the local environment. It has become clear in this study that the fundamental question on the role of geography for innovation ought to be addressed through multiple perspectives; one of which might be a knowledge based view. As it has been stressed in this paper, we believe that a sound understanding of the specific knowledge characteristics of industries can provide additional insights to the discussion on geographical patterns of innovation and add to the literature in this field. Such insights are, in our view, also crucial for the possibility to design and implement sound regional innovation support policies that are embedded in and attuned to the specific needs and available resources of the region. While part of such policy measures can be generally applicable, embracing all major sectors represented in the regional innovation system, the parts that are set out to be sector specific, for instance those usually referred to as “cluster initiatives”, must relate to the specific modes of innovation in the sector. Knowledge base characteristics are important aspects of such sector specificity.

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