



Comparing knowledge bases: on the geography and organization of knowledge sourcing in the regional innovation system of Scania, Sweden

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Abstract

This paper deals with knowledge flows and collaboration between firms in the regional innovation system of southern Sweden. The aim is to analyse how the functional and spatial organization of knowledge interdependencies among firms and other actors varies between different types of industries that draw on different types of knowledge bases. We use data from three case studies of firm clusters in the region: (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 to be symbolic (artistic based). Knowledge sourcing and knowledge exchange in each of the cases are explored and compared using social network analysis in association with data gathered through interviews with firm representatives. Our findings reveal that knowledge exchange in geographical proximity is especially important for industries that rely on a symbolic or synthetic knowledge base, because the interpretation of the knowledge they deal with tends 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 are therefore less sensitive to geographical distance. Thus, geographical clustering of firms in analytical industries builds on rationales other than the need for proximity for knowledge sourcing.

Keywords

knowledge base, innovation network, regional innovation system, Sweden

Introduction: the geography of knowledge sourcing

The geography of innovation and knowledge creation is a vital research field in contemporary economic geography. In recent decades, a large body of literature has emerged studying geographical patterns of innovation, (see for example in this journal Isaksen and Onsager,

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2011) building on a long research tradition that ranges from Marshall's (1920) early work on innovation in industrial districts to more recent work on innovative milieus (Camagni, 1991), learning regions (Asheim, 1996) and regional innovation systems (Cooke et al., 1998; Asheim and Gertler, 2005). In this stream of literature, innovation is largely understood as an outcome of interactive, non-linear processes (Kline and Rosenberg, 1986; Pavitt, 2005), emanating from interaction among various actors in industries, universities and governmental agencies (Etzkowitz and Leydesdorff, 1997, see also Hansen and Winther, 2011). These interactions do not take place randomly over space, but tend to occur within predominantly, but not exclusively, localized 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 about under which conditions the local or regional sphere matters most for the exchange of knowledge between firms and other organizations. There are, however, convincing arguments for the claim that specific knowledge characteristics contribute strongly to determining the role of space in different industries (Boschma, 2005). Whereas some types of knowledge travel easily and can be transferred over large geographical distances, others are spatially sticky and require actors to share the same sociocultural norms and understandings. The degree to which one or another type of knowledge prevails may influence the role of proximity for innovation activities in different industries. Furthermore, it is acknowledged that knowledge creation and innovation occur not only in industries that traditionally have been referred to as science based and (high-)technology oriented, but in more or less all segments of the economy, while increased attention is paid to economic activities transcending established sectoral boundaries (Boschma and Iammarino, 2009). There is nevertheless still a gap in the literature as regards how these cross-sectoral interactive processes are organized, 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 paper contributes to the existing literature by providing empirical findings on the question of how

industry-specific knowledge characteristics contribute to shaping the geography of innovation. The aim is to examine how geographical and organizational patterns of knowledge sourcing and exchange vary between industries with different knowledge bases yet located within the same regional innovation system. We study the role of regional versus global knowledge networks in different industries as well as the role of knowledge sources with lower versus higher degrees of formalization. Three different but often complementary types of knowledge sourcing and exchange are analysed and compared: (1) *monitoring* – indirect intentional knowledge sourcing by way of observing other actors, either directly or through any form of intermediary; (2) *mobility* – the sourcing of embodied knowledge through the recruitment of staff, either from other companies or from different types of knowledge generation organizations (for example, universities) or other actors in the innovation system (for example, the support structure); and (3) *collaboration* – direct (intentional or unintentional) knowledge exchange through various forms of bilateral interaction with other actors such as firms, universities or actors from the support structure of the innovation system (or beyond).

The paper is organized as follows. The first section reviews different taxonomies of knowledge such as the differentiated knowledge base concept, in particular with regard to their assumed geographical implications. Building on the theoretical discussion, we derive hypotheses concerning the geography and organization of knowledge sourcing and differences with respect to the knowledge base of industries. In order to test our expectations, we draw on case-study research on three industrial clusters in the regional innovation system of southern Sweden: (1) life science represents an analytical (science-based) industry, (2) the food sector includes mainly synthetic (engineering-based) industries, and (3) the moving media are considered to be a symbolic (artistic-based) industry. These industries are further described in the second section of the paper. The third section covers the empirical analysis, in which each case is explored and compared by means of descriptive statistics and social network analysis. The final section summarizes our findings and provides concluding remarks.

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 of types of knowledge and forms of knowledge creation and application. 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 in people and organizations and considered to be '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 et al., 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 is most effectively transmitted through direct 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 localized 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 clearly intelligible, this tacit/codified dichotomy is often criticized for a narrow understanding of knowledge, learning and innovation (Cowan et al., 2000; Lundvall et al., 2002; Gertler, 2003). The underlying assumption that the transfer and coordination of tacit knowledge take place almost exclusively on a local scale can certainly be criticized; there is little 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 with global flows of knowledge (Hagedoorn, 2002; McKelvey et al., 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 complementary rather than as substitutes for each other (Johnson et al., 2002). This complementarity was in fact also stressed in the original writings by Polanyi (1967), but tends 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 types of knowledge and the codifiability of other types, Lundvall and Johnson (1994) promote an alternative distinction between 'know-what', 'know-why', 'know-how' and 'know-who'.¹ 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 is 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, in terms not only 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 in 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 fourth type of knowledge, know-who, is closely linked to the previous category 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, little has been said in the discussion so far 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 explicitly takes into account the content of the actual interactions occurring in networks of innovators. To explain the geography of innovation in different industries theoretically, a distinction is made between three different types of knowledge base: (1) analytical, (2) synthetic and (3) symbolic (Asheim and Coenen, 2005; Asheim, 2007; Gertler, 2008). These knowledge bases differ in various respects such as the dominance of tacit and codified knowledge content, the degree of formalization and the context-specificity of the knowledge. This distinction, when applied to industries, is intended as ideal-typical. This means that the knowledge bases should be understood as generalized ontological categories that rarely make up clear-cut cases of industries. Rather, in reality, most activities comprise more than one knowledge base, and the degree to which a certain knowledge base prevails may vary considerably between industries, firms and different types of activities and occupations within those (Asheim and Hansen, 2009). This is also the case in the sample of firms in this particular study. The selection of cases is based on a qualitative assessment of the knowledge base that is crucial for innovation in each firm and, based on similarities on this dimension, the companies are grouped together to form the source population of the particular cluster. This means that the clusters may be composed of companies that belong to different industries according to traditional industrial classification systems (for example, NACE or SIC), while being similar with regard to their crucial knowledge base, that is, the knowledge base on which their competitiveness ultimately draws. This does not necessarily mean that the firm characteristics in terms of scope of activities or composition of human capital and

capabilities are similar within each category – as illustrated in the section defining each category. 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; the present study focuses on the life science industry. For these industries, basic and applied research are 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 also rely on knowledge generated in universities and other research organizations as an input to their innovation activities. Thus linkages and networks between industry and public research organizations are very important and occur more frequently than in other industries. Analytical industries deal with scientific knowledge stemming from universities and other research organizations; 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 et al., 2000; Johnson et al., 2002).

A synthetic knowledge base prevails in industries that create innovation through the use and new combination of existing knowledge, with the intention of solving concrete practical problems (Asheim and Gertler, 2005). Examples mentioned in the literature are plant engineering, specialized industrial machinery and shipbuilding; 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 universities 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. Although the knowledge required for these activities

is partially codified, the dominant form of knowledge is tacit, owing to the fact that new knowledge often results from experience gained through learning by doing, using and interacting. Compared with other industries, synthetic industries require more know-how, craft and practical skills for designing new products and processes. Those skills are often provided by professional and polytechnic 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 et al., 2007). Symbolic knowledge can be embodied in material goods such as clothing or furniture, but its impact on consumers and its economic value arise from its intangible character and 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 et al., 2007: 664). As Gertler (2008: 215) 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’. Therefore, the meaning and the value associated with symbolic knowledge vary considerably between places.

Theory-led expectations

Following the theoretical discussion, it is reasonable to expect that industries with different knowledge

bases vary also with regard to the geography and organization of knowledge sourcing and knowledge exchange. We aim to explore these industry-specific differences by focusing on the role of the regional versus the global sphere for knowledge sourcing, and on the role of more formalized sources of knowledge (connected to academic reasoning and the application of scientific laws) versus less formalized sources (connected to practical or creative involvement in the workplace).

Based on the preliminary theoretical considerations, we would expect symbolic industries to rely predominantly on knowledge sources situated in geographical proximity, because the interpretation of the knowledge they deal with tends to vary between places. Formalized knowledge sources related to academia are expected to be less important, because product and process development is driven by creativity rather than the application of scientific laws. Because creativity and artistic skills are key to these firms’ competitiveness, and because 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 through as wide channels as possible. This would imply that the monitoring of other firms through channels such as fairs, exhibitions and magazines is an important strategy for knowledge sourcing among firms in this industry.

Synthetic industries deal to a higher extent with codified knowledge that is less context specific, although the dominant form is still tacit. Therefore, cooperation and knowledge exchange are expected to occur primarily between spatially co-located partners, although actors at the national and global level may also play a considerable role. Staff recruitment between firms in the same industry is expected to be a crucial strategy for knowledge sourcing, whereas monitoring of other firms’ innovative activities

through indirect channels is 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, they 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 assumed to be less sensitive to geographical distance. In line with this, we would expect analytical industries to rely on formalized knowledge sources and to operate within globally configured epistemic communities rather than locally configured trust-based networks (Gertler, 2008; Moodysson, 2008). Because a large share of the crucial knowledge for innovation in these industries is embodied in key individuals,² staff mobility is assumed to be an important strategy for knowledge sourcing among firms. Universities are assumed to be the main source of human capital, although other firms with similar profiles also figure; the specialized nature of most of these firms makes the 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 to collaboration, which would increase the incentives for knowledge sourcing through monitoring competitors using indirect sources of knowledge such as scientific journals, surveys and questionnaires. These expectations are depicted in Figure 1 and empirically addressed in the remainder of this paper.

Research design: life science, food and moving media in Scania

Whereas previous studies applying the knowledge base approach have, with few exceptions, done so without empirics or through in-depth case studies of innovation processes carried out by single firms and/or project groups (Asheim and Coenen, 2005; Asheim and Gertler, 2005; Moodysson, 2008; Moodysson et al., 2008) or through indirect measures of knowledge collaboration (Coenen et al., 2006), this study draws on data from a collection of cases,³ with the

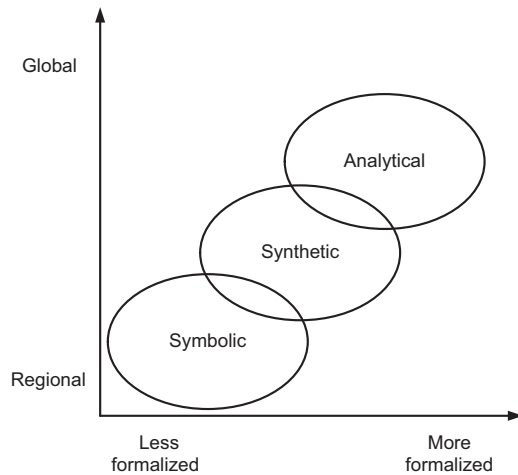


Figure 1. Expected patterns of knowledge sourcing
Source: Author's own figure.

ambition of further assessing some of the theoretically derived assumptions specified above. Consequently, the current analysis should be seen as an attempt to empirically underpin and specify some of the core arguments in the literature on knowledge bases. In order to avoid circularity in our analysis,⁴ we make a clear distinction between the rationale behind our selection of cases and the concrete events we set out to measure. 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; the geography and organization of knowledge sourcing and knowledge exchange are empirical questions not reflected in the selection of cases. The initial selection of cases is based on a qualitative assessment of the core activities of companies composing regional clusters, and the assumptions about the geography and organization of these core activities put forward in previous studies are assessed through a combined survey- and interview-based study of three industries that are located in the region of Scania, Sweden.

The region of Scania is located in the southernmost part of Sweden. With 1.3 million inhabitants, representing 13 percent of the country's total population, it is one of the most populated and urbanized regions in Sweden. Most 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 of scientific knowledge and highly skilled labour. In order to strengthen the position of Scania both nationally and internationally, the regional authorities, represented by the regional council 'Region Skåne', have for more than a decade actively implemented policies aimed towards innovation-based regional development. The existing initiatives are largely influenced by theoretical concepts such as clusters (Porter, 2003), learning regions (Asheim, 1996) and regional innovation systems (Cooke et al., 2004; Asheim and Gertler, 2005), and are geared towards improved cooperation and knowledge exchange between industry, university and government at the regional level. These policies focus on the development of selected industries in which the region is thought to have a competitive advantage and 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 companies oriented to medical technology. 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 the Lund Institute of Technology, as well as the university hospitals of Lund and Malmö, are important organizations that contribute to the development of this industry. Employing about 7000 people and accounting for around 15 percent 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, the others being 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 targeted by a cluster

initiative named the Medicon Valley Alliance, which was set up with the aim of encouraging bi-national cooperation between Swedish and Danish life science companies, stimulating industry–university linkages and improving 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 and 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 (70 percent response rate⁵). The interviewees were either chief executive officers (CEOs) or chief research officers (CROs) in the companies and were thus, owing to the size and nature of these firms, actively engaged in both management and operational work with product and process development.

The food industry in Scania plays an important role both in the regional economy and in national food production. This position is rooted in history and relates to natural conditions that are favourable for agriculture and food processing, for example fertile soils and a relatively mild climate. Today, approximately 45 percent of Swedish turnover in the food sector is generated in the region. Nilsson et al. (2002) estimate that a total of 40,000 people are employed in the industry, of whom 25,000 are active in the core activities around food production and processing, and the other 15,000 are in supporting and related industries such as food-oriented packaging, agricultural research or the manufacturing of food-related machinery. Several larger national or international companies are active in food processing, such as Nestlé, Skånemejerier, Findus and Unilever, as well as supporting and auxiliary companies such as Tetra Pak, a food-packaging company originating from Lund. Although these companies have shaped the cluster for a long time, they do not necessarily have their key activities in the region any more. As a response to increasing global competition in the agricultural sector, partly accelerated by the entry of Sweden into the European Union in 1995, many firms have gone through a sharp process of

restructuring and rationalization. The food industry faces great pressure to innovate and develop higher value-added niche products such as functional food, for example food with health-promoting or disease-preventing functions. In recent decades, a number of small knowledge-intensive firms have evolved within the food and related sectors, some of which have close contacts to R&D 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 that 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 had only sales departments in the region were excluded. After this selection process, the innovative core of the food industry was defined as being composed of 35 firms, of which 28 were interviewed (80 percent response rate). As in the case of life science, most of the companies were small and medium sized and based in the region with both headquarters and development and production units. The interviewees worked with both management and operative product and process development.

The moving media industry represents a new and growing niche in the regional economy. The growth of the industry took off at the beginning of the 21st century, after a period in which the traditional naval and heavy processing industry located in Malmö declined. In 2002, the large crane in the shipyard, a symbol of Malmö as an industrial city, was sold and transported to South Korea for future use in a motor vehicle factory. The regional authorities had the explicit ambition of creating 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 itself from the larger and more established Lund University with its core competences in science, engineering and management, the university college in Malmö decided to focus its development and educational activities on applied science and on 'creative' activities related to the arts, design and moving images (Henning et al., 2010). Around the same time, the regional authorities launched a cluster initiative with the aim of bringing

together and strengthening the media industry in the region. Moving media span a range of organizationally distinct, but functionally related, activities. Examples are film and TV production, digital arts and design, the development of computer games software and various graphical applications for computers, mobile phones and other hand-held devices (Martin and Moodysson, 2011). Because the majority of the firms working with moving media represent small and specialized niches of other more generic sectors (such as information and communication technologies, advertising and software development), 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 organization and through a manual selection process in which inactive firms and firms that had only sales departments were excluded, as were independent artists and interest organizations without real commercial activities. After this selection process, the moving media cluster was defined as being composed of 71 firms, most of them small and with fewer than 10 employees, although some were medium sized. Interviews with representatives of 37 of these companies were conducted (52 percent response rate).

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 in more detail the organizational and geographical patterns of knowledge sourcing and knowledge exchange. 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 in terms of the degree to which various types of knowledge are present, or, more accurately, in terms of 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, which 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 content involving artistic knowledge and design, often with the aim of improving the user experience and perception of a product. Although the analytical and synthetic challenge in principle could be out-sourced to advanced suppliers or subcontractors, the symbolic challenge constitutes the core competence of the moving media industry (Martin and Moodysson, 2011).

Empirical analysis: organizational and geographical patterns of knowledge sourcing

This section provides a comparative analysis of the organizational and geographical patterns of knowledge flows in the life science, food and moving media industries in Scania. Knowledge sourcing and exchange are 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.⁶ Mobility refers to the recruitment of skilled labour from other organizations and is associated with knowledge that is embodied in people.⁷ 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 organizational 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 of new knowledge. The most obvious primary sources are other actors in the innovation

Table 1. The relative importance of various sources for gathering market knowledge through monitoring

Source	Industry	Mean	SD	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
Specialized 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

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

system, such as universities, governmental agencies, other companies working with related and supportive activities (suppliers, consultants), firms with similar undertakings (competitors) or the users of the companies' products and services (customers). However, in this section attention is mainly paid to the acquisition of knowledge without direct interaction but through intermediaries carrying knowledge from these primary sources. Examples of intermediaries are scientific journals reporting results from basic research, surveys and questionnaires carried out and published by various business and support organizations, specialized magazines focusing on specific industries or technologies, and 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 particularly the moving media industry to rely primarily on knowledge sources with a lower degree of formalization, here reflected by business magazines, trade fairs and exhibitions.

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 (a mean value of 3.31) and surveys (3.31), representing more formalized sources of knowledge, whereas specialized magazines (2.83) and fairs and exhibitions (2.72) are considered to be less important. This observation is significantly different from the food and the moving media industries, where fairs and magazines representing knowledge sources with a lower degree of formalization are perceived as more important ('significance' in the following always means statistical significance at the 5 percent level (*t*-test)). In the food industry, scientific journals are almost unanimously considered to be of very little importance (1.86), whereas more importance is attributed to specialized magazines (3.07) and to 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 specialized magazines (3.19).

These results are fairly well in line with our theory-led expectations about the organizational 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 with context-specific knowledge and gossip 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 organizations, 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 in humans. Possible sources for the recruitment of skilled employees are other firms from the same or from a different industry, but also research and education organizations such as

Table 2. The relative importance of various sources for the recruitment of highly skilled labour

Source	Industry	Mean	SD	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

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

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 to be. Based on the preliminary theoretical considerations, we would expect firms in the life science industry to draw very much on graduates and experienced academics 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 a workforce with job experience in similar industries. Innovation in the moving media industry requires creativity and cultural understanding. These competences are expected to develop best through 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 (a mean value of 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 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 to be most important, followed by firms in other industries (2.93). The higher education sector is of little importance; both universities (2.11) and technical colleges (1.89) are considered to be hardly relevant. Whereas the first observation fits well 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 the 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 universities (2.94) too are to some extent considered to be relevant. This can be explained by the fact that some universities also operate in creative and artistic fields such as the arts, music and theatre, and that some activities in the moving media industry require a good general education, which is provided in classic subjects such as languages and humanities.

These observations are fairly well in line with our expectations about the organizational 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.

Knowledge sourcing through collaboration

A third fundamental mode for the acquisition of new knowledge is *collaboration*, for example, intentional knowledge exchange through direct interaction with other actors. This interaction can encompass knowledge about new developments or trends in the market as well as knowledge of a technological nature that is required as a direct input for a concrete innovation process. Based on the theoretical discussion

and the insights into 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 slightly 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 et al., 2010) and thus we would expect collaboration to take place predominantly at the regional and the national level. The moving media industry deals with knowledge that is valid within a specific, culturally defined context. Consequently, we would expect knowledge exchange to take place in networks between actors that share a similar sociocultural background and are predominantly located in spatial proximity.

In order to test these expectations, the firms were asked to indicate with whom they cooperate and exchange various types of knowledge (for example, knowledge about technologies or market opportunities), and where these exchange partners are located. The collected data were analysed by means of social network analysis, a technique for the study of relationships between actors that is increasingly applied in social science research (Wasserman and Faust, 1994; Knoke and Yang, 2008). Relationships between economic actors are commonly described in terms of networks, which are in this context understood as socioeconomic structures that connect people or firms to one another (Powell and Grodal, 2005). Recently, a number of studies in economic geography have applied social network analysis to the study of networks of knowledge and innovation (Cantner and Graf, 2006; Giuliani, 2007; Morrison, 2008; Morrison and Rabbellotti, 2009; Plum and Hassink, 2011), and some key issues related to this approach are outlined by Ter Wal and Boschma (2009). A network principally consists of nodes and linkages: nodes represent actors, while linkages (also called ties, edges or connections) represent different kinds of relationships. Networks can be knitted together by formal linkages, such as agreements or contracts between companies, and, likewise, networks can be based on informal linkages, for instance

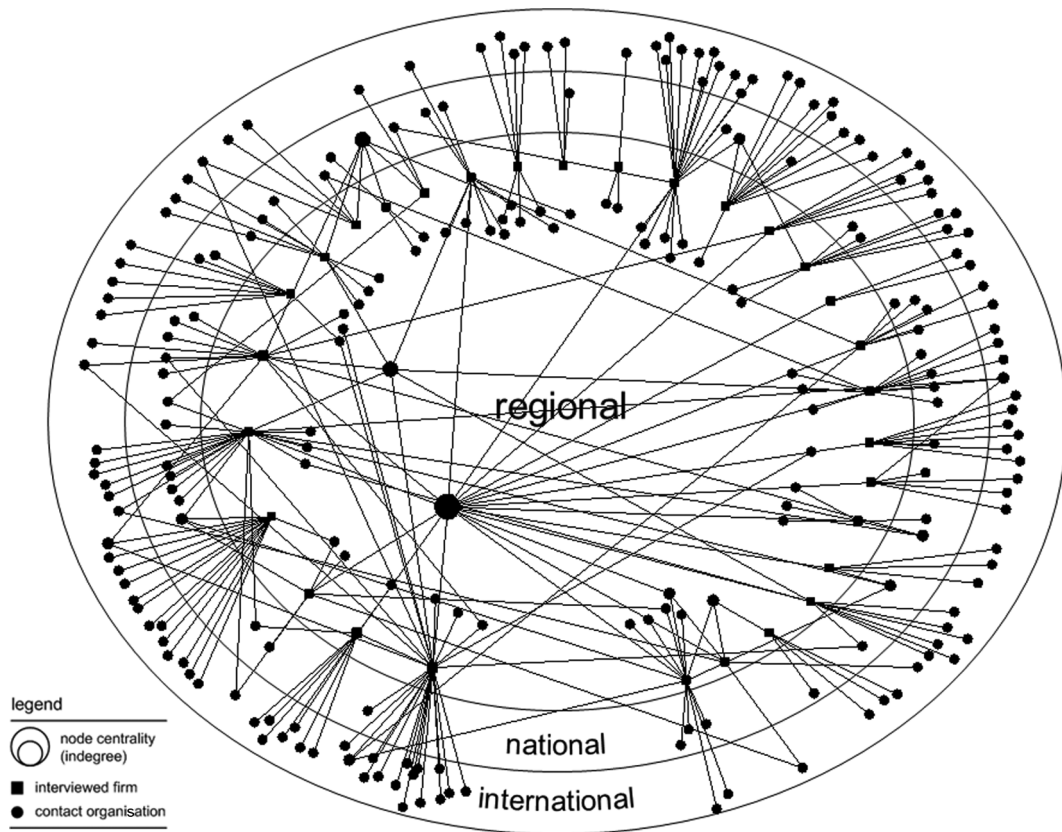


Figure 2. Knowledge sourcing through collaboration in the life science industry

Note: Nodes represent actors and links represent knowledge flows. The shape of the node indicates whether the actor is part of the interviewed group, the size of the node indicates the importance of the actor in the network (indegree centrality), the location of the node reflects the spatial dimension (regional, national and international).

Source: Author's own figure.

joint membership of a business association or, maybe even less formally, belonging to the same epistemic community or community of practice (Lave and Wenger, 1991). We captured a broad range of such linkages by asking the firms to point out all the organizations with which they were in contact and exchanged information related to their innovation activities. The results are illustrated here in the form of network graphs (Figures 2–4). The networks are composed of nodes representing actors (firms and other organizations) and linkages representing knowledge flows (bilateral exchange of knowledge). The shape of the node indicates whether the actor is part of the interviewed group, the size of the node indicates the importance of the actor in the network

(indegree centrality), the location of the node reflects the spatial dimension (regional, national or international) (see Krätke, 2011).

Figure 2 displays the network of collaboration in the life science industry. 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 science industry is not particularly dense, and only a few actors are mentioned several times as an important partner for cooperation. The actors that are most often mentioned are Lund

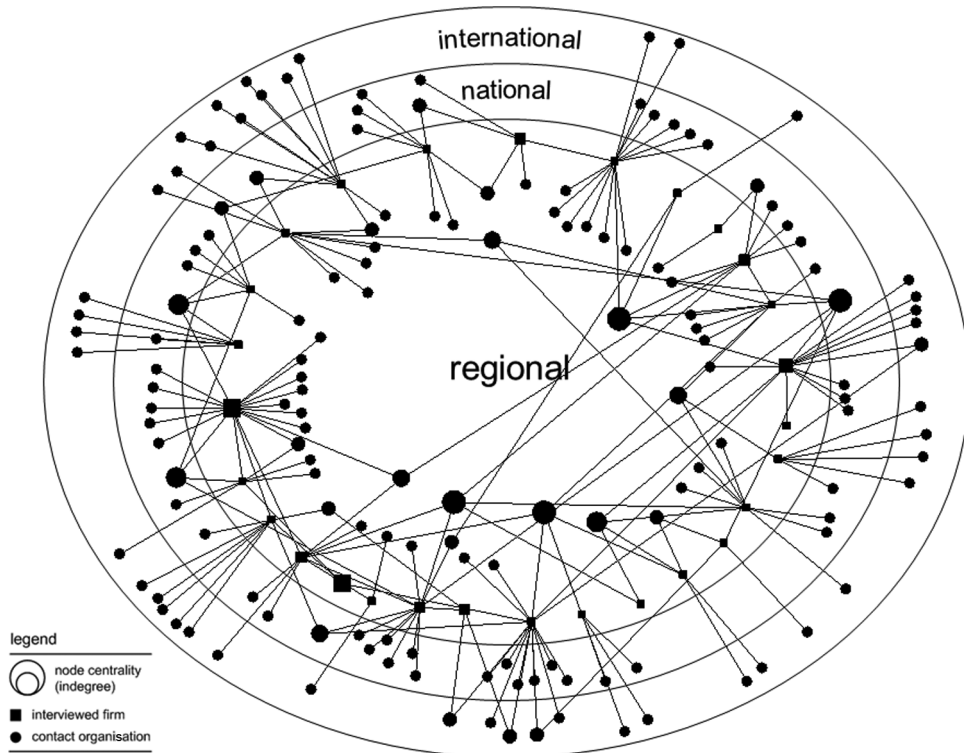


Figure 3. Knowledge sourcing through collaboration in the food industry
Source: Author's own figure.

University (17),⁸ followed by the University Hospital of Malmö (7) and Karolinska Institute (6), a large and renowned medical university in Stockholm. With regard to the spatial location of actors and exchange relations, it is obvious that contact partners are situated both inside and outside the region,⁹ while extra-regional cooperation is dominant. Of all 257 actors, 31.9 percent are situated in the region, 19.5 percent within the country and 48.6 percent outside the country. Of all 293 exchange relations, 29.4 percent occur between actors in the region, 23.9 percent with actors in other parts of the country and 46.8 percent are international. It appears that, although some collaboration takes place within the region, most knowledge flows occur at the international level.¹⁰

Figure 3 shows the knowledge network in the food industry. Compared with the life science industry, one can observe a smaller number of actors involved, but a denser network structure. Some actors are

frequently mentioned as relevant exchange partners, of which the foremost are the companies 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 foodstuffs located in Gothenburg. Overall, we count 178 nodes in the network, of which 44.4 percent are located in the region, 30.3 percent within the country and 35.3 percent in other parts of the world. Of all 204 exchange relations, 42.2 percent occur within the region, 33.3 percent within the country and 24.5 percent cross national borders. This shows that, compared with the life science industry, a smaller share of the exchange relations occur internationally, whereas national and regional exchange relations are more relevant.¹¹

Figure 4 displays patterns of knowledge sourcing through collaboration in the moving media industry. The principal actors that are mentioned often as

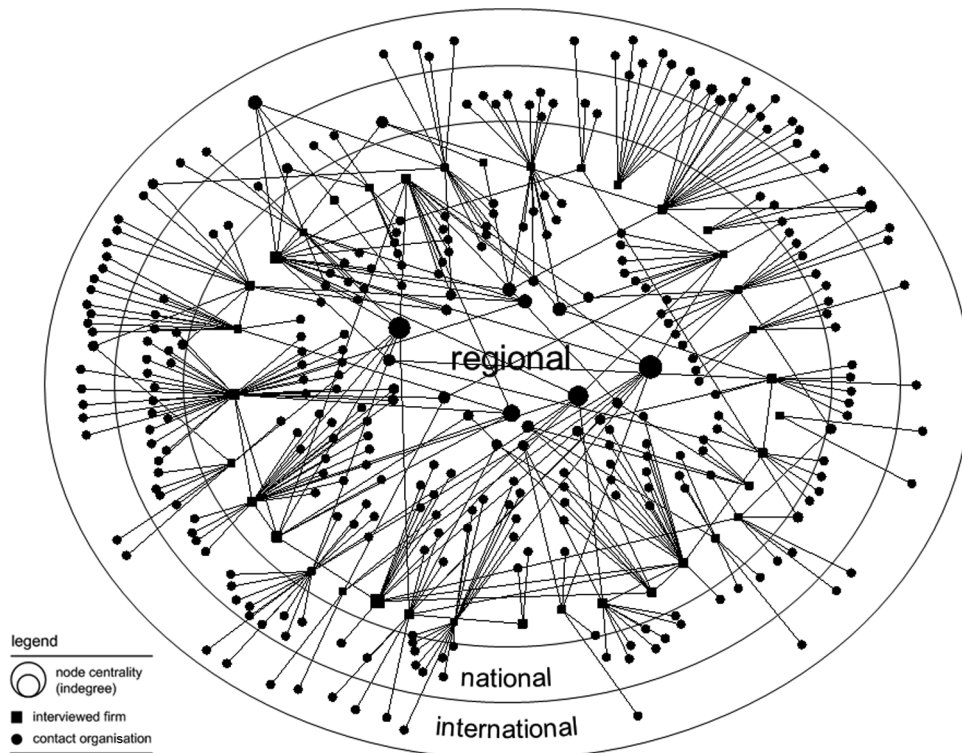


Figure 4. Knowledge sourcing through collaboration in the moving media industry
Source: Author's own figure.

important exchange partners are the Municipality of Malmö (9), the University College of Malmö (7) and Media Mötessplats 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 with the previous two networks, we observe a larger number of actors and exchange relations. Altogether, we count 349 nodes in the network, of which 51.9 percent are located within the region, a smaller share of 28.1 percent in other places in the country, and only 20.1 percent 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 percent occur within the region, 24.4 percent within the country and 20.7 percent cross national boundaries. We thus observe that, although national and international knowledge exchange is present, intraregional knowledge exchange is most prevalent,

which is well in line with the theory-led expectations about the context specificity of the knowledge dealt with in symbolic industries.

Conclusions

In this paper we have studied knowledge sourcing and exchange among different types of firms in the regional innovation system of Scania, southern Sweden. The aim was to examine how the geographical and organizational patterns of knowledge sourcing and knowledge exchange vary between industries drawing on different crucial knowledge bases. The 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 formalization. Based on the theoretical discussion, analytical industries were expected to deal with highly formalized

knowledge sources and to operate primarily on a global scale. Following the same reasoning, synthetic industries were expected to rely on knowledge sources with a lower degree of formalization, with global cooperation playing 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 the industries indeed differ considerably with regard to how various sources of 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 sourcing occurs principally in globally configured networks. The food industry retrieves new knowledge from less formalized 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 formalized sources such as fairs and magazines and recruit primarily from other firms in the same industry. Knowledge exchange takes place in highly localized networks.

These results point in the direction that, although proximity matters for innovation and knowledge exchange, 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 extent in synthetic industries, whereas analytical industries operate on a wider geographical scale. It is thus certainly true that innovation activities tend to cluster in certain locations (Feldman, 2000; Asheim and Gertler, 2005); however, the extent and driving force for co-location seem 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 organizations providing research, education and a skilled labour force. In addition to these localized sources of knowledge, firms maintain vital linkages to specialized knowledge providers situated in other parts of

the world. Strong linkages to foreign collaborators and other non-local sources of knowledge thus remain crucial for enabling innovation in analytical industries. In the case of synthetic industries, innovation is driven by cooperation and interactive learning within formally established networks between customers and suppliers, often at the national level, whereas local universities play a minor role. In order to bring new products and processes to the market, companies have to obey 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, because they build on cultural knowledge that is context specific and most easily understood by actors who share the same sociocultural background. Owing to the short-term and project-based organization of innovation activities, symbolic industries require easy access to a pool of possible cooperation partners, which is best provided in the local environment.

Thus, all three case studies presented in this paper contribute to nuancing our interpretation of the underlying preconditions for knowledge sourcing, knowledge exchange and knowledge spillovers between firms and related organizations beyond what is put forward in the existing literature, sometimes under headings such as 'buzz and pipelines' (Bathelt et al., 2004) or 'channels and conduits' (Owen-Smith and Powell, 2004). Furthermore, our empirical assessment confirms some of the core assumptions and elaborates on some of the central arguments put forward in previous, non-empirical, research on different modes of innovation and knowledge exchange. It brings us closer to a conclusion about under which conditions the local or the regional sphere matters most for exchanges of knowledge between firms and other organizations, and it contributes to filling some of the gaps identified in the literature. In particular it provides insights into how and why patterns of interaction and knowledge exchange vary between different types of economic activities and shows that the question of the role of geography for innovation and knowledge exchange ought to be addressed through multiple perspectives, one of which should be a knowledge base view.

Notes

1. 'Know-why' is similar to *episteme* and 'know-how' to *techne*, a distinction that refers back to Aristotle and is naturally made in other languages, for instance in French between *connaissance* and *savoir-faire* or in German between *Wissen* and *Können*.
2. Both codified and tacit forms of knowledge are critical for innovation in analytical industries. Because codified knowledge needs to be decoded and interpreted in order to become valuable, these two types should be seen not as substitutes but as complements to each other (Johnson et al., 2002).
3. Interviews were conducted between 2007 and 2010 in the framework of the European collaborative research project 'Constructing Regional Advantage (CRA)', funded through the EUROCORES programme by the Swedish Research Council and the European Science Foundation.
4. Circular reasoning (*petitio principii*), as described by Aristotle in *Prior Analytics II*, occurs when the conclusion of an argument is essentially the same as one of the premises in the argument, which can lead to one type of logical fallacy (Bunnin and Yu, 2004).
5. A desktop-based non-respondent analysis carried out for all three clusters revealed no systematic difference between responding and non-responding companies in terms of size, age and type of activities.
6. Malmberg and Maskell (2002) use the term 'monitoring' to refer to an intentional observation of competitors in the same industry. They argue that companies often have remarkably good knowledge of the undertakings of nearby firms even if they do not make any dedicated efforts at systematic monitoring.
7. The explanatory power of labour mobility is also emphasized in the literature on skill-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 (Boschma et al., 2009; Neffke and Henning, 2010).
8. Numbers in brackets indicate the number of links directed towards the node (indegree centrality).
9. The interviews were conducted in the administrative region of Scania, but linkages with firms in Copenhagen are considered to be intraregional, in order to account for the close connection and intensive commuting taking place between the two regions.
10. We found a highly significant difference in the absolute number of regional, national and international relations, and no systematic difference in the perceived importance of these relations.
11. The observed industry-specific difference in the number of regional, national and international linkages is statistically significant at the 1 percent level (chi-square test).

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