Knowledge Bases and the Geography of Innovation

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2012

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MEDDELANDEN FRÅN INSTITUTIONEN FÖR KULTURGEOGRAFI OCH EKONOMISK GEOGRAFI
AVHANDLINGAR V

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This study was made possible by generous financial support from:

Swedish Governmental Agency for Innovation Systems (VINNOVA)

Swedish Research Council (VR)

European Science Foundation (ESF)

Riksbankens Jubileumsfond (RJ)

Lund University

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CLIMATE COMPENSATED PAPER

ISBN 978-91-7473-374-7

Printed in Sweden by Media-Tryck, Lund University
Lund 2012

Abstract

Despite the ongoing globalisation of economic activities, innovation does not take place randomly distributed over space, but concentrates in certain locations. A central argument to explain the spatial concentration of innovation activities lies in the ability of geographical proximity to facilitate interactive learning and knowledge exchange, which in turn is seen as an important driver for regional growth and prosperity. Intensive knowledge sharing within the regional milieu is considered pivotal to continuous innovation, while at the same time, distant sources of knowledge are important for accessing new ideas and thoughts. When, why and in what respect local or non-local knowledge sourcing and exchange matters for innovation is a key question addressed in this dissertation. The thesis applies a regional innovation systems perspective where innovation is seen as the result of interactive learning processes involving various actors from industry, academia and governments, which collectively contribute to regional innovation and growth. Moreover, the thesis takes a broad-based view on innovation where innovation is seen as critical for all sectors of the economy, and not only for science and (high-) technology orientated activities. A distinction between industries is made with respect to the type of knowledge base that underlies innovation activities (i.e. analytical, synthetic and symbolic). When, why and in what respect the geography of innovation varies subject to industry specific difference in the knowledge base is a further key question addressed in this dissertation.

In order to account for the diversity of channels through which knowledge can be sourced and exchanged, particular attention is devoted to the notion of networks that connect firms and other organisations inside and outside the region, but also to other modes of knowledge transfer such as monitoring of collaborators and competitors, the mobility of knowledge embodied in skilled labour, and informal relations between individuals within knowledge communities. The dissertation reveals that the organisational and geographical scope of knowledge exchange is strongly (but not exclusively) shaped by the type of knowledge base that underlies innovation activities. The results point in the direction that symbolic industries, partly as a consequence of the context-dependency of cultural knowledge, are deeply embedded in localised knowledge networks, while knowledge exchange in synthetic industries is less locally organised and more governed by the national institutional framework. Analytical industries tend to rely less on localised sources of knowledge, and more on specialised knowledge providers in other parts of the world.

The research design is inspired by critical realist ontology, epistemology and methodology, and draws on a mix of qualitative and quantitative methods. The empirical focus lies on several regional industries (or clusters) in different parts of Europe, with the main attention on the new media, food and life science industries in Scania, southern Sweden.

The dissertation consists of five articles that are published or forthcoming in peer-reviewed journals, preceded by an opening part which outlines the theoretical and methodological background framing the individual articles.

Keywords: economic geography, regional innovation systems, learning regions, differentiated knowledge bases, knowledge networks, social network analysis, Scania, Sweden

Acknowledgements

What applies to innovation also holds for a dissertation: new ideas do not emerge in complete isolation, but result from interactive learning processes involving many individuals. In the course of writing, I have greatly benefited from discussions with colleagues at CIRCLE and the Department of Human Geography, Lund University, as well as with scholars from other research communities and universities. Discussions at conferences, workshops, seminars and PhD courses have been pivotal to the ideas developed in this thesis. I cannot make a comprehensive list of all persons who influenced my work through their own writings or through helpful comments on my work, as I would risk forgetting somebody who deserves to be acknowledged. I will thus focus on those who have been of immediate importance for the writing process, and without whom this dissertation would never have been completed:

- My supervisors Bjørn Asheim and Jerker Moodysson, who were far beyond any expectations. Bjørn has been extremely generous in all respects, not only in providing the intellectual basis for my research, but also in sharing his networks, enabling my participation at conferences and workshops, and introducing me to 'the good life' as researcher. Jerker has been exceptional as supervisor, co-author, constructive reviewer and discussion partner. Working with him has been extremely smooth and efficient, and none of my papers would be published today without his reliable and encouraging support.

- Michaela Trippl and Martin Henning, who made excellent jobs as discussants at my final and half-way PhD seminar. Their constructive critique helped me to better embed my work in a wider economic geography discourse.

- All those who contributed to the open, friendly and stimulating working environment at CIRCLE. By creating this exceptional research milieu, everyone at CIRCLE has made his/her own contribution to my thesis.

- The Institute of Economic and Cultural Geography in Hanover and the Fraunhofer ISI in Karlsruhe, in particular Knut Koschatzky, who triggered my interest for economic geography and innovation studies.

- All those who balanced my work time with leisure activities. Thanks in particular to Iskra and the THEP running team, the CIRCLE cycling team and everyone involved in the Swedish Dinners. Acknowledgements also to my family for their emotional and intellectual support, and for accepting my rare visits to Germany.

- And to finish, a personal tribute to the most important person: Hanna, you are wonderful!

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List of publications

This dissertation includes the following five published or forthcoming articles:

I. Martin, Roman. 2012. Measuring Knowledge Bases in Swedish Regions. *European Planning Studies.* Published online on Aug 02, 2012.

II. Martin, Roman and Jerker Moodysson. 2011. Innovation in Symbolic Industries: The Geography and Organization of Knowledge Sourcing. *European Planning Studies* 19 (7):1183-1203.

III. Martin, Roman and Jerker Moodysson. 2011. Comparing Knowledge Bases: On the Geography and Organization of Knowledge Sourcing in the Regional Innovation System of Scania, Sweden. *European Urban and Regional Studies.* Published online on Dec 22, 2011.

IV. Martin, Roman, Jerker Moodysson and Elena Zukauskaite. 2011. Regional Innovation Policy Beyond 'Best Practice': Lessons from Sweden. *Journal of the Knowledge Economy* 2 (4):550-568.

V. Martin, Roman. 2012. Differentiated Knowledge Bases and the Nature of Innovation Networks. *European Planning Studies.* Accepted for publication on Aug 6, 2012.

List of acronyms

CRA	Constructing regional advantage
DUI	Doing, using and interacting
ICT	Information and communications technology
LQ	Location quotient
R&D	Research and development
RIS	Regional innovation system
SCB	Statistics Sweden (Statistiska centralbyrån)
SNA	Social networks analysis
STI	Science, technology and innovation

1. Introduction

The geography of innovation and knowledge creation is a dynamic research field in contemporary economic geography. Studies on the geography of innovation build on a research tradition ranging from Marshall's (1920) early work on industrial districts to the more recent work on industrial districts (Brusco 1986; Becattini 1989; Bellandi 1989), innovative milieus (Aydalot 1986; Camagni 1991; Maillat et al. 1995), learning regions (Asheim 1996; Morgan 1997; Hassink 2001) and regional innovation systems (RIS) (Cooke, Uranga and Etxebarria 1998; Cooke, Heidenreich and Braczyk 2004; Asheim and Gertler 2005). In this stream of literature, innovation is largely understood as an outcome of interactive, non-linear processes, emanating from collaboration among various actors in industry, academia and governments (Kline and Rosenberg 1986; Edquist 2005). These interactions do not take place randomly distributed over the geographical landscape, but tend to concentrate in certain locations and occur within predominantly, however not exclusively, localised networks of knowledge (Camagni 1991; Cooke and Morgan 1993). When, why and in what respect localised or non-localised knowledge exchange matters for innovation is one of the central issues addressed in this dissertation. There is a gap in the literature with regard to how these 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 activities taking place in different types of industries. There is a growing awareness that innovation is pivotal not only to industries that traditionally have been referred to as science and (high-) technology orientated, but for all sectors of the economy (Robertson, Smith and Tunzelmann 2009; Trippl 2011). Yet, there has been a tendency to primarily study innovation in research and development (R&D) intensive sectors, while our understanding of knowledge creation in industries that build on other forms of innovation is still limited. When, in what respect and why interaction and knowledge exchange differs between industries is another core question addressed in this dissertation. Since knowledge is at the heart of every innovation process, a logical way to differentiate between industries is by the nature of knowledge that is important for innovation. To explain how the geography of innovation is shaped by the knowledge characteristics of an industry, a distinction can be made between three types of knowledge base; namely, analytical, synthetic and symbolic (Laestadius 1998; Asheim and Gertler 2005; Asheim, Coenen and Vang 2007; Asheim, Boschma and Cooke 2011). These knowledge bases differ in various respects such as the dominance of tacit and codified knowledge content, the degree of formalisation in innovation processes, and the context specificity of the generated knowledge. This dissertation aims at enhancing our understanding of how the geography of innovation and knowledge exchange varies subject to industry specific differences in the knowledge base.

1.1. Structure of the thesis

The core of the dissertation consists of five articles that are published or forthcoming in different peer-reviewed journals. These five papers are preceded by an opening part, the so-called 'kappa', which outlines the theoretical and methodological background and frames the individual articles.

The opening part is organised as follows. This first introductory chapter outlines the structure of the dissertation, elaborates on the aim and research questions addressed in the thesis[1], and summarises how these aims and questions are dealt with in the individual articles. The second chapter describes the theoretical background of the dissertation and defines some of the key concepts recurring throughout the articles, such as innovation systems, interactive learning, territorial learning, knowledge networks, and knowledge bases. The third chapter describes the research design and in particular the ontological, epistemological and methodological background, as well at the methods that have been applied in the dissertation. The fourth and final chapter provides a summary of the findings and the contribution made by this dissertation, and elaborates on some key issues for further research on differentiated knowledge bases and the geography of innovation.

The five articles have been written during a period of three years (between year 2009 and 2012). They are listed in the consecutive order in which they were written, which at the same time reflects the learning path of the author. The first article introduces the notion of differentiated knowledge bases and addresses the problem of how to quantitatively operationalise the concept. The empirical analysis provides a first impression of the variety of regional knowledge specialisations in Sweden. While most regions have a particular strength in one single knowledge base, all three knowledge bases are strongly present in Scania, the southernmost county of Sweden, which motivates a closer look at that particular region in the subsequent articles. The second article deals with the geography of innovation and knowledge sourcing in symbolic industries, empirically focusing on the new media industry in Scania. The results point towards a dominant role of the local milieu as locus for knowledge sourcing in symbolic industries. The third article builds on the ideas developed in the previous paper, but, rather than looking in depth at one single industry, it compares three regional industries with different knowledge bases, yet located within the same

[1] The terms 'dissertation' and 'thesis' are used synonymously in this dissertation/thesis.

regional innovation system. The results disclose significant differences in the geography and organisation of knowledge sourcing between analytical, synthetic and symbolic industries. These industry specific differences ought to be taken into account when designing regional innovation policies, which is the key argument in the fourth article. In the case of Scania, the existing policy initiatives seem to be insufficiently fine-tuned to the differentiated needs and demands of firms that result from knowledge base characteristics of the industry. The fifth and last article builds on the notion of networks applied in the previous articles, and develops an argument on the differentiated nature of knowledge networks in analytical, synthetic and symbolic industries. The empirical analysis encompasses several industries in different European regions, and reveals that knowledge networks of industries with different knowledge bases can vary considerably along several dimensions.

1.2. Aim and contribution of the thesis

In economic geography and innovation studies, there is an increasing agreement that innovation is a fundamentally localised practice and that the regional context plays a critical role for innovation and knowledge exchange (Moulaert and Sekia 2003; Asheim and Gertler 2005). The central argument for the role of the region is that the spatial and functional integration of innovation activities generates positive effects which co-located firms can benefit from. These geographically and functionally defined beneficial effects are often referred to as 'agglomeration economies', or likewise, as spatially constraint external economies of scale and scope (Malmberg 1996; Parr 2002). Agglomeration economies are considered as external to the firm, as they are beyond the control of the individual firm and result from the presence and collective action of other firms in the region. Agglomeration economies can arise from co-location of firms in the same industry (i.e. localisation economies) or in different industries (i.e. urbanisation economies). The idea behind the first is that co-located firms that are engaged in similar activities can minimise the social and economic costs for communication, which stimulates knowledge spillovers of the MAR-type (Marshall 1920; Arrow 1962b; Romer 1986). The idea behind the latter is that important sources of knowledge are external to the industry in which a firm operates, and that knowledge flows across industries, that is, knowledge spillovers of the Jacobs-type (Jacobs 1969), are most stimulating for innovation. Transcending the MAR- versus Jacobs spillover dichotomy, the literature on related variety suggests that sectorial diversity is important, though knowledge can spill over most effectively if a certain degree of similarity exists between sectors. The probability and the effect of knowledge spillovers is determined by the extent to which the variety of sectors in a region is related, as firms with different but related activities can benefit more from knowledge exchange than firms with unrelated activities (Frenken, Van Oort and

Verburg 2007; Boschma and Iammarino 2009; Henning 2009; Neffke 2009; Neffke, Henning and Boschma 2011).

This discussion shows that the range of benefits from co-location goes beyond cost-savings from shared infrastructure and access to spatially constrained resources, as it was emphasised in traditional location theory (e.g. Weber 1909; von Thünen 1910; Smith 1981). Rather, it also embraces various indirect benefits stemming from intangible 'untraded interdependencies' (Storper 1995, 1997) and 'localised capabilities' (Maskell and Malmberg 1999). Today, agglomeration economies are less regarded as efficiency gains and cost reductions from localised input-output relations, and more as the ability to upgrade knowledge and innovation capacity in the regional environment. These kinds of benefits are often rather subtle and of a socio-cultural and institutional nature. One key to explaining spatial clustering of economic activities is the possibility of co-location to facilitate innovation though interactive learning (Malmberg 1996; Malmberg and Maskell 2002). The central argument in the literature on regional innovation systems is that innovation is fundamentally embedded in a social, institutional and geographical context, and that it is critical to look at factors that indirectly affect the performance of firms, such as mutual trust and knowledge sharing between various actors in the local milieu (Asheim 2000; Asheim and Gertler 2005). This understanding of innovation as a socially and territorially defined process goes back to Marshall (1920), who stressed the role of the industrial atmosphere that facilitates the generation and transfer of skills and competencies in industrial districts (Brusco 1986; Becattini 1989; Asheim 2000). The influence of the socio-cultural environment on economic outcomes is also emphasised in the social capital literature (Bourdieu 1980; Coleman 1988; Putnam, Leonardi and Nanetti 1993), which emphasises the value of "networks and the associated norms of reciprocity" (Putnam 2001, 41). The region is seen as an important arena for the emergence of social relationships, common language, norms and values, which facilitate communication and add to the process of interactive learning. Such a view on innovation as socially and territorially embedded processes calls for research on regional systems as loci for innovation.

Notwithstanding its importance, the region is not the only scale that should be taken into account when studying the geography of innovation, as regions are always embedded in a wider geographical context. In the literature on regional innovation systems, there is a tendency to focus on knowledge exchange and interactive learning inside the boundaries of the region, and to highlight the role of (spatial) proximity for innovation (Cooke, Heidenreich and Braczyk 2004; Asheim and Gertler 2005). Some authors in related disciplines, in contrast, claim that in light of ongoing globalisation and the accompanying time-space compression, geography is losing importance and innovation becoming an increasingly globalised phenomenon (Ohmae 1990;

Friedman 2005). Scholars studying globalisation of innovation find that firms are increasingly embedded in global networks, and that these networks involve not only large multinational companies in industrialised countries, but companies with diverse levels of competencies in various places in the world (Chaminade and Vang 2008; Barnard and Chaminade 2011; Chaminade 2011). The role of geography in a globalising economy is subject to continuous debates that sometimes lead to conflicting arguments on the relevance or irrelevance of the local milieu. As one fundamental conceptual binary in human geography, 'local versus global' is often seen as contradictory (Cloke and Johnston 2005; Cox 2005). This seeming contradiction is also reflected in the debate on codified knowledge that is easily transferable over geographical distance and tacit knowledge that is spatially sticky and bound to a specific spatial context (Polanyi 1967; Gertler 2003). However, in line with the observation that innovation always involves both tacit and codified knowledge (Nonaka, Toyama and Konno 2000; Johnson, Lorenz and Lundvall 2002), innovation can depend equally well on a combination of local and global sources of knowledge. In order to account for the role of local and global knowledge linkages, some authors argue that regional prosperity relies on a combination of more or less unintentional knowledge exchange in the local milieu, and the intentional creation of global communication channels to selected knowledge providers in other parts of the world (i.e. buzz and pipelines) (Bathelt, Malmberg and Maskell 2004). Other scholars stress that firms can access knowledge through diverse communication channels, and that neither the exchange of tacit, nor the exchange of codified knowledge is restricted to a specific geographical scale (Asheim and Isaksen 2002; Moodysson 2008; Trippl, Tödtling and Lengauer 2009). The tension between the role of local and non-local knowledge exchange is an ongoing debate in economic geography, and a central issue addressed in this dissertation.

Hence, this dissertation aims at *nuancing our understanding of when, why and in what respect local or non-local knowledge sourcing and exchange matters for innovation.*

With the aim to better understand the role of geography for innovation, there is a need to reflect upon how knowledge exchange can vary between different territorial and functional settings. In the literature on regional innovation systems, great attention has been devoted to varieties of RIS, that is, the relationship between the production structure and the institutional set-up in a region. The resulting studies on different types of RIS (e.g. territorially embedded RIS, regionally networked innovation systems and regionalised national innovation systems) have advanced our understanding of regional and institutional variations in the geography of innovation (Isaksen 2001; Cooke, Heidenreich and Braczyk 2004; Asheim and Gertler 2005; Tödtling and Trippl 2005; Asheim 2007). In contrast to the rich work on regional variation, relatively little attention has so far been paid to industry specific differences in the geography of innovation. The existing literature on (regional) innovation deals mostly with R&D intensive and technology orientated sectors such as biotechnology or information and communications technology (ICT) (e.g. Sternberg 1998; Cooke 2002; Gertler and Levitte 2005; Coenen et al. 2006; van Egeraat and Curran 2012), whereas our understanding of knowledge creation in industries that are less R&D intensive is still limited. While the main attention by researchers and policy makers is typically devoted to high-technology industries, there is a tendency to understate the importance of medium- and low-technology industries, despite the fact that these sectors dominate the economy in terms of employment and that their contribution to aggregated growth outweighs that of R&D intensive fields (Robertson, Smith and Tunzelmann 2009; Hansen and Winther 2011). And yet, there is increasing awareness that innovation is an essential driver for all sectors of the economy (Boschma and Iammarino 2009; Asheim, Moodysson and Tödtling 2011; Trippl 2011). Medium- and low-technology industries are equally driven by continuous innovation, but build on other modes of innovation than high-tech industries. They rely less on a science and technology (STI) mode of innovation that is characterised by the production and use of codified scientific and technical knowledge, and more on a doing, using and interacting (DUI) mode that is based on informal processes of learning and experience-based know-how (Jensen et al. 2007). In order to advance our understanding of the role of geography for innovation, it is necessary to take a broad-based view on innovation and to study a wider range of industries and their specific patterns of innovation. This holds not exclusively, but especially for the European context in which this dissertation is placed. The literature on varieties of capitalism argues that coordinated market economies such as the Nordic Countries and Germany have a competitive advantage in complex and engineering-based production systems, while liberal market economies in the Anglo-American context are most competitive in activities characterised by science-based innovation (Soskice 1999; Hall and Soskice 2001). It remains questionable whether the results from research on STI based industries are equally valid for all sectors of the economy, or whether there exist inherent industry specific differences in the geography of innovation. Consequently, there is a need to advance the research agenda towards sectorial specificities in the geography of innovation.

One possible way of addressing these inherent industry specific differences is by reference to the knowledge dynamics that underlie innovation activities. Only recently, scholars in economic geography and innovation studies began to differentiate between industries based on the type of knowledge that is critical for innovation (e.g. Laestadius 1998; Coenen 2006; Moodysson 2007; Gertler 2008; Asheim and Hansen 2009; Asheim, Boschma and Cooke 2011). They argue that despite the general trend towards increased complexity and the dynamic interplay of actors and institutions on various spatial levels, "the innovation process of firms is also strongly shaped by their *specific* knowledge base, which tends to vary systematically by industrial sector" (Asheim and Gertler 2005, 295, emphasis in the original). By referring to the underlying knowledge base, they provide an alternative to industry taxonomies that are based on product categories (e.g. standard industry classification systems) or R&D intensities (e.g. low-, medium-, high-technology scheme). Three types of knowledge bases can be distinguished; namely, analytical, synthetic and symbolic, that differ in various respects such as the rationale for knowledge creation, the development and use of knowledge, the actors and types of knowledge involved and the role of spatial proximity in the innovation process (Asheim, Boschma and Cooke 2011). Innovation in analytical (also called 'science-based') industries aims at the development of new knowledge about natural systems by applying scientific laws. In these industries, scientific knowledge and models play an important role, and the main logic of reasoning is deduction. Innovation involves strongly codified and universally valid knowledge content, which is often exchanged between research units and is little restricted to a specific socio-cultural context. Synthetic (also called 'engineering-based') industries innovate by applying existing knowledge in new ways. Innovation takes the form of concrete problem solving and interactive learning with customers and suppliers, and follows an inductive logic of reasoning. The knowledge dealt with is partially codified, but involves a stronger tacit component. Innovation in symbolic (also called 'art-based') industries aims at the creation of meaning, desire and aesthetic assets and is a creative process often taking place in studios and small project teams. Interpretation and cultural knowledge is pivotal and is to a high degree determined by the socio-cultural context (Asheim 2007; Moodysson 2007; Asheim and Hansen 2009). This thesis builds on the knowledge base classification in order to reveal industry specific differences in the geography of innovation.

Hence, this dissertation aims at *nuancing our understanding of when, why and in what respect the geography of innovation varies subject to industry specific difference in the knowledge base*.

The thesis contributes to the emerging body of literature evolving around the notion of knowledge bases, by focusing on industry specific differences in the geography of innovation. The conceptual distinction between analytical, synthetic and symbolic knowledge bases has been brought forward only recently, and even though there are a growing number of studies on knowledge bases, there is still a lack of systematic empirical work. The existing literature on knowledge bases is either of a purely conceptual nature or grounded on in-depth case studies (e.g. Asheim and Coenen 2005; Asheim and Gertler 2005; Gertler 2008; Moodysson, Coenen and Asheim 2008), while relatively little effort has so far been made to scrutinise the concept in a more systematic manner, involving both intensive and extensive research methods.

Accordingly, one intention of this thesis is to empirically ground some of the arguments made in the existing literature on knowledge bases. In order to improve the applicability of the concept for empirical research and with the intention to facilitate further empirically informed research, an analytical scheme for identifying knowledge bases is developed in the thesis (article I). In addition, the dissertation intends to conceptually advance the knowledge base discussion, especially with regard to the notion of innovation networks. So far, the role and nature of innovation networks has not been taken up and theorised in the knowledge base literature, even though networks are generally regarded as important devices in the regional innovation systems literature. Likewise, the literature on innovation networks is missing an explanation on when, why and in what respect networks differ between industries. The knowledge base distinction provides a conceptual basis for explaining sectorial and geographical patterns of innovation networks (article II, III and V). Finally, with the intention to demonstrate the applicability of the concept in a policy context, the thesis discusses the option to derive recommendations for fine-tuned regional innovation policy from the knowledge base distinction (article IV).

1.3. Overview of the articles

This paragraph outlines the main outcomes of the articles included in the dissertation and explains how they deal with the aims formulated above.

The first article, *Measuring Knowledge Bases in Swedish Regions*, published in European Planning Studies (Martin 2012a), is triggered by the observation that the existing work on differentiated knowledge bases is largely grounded on in-depth case studies, while little effort has been done until now to operationalise and apply the concept in a more systematic manner. In order to facilitate extensive empirical research on knowledge bases, there is a need to approach the concept by means of quantitative measures. The method suggested in this article is to use occupation data in association with location quotient analysis, in order to evaluate whether a regional economy has a particular strength in one (or more) knowledge base(s). The empirical analysis focuses on the county level in Sweden and reveals that most regions have a particular strength in either analytical, or synthetic, or symbolic knowledge, while few regions are dominated by more than one knowledge base. The result for Scania, where all three knowledge bases are strongly present, motivates a closer look at that region in the subsequent articles.

The second article, *Innovation in Symbolic Industries: The Geography and Organization of Knowledge Sourcing*, published in European Planning Studies (Martin and Moodysson 2011a), deals with spatial and organisational patterns of knowledge flows in the new media (also called moving media) industry in Scania, an industry that is characterised by a symbolic knowledge base. The paper addresses the question of local versus non-local as a major arena for knowledge sourcing and exchange, and examines the organisational patterns of knowledge sourcing with specific attention paid to the nature of the knowledge. It is argued that innovating companies can access new knowledge through various channels, such as indirect monitoring of other organisations and their activities, labour mobility and the acquisition of knowledge embodied in key personnel, as well as direct collaboration and knowledge exchange with suppliers, customers and related organisations. These different modes for acquiring new knowledge have particular geographical and organisational characteristics, which is empirically investigated and illustrated in the paper. By stressing the importance of diverse knowledge channels and their geographical specificities, the article contributes to transcending the binary argument on the role of local versus non-local knowledge exchange which tends to dominate the literature.

The third article, *Comparing Knowledge Bases: On the Geography and Organization of Knowledge Sourcing in the Regional Innovation System of Scania, Sweden*, published in European Urban and Regional Studies (Martin and Moodysson 2011b), builds upon the ideas established in the previous paper, and develops the arguments further by taking a comparative perspective on the geography and organisation of knowledge sourcing. The article deals with the functional and spatial organisation of knowledge interdependencies among firms and other actors and how these vary between industries that are part of the same regional innovation system, but rely on different types of knowledge base. Empirically, the article is based on case study research on three industries located in Scania; namely, life science as an example of an analytical industry, the food industry encompassing many synthetic activities and new media as an example of a symbolic industry. The analysis reveals significant industry specific differences in the importance of knowledge sourcing activities at different geographical levels and with different degrees of formalisation. The article contributes to advancing our understanding of industry specific differences in the geography and organisation of innovation, and the role of knowledge bases in explaining them.

The fourth article, *Regional Innovation Policy Beyond 'Best Practice': Lessons from Sweden*, published in Journal of the Knowledge Economy (Martin, Moodysson and Zukauskaite 2011), deals with the possibility of fine-tuning regional innovation policies in view of the differentiated knowledge base concept. The preceding two articles have revealed significant industry specific differences in the geography and organisation of knowledge sourcing, and in correspondence with these findings, industries are also expected to vary with regard to how policy measures aiming to support innovation are perceived and acquired. Empirically, the article draws on case study research on three regional industries (i.e. life science, food and new media in Scania; see also article II and III) and the regional policy support programmes targeting these industries. The findings reveal that the existing policy initiatives are customised on a rather generic level and not sufficiently attuned to the needs and demands of the respective companies. Policy makers are recommended to take the characteristics of the industrial knowledge base into account, in order to provide the support that applies to the needs of the target industry. The article contributes to advancing our understanding of industry specific differences in the geography of innovation and their importance for fine-tuning regional innovation policies.

The fifth article, *Differentiated Knowledge Bases and the Nature of Innovation Networks*, forthcoming in *European Planning Studies* (Martin 2012b), returns to the notion of networks dealt with in the preceding papers (article II and III), and takes a close look at the differentiated nature of knowledge networks. It builds on social capital and network theory in order to disclose industry specific differences concerning the nature of networks. It is argued that knowledge networks differ along structural, relational and geographical dimensions, and that these differences are shaped by the specific knowledge base of the industry. The empirical analysis is based on social network analysis in association with data about patterns of cooperation and knowledge exchange in a number of industries located in different European regions. The findings suggest that there are indeed strong industry specific differences in the structural, relational and geographical nature of networks, and that the industrial knowledge base is one (but not the only) factor that can explain those differences. The article contributes to overcoming the local versus global dichotomy by stressing the diversity of network dimensions that plays a role in studying the geography of innovation.

2. Theoretical background

This chapter outlines the main theoretical ideas that guided the research in this dissertation. In preference to a comprehensive discussion on the differentiated knowledge bases concept which is subsequently provided in the individual articles, this chapter elaborates on the overarching theoretical background, that is, innovation from a systemic perspective, innovation as an interactive learning process, spatial implications of learning, the notion of networks and knowledge bases as a generic approach to classify industries.

2.1. Innovation from a systemic perspective

To begin with, it is necessary to discuss the meaning of innovation and the notions directly associated with it. The term 'innovation' refers to set of realised ideas, including economic, technological, political, cultural and societal novelties. In a definition stemming from Schumpeter (1911), an innovation is an advancement over competitors that generates economic revenues, so-called 'returns on innovation'. Innovation goes beyond invention, which is the first occurrence of an idea for a new product or process, whereas innovation is the first attempt to bring an invention into practice (Fagerberg 2005). Innovation can occur, for instance, in the form of the introduction of a new or the modification of an existing product, the opening of a new market or a change in the industrial organisation (Grupp 1998). Innovations can be differentiated with regard to their subject area, by dividing into product and process innovations. Product innovation is the development of a new or the improvement of an existing product, whereas process innovation is the development of a new or improved production method. Considering the magnitude of change, one can differentiate between incremental and radical innovations. An incremental innovation is a further development of an existing product or process, whereas a radical innovation describes the emergence of an entirely new product or process (Koschatzky 2001). A further distinction can be made as regards the context in which a novelty is implemented. If an innovation is introduced initially in one specific context, the same idea can be introduced later in a very different context. It is then considered as imitation, or, giving consideration to the novel context, as yet another innovation (Fagerberg 2005).

During the last three decades, innovation research has experienced a move towards a systemic understanding of innovation, which is reflected in a growing literature on *systems of innovation* (Lundvall 1992; Edquist 1997b; Braczyk, Cooke and Heidenreich 1998). Several variations of the innovation systems approach have been established over time, either taking geographical boundaries or specific technologies or sectors as their point of departure. Initialised by Freeman's (1987) study on the national economy of Japan, the emphasis was in the beginning first and foremost on the national context, which led to the development of the national innovation systems approach (Lundvall 1992; Nelson 1993; Edquist 1997a). Triggered by research in economic geography, increasing attention was soon also paid to subnational framework conditions for innovation, resulting in a growing literature on regional innovation systems (Cooke 1992; Asheim and Isaksen 1997; Braczyk, Cooke and Heidenreich 1998). Taking technological or sectorial specificities into account, however lacking an explicit geographical angle, the concepts of technological innovation systems and sectorial innovation systems started to become prominent around the same time (Carlsson and Stankiewicz 1991; Breschi and Malerba 1997).

These concepts have in common that innovation is neither understood as the result of a single entrepreneur's decision, as underlying Schumpeter's (1911) early work in which innovators were considered as risk-taking individuals seeking short-run monopoly gains over competitors. Nor is innovation understood as a linear sequence from invention to innovation and diffusion, or as a causal chain beginning with R&D and ultimately leading to productivity growth, as assumed by neo-classical economists (Edquist 1997b; Godin 2006). Instead, innovation is seen as result of interactive learning processes between actors in- and outside companies, and as dependent on relations between firms and their external environment (Edquist 2005; Fagerberg 2005).[2] Innovation activities are influenced by the external environment in several ways. Companies cooperate with other actors in order to access new knowledge and other resources required for innovation. Potential cooperation partners are other firms (i.e. customers, suppliers, competitors and service providers), but also universities and research institutes providing education and basic research, as well as governmental agencies proving various forms of policy support. Moreover, the innovation behaviour of firms is determined by the institutional framework, understood as the formal legal rules and the informal social norms that govern individual behaviour and social interactions (North 1990; Gertler 2010). Innovation is thus seen as the result of interaction between firms and other actors, governed by a mutual institutional framework. The institutional framework is defined and shaped by the geographical setting, which is the core argument in the RIS literature (Cooke, Uranga and Etxebarria 1998; Cooke, Heidenreich and Braczyk 2004; Asheim and Gertler 2005).

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[2] In a similar vein, the term 'open innovation' has recently become prominent to refer to the idea "that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology" (Chesbrough 2007, xxiv).

A RIS is often described as two subsystems that are engaged in interactive learning: first, the knowledge application and exploitation subsystem, which is the regional production structure and consists of firms that are engaged into vertical and horizontal collaboration, and second, the knowledge generation and diffusion subsystem, which is the supportive infrastructure of public and private organisations providing research and education, as well as technology and workforce mediating organisations (Autio 1998; Cooke 2002). The systemic character arises from the interconnection of actors within and between the two subsystems and with actors outside the system. Obviously, relations within the regional environment play an important role, however not all interactions are regionally configured, and exchange relations may also cross regional and national boundaries (Asheim and Isaksen 2002; Chaminade and Vang 2008; Trippl, Tödtling and Lengauer 2009). The conceptualisation of regions can be manifold. In this thesis, it is usually understood as a functional region corresponding to an area between the local and the national level that is connected through daily commuting and business-to-business relationships (Aoyama, Murphy and Hanson 2011). Since the RIS concept has a strong policy orientation, the notion of regions is usually applied to administrative units with a certain degree of political autonomy and the competence to design their own innovation strategies (Cooke, Uranga and Etxebarria 1998; Cooke 2002).

2.2. Innovation as an interactive learning process

In view of the ongoing development towards a knowledge-based economy in which knowledge is the most important factor of production, it is logical to study the process through which new knowledge is created. With this perspective in mind, different forms of *learning* are discussed in particularly in the literature on the learning economy (Lundvall 1992; Lundvall and Johnson 1994) and the learning region (Asheim 1996; Morgan 1997; Hassink 2001). Along this line of thought, the ability to engage in continuous learning and forgetting is seen as critical for innovation.

Different modes of learning play a role in the process of knowledge creation. A distinction is typically made between three interrelated ways; namely, learning-by-doing, learning-by-using and learning-by-interacting (Arrow 1962a; Rosenberg 1982; Lundvall 1988). The first was brought forward by Arrow (1962a) who argued that learning is a result of practical experience and takes place by resolving concrete problems. His argument was, amongst others, inspired by the so-called 'Horndal effect', referring to a Swedish steel company in which the annual output per worker increased steadily, in spite of the fact that no major investments in equipment were undertaken. The observed productivity gain could only be explained by the accumulation of experience through learning-by-doing (Lundberg 1961; Arrow 1962a; David 1973). Later, Rosenberg (1982) developed the idea of learning-by-using to account for the fact that learning occurs not only during the course of production, but also while a product is in use by the customer. His empirical illustrations were air transport companies and their introduction of latest generation jet engine aircrafts, where he argued that the viability of a complex engineering product can often only be assessed during its actual use, and that feedback loops between users and producers can help to incrementally improve the product.

Learning-by-doing and learning-by-using are mainly associated with innovation inside companies; however, the latter already implies that innovation does not take place in complete isolation. Important forms of learning occur in collaboration between users and producers, and are consequently labelled as learning-by-interacting (Lundvall 1988). Lundvall (1988) argues, from a transaction-cost point of view, that both users and producers can benefit from collaborating throughout the innovation process. By means of cooperation and the accompanying learning processes, producers can benefit from insights into user needs and can adjust their product accordingly, while users can increase their understanding of the use-value characteristics of a new product (Lundvall 1988). Those interactive learning processes do not necessarily function without friction, but call for a high level of trust, which can be quickly and substantially corrupted by opportunistic behaviour (Arrow 1974). Trust is a highly valuable resource, as it saves a large amount of trouble to have a reasonable degree of confidence in others. But trust cannot be bought; it can only be earned by repeated interaction. Building up trust with new partners involves costs, risks and a high degree of uncertainty; therefore existing relations tend to be maintained over a long period of time (Lundvall 1988). Besides this evolutionary notion, learning-by-interacting has strong geographical implications. Proximity is important for interactive learning to take place, as efficient communication is enabled, or at least facilitated, if the involved partners have a common socio-cultural background. Such a view on innovation as an interactive learning process calls for a broad understanding of innovation as socially and territorially defined practice, which can hardly be understood independent of the cultural and institutional context (Lundvall 1992).

2.3. Spatial implications of learning

The geographical implications of innovation as interactive learning processes are discussed in the literature on the learning economy (Lundvall 1992; Lundvall and Johnson 1994) and the learning region (Asheim 1996; Morgan 1997; Hassink 2001).

The central argument in the learning economy debate is that the contemporary economy has reached the stage where knowledge is the most strategic resource and learning the most important process (Lundvall and Johnson 1994). Learning economies are characterised by high knowledge turnover, intensive learning and forgetting, a rapid diffusion of new knowledge and a frequent revision of the existing stock of knowledge. They involve a variety of learning processes that are interactive and dependent on the ability to recombine existing pieces of knowledge into something novel (Lundvall and Johnson 1994; Gregersen and Johnson 1997). One of the main features of learning is its cumulative and path dependent character, resulting from the fact that learning always builds on previous knowledge. Therefore, learning economies are highly affected by the existing industrial structure and other legacies of the past. Consequently, not only learning, but also unlearning is essential to remain competitive. It is not easy to forget practices and habits that were previously successful, even if they hamper future success (Maskell and Malmberg 1999). Forgetting and unlearning implies a considerably large burden, which can be levelled out by the state, for instance through a social security system and policies for re-education and training (Lundvall and Johnson 1994; Gregersen and Johnson 1997). It is noticeable that the learning economy literature neither supports a neo-liberal rationale that overlooks the limitation of pure market mechanisms, nor does it advocate a state-socialist thinking with a naïve believe in the ability of the state. Instead, it tries to eschew such binary argument on the role of state versus market by promoting an alternative emphasis on institutions as important mechanisms that underlie economic activities (Amin and Thrift 1995; Morgan 1997).

Institutions can be defined in various ways. The learning economy and learning region literature mostly adapts a sociologically informed, broad understanding of institutions as "the rules of the game in a society" (North 1990, 1) or the "settled habits of thought common to the generality of men" (Veblen 1919, 239). When individual habits and routines become common to a group, they lead to various types of social regulations, such as norms, customs, traditions, rules and laws. Institutions can be explicit and formalised, for instance in the case of laws and administrative rules, but they can also be implicit and informal, such as in the case of social norms, everyday customs and moral conceptions. Their common characteristic is that they regulate how actors and groups of actors interact and relate to one another. By regulating interaction and guiding social and cognitive processes, institutions influence all types of learning processes. They are characteristic of a specific socio-economic context and can vary considerably even between closely related geographical areas, such as neighbouring countries or neighbouring regions within one county (Johnson 1992; Maskell and Törnqvist 1999; Koschatzky 2000; Gertler 2010).

Moreover, institutional settings do not only differ between geographical areas, they are also subject to variation over time (Hägerstrand 1953; Boulding 1985). Institutions that support innovation and learning in one period of time can easily impede innovation in the following period, when the economy is exposed to a new techno-economic paradigm (Perez 2004). While technological change can come about rapidly, it takes time before a new paradigm gradually reaches the collective consciousness, replacing old habits and routines and turning into new common sense. Institutional change tends to be incremental and slow, because of the inertia of many of the informal and cultural elements in institutions (North 1990). Institutional restructuring is neither an automatic nor a costless process, and the ability to rapidly and effectively adapt the institutional system to a changing socio-economic environment is decisive to preserve national and regional competitive advantage (Johnson 1992).

The notion of interactive learning is equally (if not more) valuable when assigned to the subnational level. Consequently, the literature on the learning region considers the region as the focal point for innovation and learning (Storper 1993; Florida 1995; Asheim 1996; Morgan 1997). In the North American context, learning regions are mainly associated with the presence of a well-developed research and education infrastructure, combined with social and environmental features that can attract and retain highly skilled labour (Florida 1995). In the European context, in which this thesis is placed, the focus is more on the contribution that mutual trust and social capital can make to support innovation networks and interactive learning (Asheim 1996; Morgan 1997; Hassink 2001).[3] The learning region literature stresses the role of proximity and the institutional structures that govern innovation, knowledge creation and learning. Innovation is seen as a result of cumulative and interactive learning between companies and other organisations. Regional economic growth is seen as less dependent on the performance of individual companies, research institutes or universities, but more on their ability to interact in a system of collective knowledge production and their compliance with institutional structures. Social interaction is facilitated if the involved actors dispose of a common language and shared social conventions, and if they have gained mutual trust through cooperation in the past. Interactive learning is enabled by spatial proximity between learning counterparts, but other forms of proximity also play a role (Torre and Gilly 2000; Boschma 2005). Geographical proximity is seen as adjuvant because it enables personal face-to-face contacts, be it planned or accidentally. However, geographical proximity is not a sufficient precondition for interactive learning, as it is unlikely that

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[3] This distinction between a North American and a European notion of learning regions is made explicitly for the first time by Rutten and Boekema (2007).

interactive learning will take place simply by 'being-there' (Gertler 2003). Equally important are other types of proximity such as social proximity (i.e. shared values and norms and similar personal characteristics such as age, vocation, language) and organisational proximity (i.e. firm structures, intra- and inter-firm network structures) (Torre and Gilly 2000; Hassink 2001; Boschma 2005).[4]

Although the importance of continuous and collective learning is generally acknowledged, the concept of the learning region has been exposed to some criticism (Cooke 2007; Hassink 2007). Martin (2001, 198) considers the concept to be a "vague and impressionistic neologism", and Hassink (2001, 226) criticises its general "fuzziness". There is a strong overlap with other territorial innovation models and no consensus how to distinguish learning regions from regional innovations systems. While some authors argue RIS to be broader as it embraces a variety of actors and functions (Cooke and Morgan 1998; Hassink 2007), others consider the learning region to be more wide ranging as it stresses learning processes in all segments of the economy (Asheim 2001, 2011). Some of this disagreement results from different understandings of the concepts in the literature. Learning regions understood as regional development coalitions (i.e. bottom-up and horizontally based cooperation between various actors in the regional milieu) can be distinguished from a narrowly defined RIS (i.e. the knowledge exploration subsystem, the knowledge exploitation subsystem, and the systemic interaction between them), but strongly resemble a broadly defined RIS (i.e. the wider setting of organisations and institutions affecting and supporting learning and innovation in a region) (Ennals and Gustavsen 1999; Asheim 2011). Another criticism concerns industry specific differences which have been frequently overlooked. The learning region literature has often disregarded that "different kinds of products will 'demand' different kinds of innovation systems" (Storper 1997, 107-108), and that companies in different industries behave differently with regard to their patterns of interactive learning and knowledge exchange (Hassink 2007). Recent theoretical development accounts for this criticism by placing emphasis on different modes of innovation and differentiated knowledge bases that play a role in learning regions (Asheim 2011).

2.4. Networks of knowledge and innovation

In line with the emphasis on interactive learning, there is a need to reflect upon how interactive learning processes are organised across space. Relationships between economic actors are commonly described in terms of networks, which in this context

[4] Mattes (2011) argues that different proximity dimensions play a role for analytical, synthetic and symbolic knowledge bases, and can complement and substitute one another.

are understood as socio-economic structures that connect individuals, firms and other organisations to one another (Powell and Grodal 2005). Networks consist of nodes and linkages, and while nodes represent actors, linkages represent different types of relationships. Networks can be knit together by formal linkages, for example in the case of contract-based cooperation, or by informal linkages, such as belonging to the same epistemic community or community of practice (Lave and Wenger 1991; Haas 1992; Knorr-Cetina 1999). In this dissertation, knowledge flows are regarded as the linking elements in the network. These knowledge flows can occur through direct collaboration between actors, but also through monitoring without direct interaction, through the mobility of skilled labour or though informal alliances between individuals in knowledge communities (article II, III and V).

The notion of networks entered into the economic geography literature not later than with Piore and Sabel's (1984) work on flexible specialisation, when networks were first incorporated in the definition of industrial districts (Scott 1988). Later, the notion of networks became prominent up to the point that some authors argued that economic geography had undertaken a 'relational turn', in which actors, linkages and the processes of change were the centre of interest (Bathelt and Glückler 2003; Boggs and Rantisi 2003; for a critique see Sunley 2008). The notion of innovation networks has been pioneered in the literature on innovative milieus, in which innovation is seen as the result of collective learning processes involving numerous actors in a region who form networks of synergy promoting relations (Aydalot 1986; Camagni 1991; Maillat et al. 1995; Crevoisier 2004). Camagni (1991) defines an innovative milieu as "the set, or the complex networks of mainly informal social relationships in a limited geographical area, […] which enhance the local innovative capability through synergetic and collective learning processes" (Camagni 1991, 3). In the literature on industrial districts, networks were used to refer mainly to cooperation among producers, while the innovative milieu literature stresses the collective realisation of innovation through cooperation among various actors in the region. According to Koschatzky (2001), innovative milieus arise from intensive interaction between small and medium sized enterprises, political decision makers, various institutes and the local workforce, who engage in collective and cooperative learning in order to reduce uncertainty induced by paradigm-shifts and technical change. Innovative milieus are formed by informal networks that are governed by regional cultures and identities, and the dissemination and accumulation of knowledge that is required for continuous innovation is facilitated by spatial and cultural proximity in the milieu (Maillat et al. 1995).

Networks are considered as a means through which transaction costs can be reduced and innovation can be facilitated, since embeddedness into networks fosters mutual trust and enables the exchange of knowledge (Giuliani 2010). But then again, network embeddedness also implies the risk to reinforce (rather than renew) existing structures, which can lead to negative lock-in situations (Grabher 1993). The tension between positive and negative network effects is taken up in Granovetter's (1973) sociological work on the strength of weak ties. Strong ties (i.e. close family and friends) are important as they provide social or emotional support; nonetheless new knowledge and ideas are acquired predominantly by interacting through weak ties (i.e. remote acquaintances). This is because strong ties are usually grounded on shared viewpoints and interests; therefore knowledge exchange with strong ties is likely to reinforce rather than to challenge existing views. Weak ties in contrast provide access to dissimilar thoughts and views and can introduce novelty in the form of different ideas and thinking (Granovetter 1973). In a similar vein, Nooteboom (2000) argues that some degree of cognitive proximity is required for effective communication and knowledge exchange, while too much cognitive proximity may hamper interactive learning, because not much learning occurs when actors have identical competences. Although the notion of strong and weak ties lacks an explicit geographical angle, it has been taken up frequently for the analysis of regional innovation networks (e.g. Grabher 1993; Gulati 1995; Uzzi 1997).

A number of conceptual and empirical studies deal with the geography of innovation networks. One main point of interest lies in the tension between the role of regionally embedded networks and the need to link up to global knowledge providers. Some authors stress that the innovation performance of regional industries rests on both local and global knowledge linkages, that is, the combination of 'local buzz' and 'global pipelines' (Bathelt, Malmberg and Maskell 2004; for a critique see Trippl, Tödtling and Lengauer 2009). Other authors emphasise that collaboration within geographical proximity is critical for innovation, however even within regions, innovation-related knowledge is diffused in a highly selective way, and therefore structural properties of knowledge networks need to be considered (Giuliani 2007; Morrison 2008; Morrison and Rabellotti 2009). Some authors stress that a static view on networks has only limited explanatory power, and that evolutionary economic geography calls for research on network formation over time and space (Glückler 2007; Boschma and Frenken 2010; Ter Wal 2011). And only lately, there is an increasing recognition that innovation networks are highly contingent upon sectorial specificities of the respective industry. Most existing studies focus on technology orientated and R&D based industries that commonly use patents to protect their intellectual property (e.g. Smith 2005; Cantner and Graf 2006; Ejermo and Karlsson 2006), while few studies deal with innovation networks that are based on other modes of innovation than formal R&D (e.g. Giuliani 2007; Trippl 2011; Andersen 2012).

2.5. Knowledge bases as generic industry classification

In order to understand industry specific differences in the geography of innovation, it is logical to group industries according to similarities and differences in their innovation activities. One influential industry classification that deals with sectorial patters of innovation is Pavitt's (1984) taxonomy (Archibugi 2001; Castellacci 2008). Instead of product characteristics, as is the case with standard industrial classifications, the Pavitt taxonomy is based on characteristics of innovating companies, and is composed of four broad categories: (1) supplier dominated companies that innovate by acquiring machinery and equipment from their suppliers, (2) specialised suppliers of capital goods and equipment that work in close cooperation with their customers, (3) science-based firms that innovate in in-house R&D laboratories, and (4) scale-intensive companies that are active in mass production manufacturing (Pavitt 1984; Archibugi 2001). This taxonomy has been widely applied in innovation studies and has also entered into official statistics such as the Community Innovation Survey (CIS) (Castellacci 2008). According to Castellacci (2008, 980), "Pavitt's model […] provides a stylised and powerful description of the core set of industrial sectors that sustained the growth of advanced economies during the Fordist age". The methodological approach for developing the taxonomy has been strongly inductive and based on empirical evidence from the British manufacturing sector in the mid-20th century. It remains unclear, though, to what extent it is still equally valid to describe today's post-Fordist knowledge economies (Archibugi 2001).

The knowledge base concept[5] that is at the heart of this dissertation can be seen as more generic classification of sectorial patters of innovation, as it highlights the type of knowledge that is critical for innovation rather than the characteristics of particular companies. Knowledge is a key concept for studying the geography of innovation, as it is both a central ingredient and a main outcome of all innovation activities (Polanyi 1967; Nonaka 1994). Knowledge is a multidimensional concept with a broad range of different meanings, and philosophers have been continuously searching for the meaning of knowledge ever since the ancient Greeks. The knowledge base concept with its distinction between analytical, synthetic and symbolic knowledge is grounded on universal categories of knowledge that refer back to the Aristotelian notions of episteme and technê, and to the notion of art. While the division between the first two intellectual virtues is still vague in Plato's writings, Aristotle's makes a clear distinction between epistêmê and technê, that is, between theoretical and practical knowledge and skills (Parry 2008). The analytical knowledge base is associated with

[5] Comprehensive discussions on the knowledge base concept and its theoretical foundations are provided in the five articles included in this dissertation.

epistêmê and refers to universal and theoretical knowledge that is applied to understand and explain features of the (natural) world. The synthetic knowledge base derives from technê and refers to knowledge that is practical in nature and applied for the purpose of designing or creating goods to attain functional goals. The notion of art, which is at the centre of the symbolic knowledge base, occurs in Plato's work in the Republic where he describes artwork as mimetic.[6] Plato considered art as inferior to ordinary objects and claimed that artistic experience cannot yield knowledge, and that producers of artworks do not work from knowledge. His student Aristotle, in contrast, argued that art is essentially related to knowledge because artistic work reflects and reproduces the reality and our understanding of it (Adajian 2008). By referring to the very fundamental notions of epistêmê, technê, and art, the knowledge base concept is not limited to a specific geographical area, period of time or level of analysis, and can serve as a heuristic device to study the geography of innovation and knowledge creation in a broad range of regions, sectors and companies. This dissertation builds on the notion of knowledge bases, and by this means, intends to enhance our understanding of how the geography of innovation and knowledge varies subject to industry specific difference in the knowledge base.

[6] It should be noted that the conceptualisation of art in ancient Greek philosophy is very different from ours today, and that the definition of art is controversially debated also in contemporary philosophy (see also Adajian 2008; Livingston 2012).

3. Research design

When conducting research, it is important to reflect upon questions related to what can be studied, what kind of answers can be obtained, and what combination of methods can lead to the best possible answers. A first step into such a discussion lies in the distinction between ontology, epistemology, methodology and method. Epistemology is the philosophy of knowledge or of how we come to know the world, while ontology concerns the theory of what exists in the world. Likewise, ontology deals with the nature of objects, while epistemology deals with the social knowledge of them (Bhaskar 1975). Methodology is also concerned with how we come to know, but is more practical in nature, as it focuses on the specific ways (i.e. the combination of methods) that can be used in order to better understand the world. Method can be seen as techniques of data collection and transformation, whereas methodology comprises combinations of methods, the practices involved in implementing them and the interpretation applied by the researcher (Olsen and Morgan 2005).

3.1. Epistemological and ontological perspective

Two conflicting philosophical positions are often highlighted; namely, positivism (or objectivism) and relativism (or subjectivism) (Chalmers 1999; Sayer 2000). The logic behind the first is that scientific research is in principle able to generate objective knowledge, while the latter stresses that all knowledge is subjective to the individual researcher and socially and culturally constructed. This dissertation takes a position that is placed somewhere in between those two extremes; namely, a *critical realist* position which acknowledges on the one hand that there is a world existing independent of our knowledge of it, and on the other hand that all our knowledge about the world is to some extent fallible and theory-laden (Bhaskar 1975; Sayer 1992; Collier 1994; Sayer 2000).

Critical realism has emerged out of disagreement with some of the arguments made in the positivist philosophy of science (Bhaskar 1998). Positivism, in its stylised form, rejects any kind of metaphysics and claims that science should only describe phenomena that can be experienced (i.e. empirically observed). Positivism relies on empiricism, which is the idea that observation and measurement is the core of scientific advancement. Science should rely on what can be observed and measured, as knowledge of anything beyond what can be measured is impossible. Scientific reasoning is the only way to come closer to the truth and to understand the world well enough to become predictable and controllable. The world and the universe are seen as deterministic and operated by laws of cause and effect which can be discriminated by applying scientific methods. Deductive reasoning is used to put forward theories that can be tested and, based on the results of empirical research, adjusted in order to better predict reality (Moutinho and Hutcheson 2011). A strong positivist epistemological position has been advocated by scientific communities up to a few decades ago, while current research in social science has largely shifted away from positivism into what can be termed 'post-positivism' (Chalmers 1999). Post-positivism is much more than a slight adjustment of the positivist position, but rather a wide-ranging rejection of the central beliefs of positivism. One form of post-positivism that has received wide attention in the economic geography literature is critical realism (Pratt 1995; Yeung 1997).

Critical realism argues that there exists a reality independent of our knowledge of it, and that this reality can be scrutinised by scientific research (Sayer 1992, 2000). This standpoint is in contrast to relativism which argues that there is no such thing as an external reality and that the world is only constructed in our minds. But then, and in sharp contrast to positivism, critical realism acknowledges that all our observations are fallible and that all theory is temporary and revisable in nature. Hence, critical realism is critical of our ability to know reality with certainty. Rather than believing that the goal of science is to reveal the truth, critical realism argues that the goal of science is to work constantly with the aim to understand and explain reality, even though this ultimate goal will never be reached with certainty (Moutinho and Hutcheson 2011). With regard to the notion of truth, critical realism rejects the positivist concept of truth as absolute, that is, as an unchangeable and pre-existing reality that only needs to be uncovered. Rather, truth should be seen as conditional, produced by individuals in the social world, and not only as fallible, but also in need of ongoing critical reassessment (Pratt 1995).

Critical realism stresses that all observation is theory-laden and that all scientists are inherently biased by their personal socio-cultural experience and viewpoints. That does not imply that communication and translation of experiences from one person to another is utterly impossible. Rather, critical realism rejects the relativist idea of the incommensurability of different perspectives, that is, the idea that we can never understand each other because of our different socio-cultural experiences (Moutinho and Hutcheson 2011).

Critical realism is also related to constructivism, given the fact that our view of the world is based on our observations of outcomes of underlying structures and mechanisms, and that our understanding of the world is generated through a series of theoretical constructions or abstractions (Sayer 2000). Because our perception and observation is inherently fallible, our construction of the world can never be perfect. In consequence, also the term objectivity has a particular meaning in critical-realist philosophy. Positivism supposes that objectivity is in control of the individual scientist, and that scientists should set besides their biases and opinions in order to see the world as it really is. Critical realism, in contrast, rejects the idea that individuals can see the world as it really is, because all individuals are biased and all our observations are theory-laden. Therefore, the only way to come closer to objectivity is to triangulate across multiple fallible perspectives (Sayer 2000). Objectivity should be seen as a social phenomenon rather than in control of a single individual. The best way to improve objectivity is to conduct research within the context of a broader community of truth-seeking individuals (i.e. other scientists who criticise and challenge each other's work). Criticism in scientific discussions can be compared with the evolutionary selection process, where the ideas that manage to survive the intense scientific selection are likely to come closest to objectivity. This process can be seen as natural selection of knowledge, meaning that knowledge evolves in an evolutionary process through variation, selection and retention (Campbell 1974; Moutinho and Hutcheson 2011).

Critical realism stresses the need to distinguish between the world and our experience of it by differentiating between the intransitive and the transitive dimension of science (Sayer 1992, 2000). The intransitive dimension consists of all objects of science, that is, the physical and social phenomena we attempt to understand. The transitive dimension consists of the theory and concepts that we apply in order to study these objects. These two dimensions reflect the distinction between the existing world and our subjective and fallible experience of it. Even if rivalling theories are used to explain a specific phenomenon, and even if these theories and conceptualisations may change, the object of study may well remain the same. This standpoint is in contrast to positivism (and empiricism) which limits the world to what can be experienced, while critical realism emphasis the conceptually-mediated and theory-laden nature of experience (Bhaskar 1975; Sayer 2000).

Bashkar (1975) responds to the tension between the world and our limited understanding of it by distinguishing between the real, the actual and the empirical domain. The real refers to everything that exists in the world, independent of our knowledge and understanding of it. It consists of the entirety of objects, be it physical or social objects, including the structures and causal powers that regulate and govern their conduct, and which are not directly observable (Collier 1994). The actual refers to what happens once these powers are activated, and refers to the entirety of events that can actually or potentially be observed. The empirical, then, refers to the concrete experience of these events. The distinction between the real, the actual and the empirical is useful as it provides a stratified (or deep) ontology in contrast to other philosophical positions that tend to concentrate on the actual or the empirical without taking into account the domain of the real. Critical realism acknowledges that there may well be structures and powers that are inactive or dormant and can hardly be captured and experienced through concrete, empirical research. The main objective of theoretical critical realist research is to identify the structures and causal powers in the domain of the real in order to better understand the world and its phenomena (Sayer 1992, 2000).

3.2. Methodological perspective

In order to come closer to the real and explain the hidden or dormant structures and causal powers, it is necessary to conduct *abstract research* (Sayer 1992, 2000). Abstract research is a central tool in realist methodology, as it helps to conceptualise the powers and mechanism of objects (Yeung 1997). By way of cautious conceptualisation, it is possible to reduce the number of contingencies (i.e. the factors that may or may not have explanatory power) and to separate the essential from the incidental (Sayer 1992). In the beginning of every research, as Sayer (1992) argues, "our concepts of concrete objects are likely to be superficial and chaotic. In order to understand their diverse determinations we must first abstract them systematically. When each of the abstracted aspects has been examined it is possible to combine the abstraction so as to form concepts which grasp the concreteness of their objects" (Sayer 1992, 87). Accordingly, the generation of concepts through careful abstraction is at the heart of critical realist methodology. Abstraction should thereby not be seen as a linear process, but rather as a dual and iterative movement from the concrete to the abstract and back to the concrete: With an abstraction in mind, it is possible to better approach the empirical and then, with more empirical observations in mind, continuing with further abstraction. Such continuous moving between abstract and empirical research is also referred to as retroduction (Bhaskar 1975). Retroduction can be seen as a "mode of inference in which events are explained by postulating (and identifying) mechanisms which are capable of producing them" (Sayer 1992, 107). In some cases, the identified mechanisms will already be familiar from previous experiences, while in other cases, previously unidentified mechanisms can become apparent through abstraction and retroduction. Research starts from an empirical problem by abstracting the relation between the concrete object and the deeper causal powers and structures. As more empirical evidence is collected, the generated abstraction is revised or reconfirmed in an iterative process that continues until no further contradictory evidence is found and the discovered generative mechanisms are robust and powerful enough to explain the concrete phenomenon. The process of abstraction continues up to a point where theoretical saturation is reached, that is, when further abstraction brings no significant additional theoretical rigour to the explanatory power of the generative mechanism (Yeung 1997).

A further issue at the centre of critical realism methodology is *triangulation*. Triangulation refers to checking the validity of an interpretation or experience by recourse to several sources that are of a strategically different nature (Denzin 1970). Triangulation is a common technique in critical realism, as it goes in line with the central realist argument that all individuals are biased and all observations are theory-laden. Since all observations are fallible, there is a need to integrate multiple perspectives and observations, each of which may have different types of errors, and a need to use triangulation across these multiple sources in order to reach a better understanding of reality (Sayer 1992, 2000). Triangulation in empirical research can refer to the use of different sources of data, but also to the involvement of different scientists in the research process, to the inclusion of different theoretical and disciplinary perspectives, and to the use of different but complementary research methods (Denzin 1970; Downward and Mearman 2007). Critical realist research can draw on a wide range of methods, comprising extensive (i.e. quantitative) or intensive (i.e. qualitative) techniques. While an intensive research design typically begins with the unit of analysis and explores its contextual relations, extensive research emphasises the formal relations of similarity between them (Sayer 2000; Downward and Mearman 2007). Even though Sayer (1992, 2000) stresses the importance of intensive research for theory development, he argues that critical realism is compatible with both qualitative and quantitative methods, as long as the research design corresponds to the appropriate level of abstraction and the material under investigation. Intensive and extensive approaches have different strengths and weaknesses and supplement one another. The need for triangulation between intensive and extensive methods is based on the belief that "there is no fundamental clash between the purposes and capacities of qualitative and quantitative methods or data. What clash there is concerns the primacy of emphasis on verification or generation of theory" (Glaser and Strauss 1967, 17).

3.3. Methods

The research carried out in this dissertation draws on a critical realist methodology, involving abstraction, a mix of intensive and extensive methods, as well as triangulation between different sources of data, different investigators and different theoretical schemes for data interpretation and analysis. Abstraction (i.e. theoretical reasoning and conceptualisation), has been a central approach throughout the whole research process. In order to approach the research problems formulated in the introduction and in the articles, existing scholarly work related to the geography of innovation has been reviewed systematically and interpreted with regard to each research problem. In that way, it was possible to structure the theoretical work and reduce the number of contingencies before approaching the empirical material through concrete research. Abstraction is necessary to create a conceptual basis for interpreting the observations made through concrete research. Likewise, abstraction is not a one-way procedure, but comprises an iterative movement between abstract and empirical research. The conceptual framework initially generated by reviewing the literature has been continuously challenged and advanced by concrete research drawing on empirical material. Relating this logic to the thesis, the notion of knowledge bases has been applied to conceptualise industry specific differences in the geography of innovation, scrutinised with empirical material and complemented with theoretical reflections on the nature of knowledge networks.

Abstraction is not a stand-alone method, but is always accompanied with concrete methods for data collection and analysis. This thesis adopts a combined intensive and extensive research design, that is, a mix of qualitative methods that allows exploration of the contextual relations between the units of analysis (i.e. firms and other organisations that constitute a regional industry), and quantitative methods to understand the formal relations of similarity between them (Sayer 2000). The purpose of combining qualitative and quantitative approaches is neither to use quantitative methods to validate qualitative results, nor to use qualitative work as preparation for quantitative work. Such an interpretation of mixed-methods would lead to epistemic fallacy, that is, reducing questions of ontology to questions of epistemology (Bhaskar 1975; Collier 1994). Rather, the purpose of combining methods is to explore the communality of qualitatively understood phenomena, and to add to theory development by using complementary approaches to discover generative mechanisms (Downward and Mearman 2007). Such a mixed-methods approach is advocated in critical realist methodology as it serves "to reveal different aspects of the constituency of phenomena, that is their ontic character, as structural, that is cause and effect, relations more broadly" (Downward and Mearman 2007, 91).

The intensive methods applied in this dissertation range from desk-based analysis of websites, databases, business magazines and policy reports, to structured and semi-structured interviews with firm representatives and other innovation system actors. Intensive desktop based research has been essential throughout the thesis (article I-V), while face-to-face interviews have been relevant for several of the articles (article II-IV). Initial interviews were carried out by colleagues and co-authors involved in the research process, and additional follow-up interviews were carried out by the author. They were recorded and transcribed and served as the basis for the interpretation and validation of further sources of information. The extensive methods applied in the dissertation range from descriptive statistics to location quotient (LQ) analysis and social networks analysis (SNA). Descriptive statistics have been used to complement results from intensive research (article II-IV), and to proceed with the results obtained from other extensive research methods (article II, III and V). LQ analysis has been used to measure regional specialisations in knowledge bases (article I), whereas SNA has been applied to study the geography and organisation of knowledge networks in different regional industries (article II, III and V).

Different forms of triangulation have been employed to enhance confidence in the research findings. Realist methodology usually distinguishes between four types of triangulation; namely, methodological triangulation, data triangulation, investigator triangulation, and theoretical triangulation (Denzin 1970; Jick 1979; Flick 1998). Methodological triangulation refers to the use of more than one method for addressing a research problem. As discussed earlier, one form of methodological triangulation applied throughout the dissertation is a complementary use of qualitative and quantitative approaches, sometimes also termed 'between-method' triangulation. Another form of methodological triangulation is the use of varieties of the same method to investigate one research issue, sometimes called 'within-method' triangulation (Denzin 1970; Jick 1979). This technique has been employed, for instance, when different but related network measures were calculated to support the theoretical arguments on the nature of innovation networks (article V).

Data triangulation involves the gathering and use of data from strategically different sources (Denzin 1970; Jick 1979; Flick 1998). A variety of data sources has been applied to deal with the research problems addressed in this thesis, that is, the role of local versus non-local knowledge sources and industry specific differences in the geography of innovation. While intensive research naturally involves a wide range of data sources, the extensive part of the research is based on official statistics provided by Statistics Sweden (SCB), and on data collected in the framework of the European collaborative research project 'Constructing Regional Advantage (CRA)'.[7] Official statistics with regionally aggregated occupation data were used to quantitatively assess the knowledge base concept (article I). Such official statistics are typically highly reliable, comparable over time and space, and well suited for extensive research on individuals, firms and spatial entities. Nevertheless, official statistics have several limitations for addressing the questions dealt with in this dissertation. One limitation is related to the nature of industries, which in this context are defined by the underlying knowledge base. Knowledge bases can hardly be delimited by standard industry classification systems, which in turn structure most official statistics. Also, innovation is understood as interactive learning process, which calls for research on relations between innovation systems actors, rather than on attributes of individual companies or firm aggregates. Such relational data is barely accessible from official statistics, especially when the aim is to study various types of knowledge interdependencies in a wider range of industries (and not only formal collaboration in

[7] Article II-V were written in connection to the European collaborative research (EUROCORES) project 'Constructing Regional Advantage: Towards State-of-the-Art Regional Innovation System Policies in Europe?', coordinated by Bjørn Asheim in the period 2007-2010, co-funded by the European Science Foundation (ESF) and different national research councils, amongst them the Swedish Research Council (VR).

science-based industries, which may well be captured by co-publishing and co-patenting data). In order to study the geography of innovation in various industries that are based on different types of knowledge and situated in different regional contexts, the dissertation partly draws on data collected in the CRA project (article II-V). The project involved eight research teams in different European countries who used a jointly developed questionnaire to interview firm representatives in a number of regionally clustered industries. The individually collected data was brought together by the author and merged into one database. The database incorporates general information on the interviewed firms and detailed information on the relationships between firms and other actors, which can be analysed with SNA. Large parts of this database, including attribute and network data for different regional industries, have been considered and employed during the course of the research.

The third type of triangulation, investigator triangulation, refers to the use of more than one researcher to collect and analyse data, and is closely related to the forth type, theoretical triangulation, which refers to the use of more than one theoretical position in interpreting data (Denzin 1970; Jick 1979; Flick 1998). Both kinds have been essential during the exploration, writing, and publication process. Parts of this dissertation have been co-authored by scholars with a disciplinary background in economic geography, which allowed triangulating between investigators with similar intellectual perspectives (article II-IV). Parts of the research were carried out in the framework of an international collaborative research project, which was conducive to integrating different viewpoints and to securing the reliability of the conclusions drawn from the data (article II-V). Furthermore, all articles included in the dissertation went through several stages of scientific peer-review and quality assessment, both in a disciplinary and interdisciplinary setting. They were presented at various workshops and conferences in the field of economic geography, innovation studies and related disciplines, inducing feedback from different scholarly and disciplinary perspectives.[8] And finally, they went through a double-blind peer-review process, which is a quality control mechanism in the publication routine of scientific journals, leading to profound comments from experienced scholars that were taken into account before inclusion into this dissertation (article I-V).

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[8] In addition to internal feedback from colleagues at Lund University, external presentations with feedback include: Swedish national PhD course in Economic Geography 2009 (article I); International PhD course in Economic Geography 2010 (article II); DRUID Summer Conference 2010 (article II); Schumpeter Conference 2010 (article II); Annual Meeting of the Association of American Geographers 2010 (article III); DRUID-DIME Academy Winter Conference 2011 (article III); Third Global Conference on Economic Geography 2011 (article III); 5th International Seminar on Regional Innovation Policies 2010 (article IV); DRUID-DIME Academy Winter Conference 2012 (article V); Annual Meeting of the Association of American Geographers 2012 (article V).

4. Findings, conclusions and outlook

This chapter summarizes the main findings of the articles included in the thesis, draws general conclusions in view of the research results, and elaborates on possibilities for further research on knowledge bases and the geography of innovation.

4.1. Summary of the main findings

All five articles included in this dissertation deal with the geography of innovation and the notion of differentiated knowledge bases, and contribute to this stream of literature through theoretical and empirical research inspired by realist epistemology and methodology.

The first article (Martin 2012a) is an attempt to operationalise the knowledge base concept by means of quantitative measure, and follows an extensive research design with empirical focus on all Swedish regions. It is based on the observation that the literature on differentiated knowledge bases is largely grounded on in-depth case studies, while surprisingly little effort has been made to operationalise the concept in a more systematic manner. After introducing the knowledge base concept and related knowledge taxonomies, an analytical scheme is developed that serves to identify the knowledge base of regional and other territorial entities. The suggestion is to use occupation data in association with location quotient analysis, in order to assess whether a regional economy has a particular strength in one (or more) knowledge base. Each knowledge base is attributed to a set of occupations, and a region with a high share of persons occupied in one of the three areas is considered to have a strong analytical, synthetic or symbolic knowledge base. To bring the scheme into practice, it is applied at county level in Sweden. The results show an analytical knowledge base that is particularly strong in Uppsala and West Bothnia, a rather balanced specialisation in synthetic knowledge across all Swedish regions and a strong specialisation in symbolic knowledge especially in Gotland and Stockholm. Moreover, it reveals that most regions have a particular strength in one knowledge base, while some, especially Scania, are dominated by a combination of more than one knowledge base. These findings are explained and contrasted with insights on the regional economies taken from secondary sources. The conclusion is made that the proposed scheme of analysis leads to fairly reliable results, and could stimulate further empirical research on differentiated knowledge bases.

The second article (Martin and Moodysson 2011a) triangulates between intensive and extensive research methods and focuses on one symbolic industry that is part of the regional innovation system of Scania; namely, new media. The paper addresses the question of the local versus the non-local as prime arena for knowledge exchange with specific focus on the geographical distribution of knowledge networks and the distinctive nature of knowledge flows in symbolic industries. The notion of knowledge flows is captured from three different angels; namely, monitoring (i.e. acquisition of knowledge without direct interaction), mobility (i.e. acquisition of knowledge embodied in skilled labour) and collaboration (i.e. acquisition of knowledge through direct cooperation with other firms and organisations). These different knowledge channels have distinct organisational and geographical features. The article reveals that localised networks and non-formalised knowledge sources are of particular importance for symbolic industries. Innovation in symbolic industries is based on creative production and on cultural responsiveness that is determined by the socio-cultural context, and as a result, knowledge flows and networks are most of all locally configured, and firms rely on less-formalised knowledge sources instead of formalised and codified knowledge. Furthermore, the analysis discloses that concrete innovation projects in companies often involve all three knowledge bases, while there is one which is critical to the competiveness of the firm. These arguments are assessed through a micro-perspective on innovation in a company and a systems-perspective on knowledge sourcing activities in the regional industry. The empirical analysis is based on structured and semi-structured interviews with firm representatives, SNA and descriptive statistics.

The third article (Martin and Moodysson 2011b) builds on the ideas developed in the previous and deals with knowledge flows and inter-organisational collaboration. But rather than focusing on one industry, it takes a comparative perspective on three industries with different knowledge base situated in the same region. The aim of the paper is to analyse how the functional and spatial organisation of knowledge interdependencies among firms and other actors vary between industries that rely on different types of knowledge bases. It is argued that knowledge sourcing in geographical proximity is especially important for industries that rely on symbolic and synthetic knowledge, since the interpretation of the types of knowledge they deal with tends to vary between places. This is less the case for industries with an analytical knowledge base, as they rely more on scientific knowledge that is codified, abstract and universal, and therefore less sensitive to geographical distance. These expectations are empirically investigated with case study research on three industries located in Scania; namely, the life science cluster representing an analytical case, the food cluster including mainly synthetic activities, and the new media cluster as a symbolic case. The empirical focus on one single region adds to the analytical rigour of the study, as it permits comparison of cases with similar institutional frameworks in the same regional context.[9] Knowledge sourcing and knowledge exchange in each of the three cases are explored and compared using social network analysis in association with data gathered through interviews with firm representatives. The results point in the direction that even though the local milieu matters for innovation, the extent and driving force for localised knowledge exchange differs between industries. Localised knowledge exchange with companies and other organisations is critical for symbolic industries (see also article II). What drives co-location in analytical industries is not necessarily the exchange of knowledge between companies, but most importantly linkages with organisations providing research, higher education and skilled labour, while linkages to knowledge providers in other parts of the world remain crucial. In the case of synthetic industries, innovation is driven by cooperation and interactive learning with customers and suppliers, often on a national scale, while local universities play a minor role.

The fourth article (Martin, Moodysson and Zukauskaite 2011) compares the type of policy support provided in the region of Scania with the particular needs and demands that arise from knowledge base characteristics of firms. The preceding articles have revealed profound industry specific differences in the geography and organisation of knowledge sourcing. In correspondence with these findings, industries are also expected to vary with regard to how policy measures aiming to support innovation are perceived and acquired. Yet, there is a tendency among regional policy programmes to base their strategies on 'best practice' models, inspired by successful (or sometimes less successful) cases in other parts of the world. Empirically, the article deals with three regional policy programmes targeting the life science, the food and the new media industry in Scania. Structured interviews with firm representatives and in-depth interviews with policy representatives revealed that the policy support schemes provided typically aim at regional networking between academia, industry and government, and do not fully comply with the needs and demands of the companies. Networking between industry and academia seems to be most appropriate for analytical industries that innovate based on scientific knowledge and practices, but less for synthetic and symbolic industries that rely on other modes of innovation. The intra-regional focus of most policy initiatives, in contrast, is best suited to symbolic industries that rely on localised knowledge sources, but not equally well to analytical industries, where companies search for linkages to global knowledge providers. The existing policy programmes seem to be customised on a generic level, but not sufficiently fine-tuned to the particular needs and demands of the respective

[9] In a similar vein, Hägerstrand (1953, 307, p. 246 in the original) argues that: "There is some merit in [repeatedly] using the same area... because of the opportunities it gives for comparing cases against a fairly stable pattern of population distribution and infrastructure."

companies. Policy makers are recommended to take the specific characteristics of the industrial knowledge base into account, in order to provide the appropriate support and to become an effective part of the institutional framework of the regional innovation system.

The fifth paper (Martin 2012b) deals with the differentiated nature of innovation networks. It builds on social capital theory and argues that knowledge networks between innovating companies can be analysed in various dimensions, such as structure, relation and geography. It is argued that these dimensions can vary substantially between industries that innovate on different types of knowledge bases. The paper comprises a conceptual discussion on social capital theory, which is connected to the notion of networks and knowledge bases, and is subsequently illustrated with empirical material collected in the CRA project. It adds to the previous research on industry specific differences in the geography of innovation with an extensive analysis on networks in various industries and regional settings. The empirical analysis is based on SNA in association with data about patterns of cooperation and knowledge exchange in ten industries located in different regions of Europe. It reveals that there are indeed strong differences in the structural, relational and geographical nature of networks, and that, even though various dynamics can play a role, the industrial knowledge base is one factor that can explain those differences. The findings suggest that networks in analytical industries are little constrained by geographical distance; knowledge is exchanged in a highly selective manner between research units and scientists in globally configured epistemic communities. Synthetic industries source knowledge within nationally or regionally configured networks between suppliers and customers, and within communities of practice. Symbolic industries rely on knowledge that is culturally defined and highly context specific, resulting in knowledge exchange in interpretive communities and localised networks between small firms and service providers that are temporary and flexible in nature.

The following table provides an overview of the articles with respect to the main research questions, theoretical framework, level of analysis, research design, and some of the findings.

Table: Overview of the five articles included in the thesis

Article number and title	Research questions	Theoretical framework	Level of analysis	Methods	Findings
I - Measuring knowledge bases in Swedish regions	How can the knowledge base concept be operationalised by means of quantitative measures?	Knowledge bases	Regional level	Location-quotient analysis	Knowledge bases can be measured with occupation data; most regions have strengths in one (or more) knowledge bases
II - Innovation in symbolic industries: The geography and organisation of knowledge sourcing	How is innovation organised in symbolic industries? What is the role of local/non-local and formalised/non-formalised knowledge sources?	Knowledge bases; RIS	Firm level, industry level	Case study; social network analysis	All three knowledge bases play a role for innovation; knowledge can be acquired through different channels; symbolic industries rely on localised networks and non-formalised knowledge sources
III - Comparing knowledge bases: On the geography and organization of knowledge sourcing in the regional innovation system of Scania, Sweden	How does the geography and organisation of knowledge sourcing vary subject to the knowledge base of an industry?	Knowledge bases; RIS	Industry level	Case study; social network analysis	Analytical industries rely on global and formalised, synthetic industries on national and less-formalised, symbolic industries on localised and non-formalised knowledge sources
IV - Regional innovation policy beyond 'best practice': Lessons from Sweden	How does the perception and acceptance of regional innovation policy initiatives differ subject to the knowledge base of an industry?	Knowledge bases; RIS; institutional theory	Industry level	Case study	Needs and demands differ between industries with different knowledge bases; policy measures are hardly fine-tuned
V -Differentiated knowledge bases and the nature of innovation networks	In what respect do innovation networks vary between industries with different knowledge base?	Knowledge bases; RIS; social capital theory	Industry level	Social network analysis	Industries with different knowledge base vary with regard to the structural, relational and geographical dimension of networks

Source: own draft

4.2. Conclusions and outlook

The overarching aim of this thesis is to enhance our understanding of when, why and in what respect local or non-local knowledge sourcing and exchange matters for innovation, and to shed light on the role of knowledge bases in explaining industry specific differences in the geography of innovation. In order to address this aim, a systemic perspective is applied where innovation is seen as the result of interactive learning processes involving various actors from industry, academia and governments, which collectively contribute to regional innovation and growth (Asheim and Gertler 2005; Edquist 2005). These interactive learning processes are governed by spatially and socio-culturally defined institutions, understood as the formal and informal rules that pattern our behaviour (North 1990; Edquist and Johnson 1997). Key for innovation based regional growth is a continuous upgrading of knowledge in the local milieu, which is enabled through trust-based collaboration and exchange of ideas inside the region, combined with an inflow of new knowledge from outside the region (Malmberg 1996; Asheim and Isaksen 2002).

It is argued in this dissertation that the question of local versus non-local knowledge exchange can be addressed from different angles. It is pivotal not to reduce the discussion on the geography of innovation to a binary argument on the importance or the irrelevance of the local milieu, but rather to develop a fine grained view that takes into consideration the type of actors involved, the nature of knowledge relationships and the specificities of the industry. In order to account for the diversity of channels through which knowledge can be acquired and exchanged, particular attention is devoted to the notion of networks that connect firms and other organisations, but also to other modes of knowledge transfer such as monitoring of collaborators and competitors without interaction, the mobility of knowledge embodied in skilled labour and informal collaboration between individuals within knowledge communities. Furthermore, the thesis provides theoretical and empirical support for the role of knowledge bases in explaining industry specific differences in the geography of innovation. It is argued that the organisational and geographical scope of knowledge exchange is strongly (but not exclusively) determined by the type of knowledge base that underlies innovation activities. More concretely, the thesis reveals that symbolic industries, partly as a result of the flexible organisation of innovation projects and the context-dependency of cultural knowledge, tend to rely on knowledge provided in the local milieu, while knowledge exchange in synthetic industries tends to be less locally configured and more governed by the national institutional framework. Analytical industries, despite their propensity to agglomerate, tend to be less embedded in localised networks and to source knowledge from specialised knowledge providers in different parts of the world.

The role, the nature and the extent of local collaboration and knowledge exchange can vary substantially between industries that are based on different knowledge base. This finding points towards knowledge bases as a suitable device for studying industry specific differences in the geography of innovation. This does not, however, imply that knowledge bases should be seen as a stand-alone approach to explaining geographical patters of innovation. Indeed, the spatial configuration of innovation activities is shaped by more than industrial specificities. Regional factors such as the institutional set-up and the production structure play a key role in this respect, as the literature on varieties of regional innovation systems demonstrates (Cooke, Heidenreich and Braczyk 2004; Asheim and Gertler 2005; Asheim 2007). There is a strong argument that knowledge dynamics in well-performing and institutionally thick RIS differ from those in less favoured organisationally thin, fragmented or locked-in regions (Isaksen 2001; Tödtling and Trippl 2005). Organisationally thin peripheral regions are characterised by low levels of clustering and weakly developed knowledge exploration subsystems, which naturally implies a lower chance to form regional networks between firms, universities and other research organisations. Fragmented metropolitan regions, in contrast, are typically well endowed with public research and education and knowledge transfer organisations, but, due to their fragmentation, lack dense networks between and within the knowledge exploration and exploitation subsystems. Locked-in old industrial regions face yet another problem; namely, overly strong regional networking, which in turn hampers innovation and regional renewal. Reasons for over-embeddedness can be related to overly rigid inter-firm networks (i.e. functional lock-in), too homogenous world views (i.e. cognitive lock-in) and a disproportionate symbiosis between the private and the public sector (i.e. political lock-in) (Grabher 1993; Isaksen 2001; Tödtling and Trippl 2005). The debate on varieties of regional innovation systems demonstrates that the regional context does play an important role in expounding the scope and intensity of local and non-local knowledge exchange.

And yet, the notion of knowledge bases does not contradict, but add to the role of the regional context for explaining geographical patters of innovation. The literature on varieties of RIS places emphasis on regional differences, whereas the discussion on knowledge bases emphasises sectorial specificities. These two dimensions are closely interconnected, as regional innovation systems always consist of the institutional set-up and the local production structure. While the production structure of institutionally thick RIS can comprise a wide range of clusters, including analytical, synthetic and symbolic industries, as it has been shown for the region of Scania, less favoured regions typically have strengths in only one (or few) industries and knowledge bases. Depending on the prevailing industrial and institutional setting, organisationally thin, fragmented and locked-in regions can generate competitive advantage in sectors that are less contingent upon the presence of a strong and well-connected knowledge exploration subsystem, but built on other types of knowledge. The knowledge base discussion implies that there exists more than one (high-technology) road towards regional prosperity, and that diverse knowledge base configurations can serve as a basis for creating competitive regional advantage.

The question remains how to further expand the research agenda on knowledge bases and the geography of innovation. In view of the results presented in this dissertation, several pathways open up for further research.

Since this thesis deals with knowledge bases as a means to disclose industry specific differences in the geography of innovation, the main attention has been devoted to disentangling knowledge bases and highlighting their peculiarities. However, knowledge bases remain idea-typical categories which are not always easy to separate in concrete reality. The empirical results point in the direction that there is typically one knowledge base that is critical for innovation, even so, concrete innovation projects often involve mixed knowledge inputs (article II) and regions may well have strengths in more than one knowledge base (article I, III and IV). In cases where analytical, synthetic and symbolic knowledge bases are combined, the geography of innovation may well show new patterns, involving different actors and relations. Future research could look even closer at the structures and powers that occur at the intersection of knowledge bases, that is, when analytical, synthetic and symbolic knowledge acts together. A challenge for future research is to account for the diversity and interplay of knowledge bases that occurs in companies, industries and territorial entities.

The empirical analyses in the thesis have shown that some regions specialise on one knowledge base while others rely on a combination of two or more knowledge bases. Future research could link knowledge bases to regional performance and address the question of whether knowledge base specialisation or diversification leads to the best outcomes in terms of regional innovation and growth. This refers back to the discussion on agglomeration economies and the argument that positive effects can arise from co-location of firms in the same industry or in different industries. The literature on agglomeration economies deals with the question of whether knowledge spillovers are geographically bounded, and whether regional specialisation or regional diversification in the industrial structure is more conducive to innovation and growth (Audretsch and Feldman 2004). The literature on related variety, in a similar vein, suggests that sectorial variety is important although knowledge can spill over most effectively if a certain degree of relatedness exists between sectors (Frenken, Van Oort and Verburg 2007; Boschma and Iammarino 2009). Transferring this discussion to the realm of differentiated knowledge bases, the question is whether knowledge exchange within the same knowledge base is most conducive to regional innovation and growth or whether additional benefits can arise from knowledge flows between analytical, synthetic and symbolic activities; or, formulated differently, whether related variety occurs within or between knowledge bases.

Another way to expand the research agenda is to take a more evolutionary perspective on knowledge bases and to study why and in what respect regional industries and knowledge characteristics transform over time and space (Boschma and Martin 2010a). This dissertation stresses the role of knowledge bases in explaining spatial patterns of innovation, and thereby adopts a systemic view on innovation dealing with different actors, relations and institutions. In the same research tradition, evolutionary economic geography deals with the spatial configuration of (regional) economic systems and the underlying knowledge dynamics, but then again, is more concerned with the processes by which economic systems evolve and transform over time. The theoretical foundation of evolutionary approaches is diverse and ranges from generalised Darwinism (and the processes of variation, selection, retention, etc.) to complexity theory (and the processes of emergence, self-organisation, adaption, etc.) and path dependence theory (and the processes of branching, path creation, lock-in, etc.) (Boschma and Martin 2007, 2010b). An evolutionary view on knowledge bases could open up new research areas by placing more emphasis on the dynamic processes of change and transformation. A number of recent studies deal with the evolution of regional industries and the processes that trigger cluster emergence, growth, decline and renewal (Boschma and Fornahl 2011; Martin and Sunley 2011; Neffke et al. 2011; Shin and Hassink 2011). These studies point towards distinct geographical patterns of innovation and knowledge exchange at different phases of cluster evolution. From this perspective, further research could address the question of whether the role and the nature of knowledge bases varies during the transformation of a cluster, whether successful clusters tend to specialise or diversify their knowledge bases over time, or whether declining clusters can renew themselves by shifting to another combination of knowledge bases. Such an evolutionary perspective could provide fertile ground for further research on knowledge bases and the geography of innovation.

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Article I

European Planning Studies, 2012, 1–14, iFirst article

Measuring Knowledge Bases in Swedish Regions

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(Received 21 November 2011; accepted 12 March 2012)

ABSTRACT *Within the literature on innovation systems, there are a growing number of scholars emphasizing the importance of differentiated knowledge bases underlying innovation activities. The existing work on knowledge bases is largely grounded on in-depth case studies; while surprisingly little effort has been done so far to operationalize the concept in a more systematic manner. In this article, an attempt is made to develop a scheme of analysis to identify the knowledge base of a regional economy. We suggest using occupation data in association with a location quotient analysis, to assess whether a regional economy has a particular strength in one (or more) knowledge bases. To bring the analytical scheme into practice and assess it, we apply it on the county level in Sweden. The results are explained and contrasted with insights into the regional economies taken from secondary sources. We conclude that the proposed scheme of analysis leads to fairly reliable results, and could stimulate further empirical research on differentiated knowledge bases.*

1. Introduction

The geography of innovation and knowledge creation is a vital and extensive research field in contemporary economic geography. In the last decades, a large literature has emerged studying the relation between geography and knowledge creation, building on a long research tradition ranging from Marshall's early work on innovation in industrial districts (Marshall, 1920) to the more recent work on the creative class (Florida, 2002; Peck, 2005; Pratt, 2008), learning regions (Asheim, 1996; Boekema *et al*., 2000; Morgan, 1997) and regional innovation systems (Asheim & Gertler, 2005; Cooke *et al*., 1997). Many studies dealing with the role of proximity for interactive learning and knowledge generation emphasize that knowledge generation is dependent on unique and exclusive regional framework conditions (Boschma, 2005). With the aim to formulate fine-tuned recommendations for regional innovation policy, it is essential to strive for a differentiated and

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ISSN 0965-4313 Print/ISSN 1469-5944 Online/12/000001–14
http://dx.doi.org/10.1080/09654313.2012.708022

nuanced understanding of the conditions and processes underlying knowledge creation, by taking a systemic perspective on innovation (Edquist, 1997). Following such a systemic view, innovation is largely seen as emanating through interactive learning between various actors in industry, government and academia, which is often, however not always, a highly localized phenomenon. A systemic approach on innovation and knowledge creation has been followed by a number of scholars explaining spatial patterns of innovation (Asheim & Isaksen, 1997; Bathelt *et al.*, 2004; Cooke *et al.*, 1997). Stemming from this line of research, different knowledge taxonomies have emerged that can be applied as heuristic models for the analysis of innovation systems. Only recently, the knowledge base concept has been brought forward by Asheim and Gertler (2005), who differentiate between different types of knowledge underlying innovation activities. The knowledge base concept has been developed further and proved to be a useful heuristic for the analysis of regional innovation systems. It has been applied and advanced by a number of scholars, whose work is mainly based on in-depth case studies analysing a variety of regions and industries within those regions (Asheim & Coenen, 2005, 2006; Coenen & Moodysson, 2009; Moodysson *et al.*, 2008). Case studies are seen as the appropriate framework for the study of regional innovation systems, because knowledge generation and innovation are complex and unique processes that can hardly be captured by a set of quantitative measures. However, we suggest that a quantitative and more formalized research design can provide additional insights into the empirics of knowledge bases, facilitate interregional comparisons and help us to identify the knowledge specialization of companies, industries and territorial entities such as regions.

In this article, an attempt is made to develop a comprehensive scheme of analysis for detecting the knowledge specialization of a regional economy. The main idea is to identify the knowledge specialization of a region by means of quantitative measures.[1] We propose an empirical approach to assess whether a regional economy has a particular strength in one (or more) knowledge bases. The main research question dealt with in this article is the following:

How can the differentiated knowledge bases concept be operationalized by means of quantitative measures?

This article is organized as follows. First, we review the theoretical background of the differentiated knowledge base concept. Related knowledge taxonomies such as the tacit versus codified dichotomy (Gertler, 2003; Nelson & Winter, 1982; Polanyi, 1967) are discussed briefly, before explaining more detailed the differentiated knowledge base concept promoted by Asheim and Gertler (2005). Second, a method for an operationalization of the knowledge base concept is developed. We suggest using occupation data reflecting the tasks and duties undertaken by the local workforce, in association with a location quotient (LQ) analysis. To bring the analytical scheme into practice and assess its usability, we apply it on the county level in Sweden. The results are explained and contrasted with insights on the according regional economies taken from secondary sources. Finally, we conclude this article and provide ideas for further research on the topic.

2. Theoretical concept of differentiated knowledge bases

At least three prominent knowledge taxonomies can be found in innovation system literature. Most frequently applied is the distinction between "codified knowledge" that is easily transferrable over time and distance and "tacit knowledge" that is embedded in people and organizations. This classification, originates from Polanyi's (1967) work, has been brought forward by Nelson and Winter (1982) and has received much attention within the literature on innovation. The basic notion is that tacit knowledge is by definition difficult to write down and strongly context-specific. Therefore, it is not easy to share over distance and most effectively transmitted through direct fact-to-face interaction. Consequently, innovating economic actors who are largely dependent on tacit knowledge will tend to locate close to each other in order to facilitate frequent and frictionless interaction. Geographical proximity will be less important if innovation activities depend more on codified forms of knowledge, because those are relatively easy to share and to understand over distance (Gertler, 2008). The tacit-codified dichotomy can be criticized for a restrictively narrow understanding of knowledge, learning and innovation (Johnson *et al.*, 2002). Many forms of tacit knowledge do not remain embodied into people, because people articulate their thoughts, experiences and viewpoints through mimic, gesture and language. Nor is codified knowledge objective, because codification and interpretation is dependent on the individual and subjective understanding. Most forms of economically relevant knowledge are mixed in these respects, and while knowledge creation and innovation always involves both kinds, the two forms should be seen as complements rather than as substitutes to each other (Johnson *et al.*, 2002; Nonaka & von Krogh, 2009; Nonaka *et al.*, 2000).

A further classification has been brought forward by Lundvall and Johnson (1994), who distinguish between "know-what", referring to knowledge about facts, "know-why" referring to knowledge about principles and laws in nature and society, "know-how" referring to skills and "know-who" referring to knowledge about possible partners for cooperation and knowledge exchange. The notion of know-what is closely related to what one would term information, i.e. knowledge about mere facts. Technological progress has made access to information easier and know-what almost ubiquitous, so that other types of knowledge have become increasingly relevant. Know-why is usually associated with science-based industries, where the application of scientific laws and principles reduces the need for expensive trial-and-error procedures and accelerates innovation. At the same time, the use and creation of know-why requires intuition and skills, and even the application of very basic mathematical skills is reliant on experience-based learning (Lundvall & Johnson, 1994). Consequently, scientific activities always involve a combination of know-why and know-how (Polanyi, 1967). As products and processes are becoming increasingly complex, there is a growing need for companies to share and exchange elements of know-how (Johnson *et al.*, 2002). As a result, knowledge about possible cooperation partners is becoming more relevant. Know-who involves information about "who knows what and who knows what to do" (Johnson *et al.*, 2002, p. 251), but also the ability to communicate with partners from different professional and socio-cultural background, and is therefore highly context depended and hard to codify.

Only recently and referring to Laestadius (2000), Asheim and Gertler (2005) have introduced an alternative conceptualization that takes more explicitly into account the content of the actual interactions taking place in networks of innovators. To explain the geography of innovation in different industrial sectors, a distinction is made between three types of knowledge base: (i) analytical, (ii) synthetic and (iii) symbolic. These knowledge bases differ in various respects such as the rational for knowledge creation, the development and use of knowledge, the actors and types of knowledge involved and the meaning of geographical proximity in the innovation process[2] (Table 1).

Table 1. Differentiated knowledge bases (a typology)

	Analytical (science-based)	Synthetic (engineering-based)	Symbolic (arts-based)
Rationale for knowledge creation	Developing new knowledge about natural systems by applying scientific laws; know why	Applying or combining existing knowledge in new ways; know how	Creating meaning, desire, aesthetic qualities, affect, intangibles, symbols, images; know who
Development and use of knowledge	Scientific knowledge, models, deductive	Problem solving, custom production, inductive	Creative process
Actors involved	Collaboration within and between research units	Interactive learning with customers and suppliers	Experimentation in studios, project teams
Knowledge types	Strong codified knowledge content, highly abstract, universal	Partially codified knowledge, strong tacit component, more context specific	Importance of interpretation, creativity, cultural knowledge, sign values; implies strong context specificity
Importance of spatial proximity	Meaning relatively constant between places	Meaning varies substantially between places	Meaning highly variable between place, class and gender
Outcome	Drug development	Mechanical engineering	Cultural production, design, brands

Source: Asheim and Gertler (2005), Asheim *et al*. (2007), and Gertler (2008).

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 & Gertler, 2005). Typical examples mentioned in the literature are genetics, biotechnology and information technology. For these industries, basic research and applied research as well as systematic product and process development are relevant activities. Companies usually have their own R&D departments, but rely at the same time heavily on knowledge generated at universities and other research organizations as input to their innovation activities. For that reason, cooperation and knowledge exchange between industry and academia is critical and takes place more often than in other types of industries. Because these industries deal with scientific knowledge stemming from universities and other research organizations, they rely to a large extend on codified forms of knowledge. Knowledge exchange is only little constraint by geographical distance and often takes place in globally configured networks (Martin & Moodysson, forthcoming; Plum & Hassink, 2011).

A synthetic knowledge base prevails in industries that create innovation through use and new combination of existing knowledge (Asheim & Gertler, 2005). This is often the case when specific problems that appear in interaction between clients and suppliers need to be solved. Examples mentioned in the literature are plant engineering, specialized advanced industrial machinery and shipbuilding, where products are often created in small series. Formal R&D activities are of minor importance; they take the form of applied research or more often of incremental product and process development. Linkages between university and industry are relevant, however they occur more in the field of applied R&D than in basic research. Knowledge generation is conducted partly through deduction or abstraction, but primarily through induction, encompassing the process of testing, experimentation or practical work. Knowledge embodied in the respective technical solution or engineering work is at least partially codified. And yet, tacit knowledge is particularly important, due to the fact that knowledge often results from experience gained by learning by doing, using and interacting. Synthetic industries require know-how, craft and practical skills for their product and process development. Those skills are often provided by professional and polytechnics schools or by on-the-job training (Asheim & Coenen, 2006; Broekel & Boschma, 2011).

The symbolic knowledge base is a third category that has been introduced recently to account for the growing importance of cultural production (Grabher, 2002; Scott, 2006). It is strongly present within a set of cultural industries such as film, television, publishing, music, fashion and design, in which innovation is devoted to the generation of aesthetic value and images and less to a physical production process (Asheim *et al*., 2007). Symbolic knowledge can be embedded in material goods such as clothing or furniture, while its commercial value and impact on consumers arises from its intangible character and artistic quality. Symbolic knowledge also includes forms of knowledge applied and created in service industries such as advertising (Gertler, 2008). Because these industries often produce through short-term projects in flexible constellations, 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, p. 664). The meaning and the value associated with symbolic knowledge can vary considerably between places, and therefore exchange of knowledge typically takes place in localized networks between partners that share a similar socio-economic background (Martin & Moodysson, forthcoming).

3. Methodology for measuring knowledge bases

3.1 *Indicators*

Prior to developing a methodological approach, it is important to decide on a set of indicators that suits best for the purpose of the analysis. We consider the knowledge characteristic of the local labour force as key variable for measuring the knowledge base of a region. The scientific discourse on the role of human capital for regional development is rooted among others in endogenous growth theory, with Romer (1986) who argues that increasing returns to scale can be accomplished by investments into the production of knowledge. Moreover, the discussion on tacit knowledge and interactive types of learning implies that particular attention must be paid to knowledge that is embodied in individuals in form of personal skills and experience, and thus cannot easily be transferred from one person to another (Maskell & Malmberg, 1999; Polanyi, 1967).

To measure the knowledge characteristics of the local labour force, one can draw on three core statistics: occupation data (reflecting the tasks and duties undertaken by the local workforce), industry sector data (reflecting the industry sectors in which the local workforce is active) or education data (reflecting the type and level of education acquired by the workforce). We argue that occupation statistics are most suitable for capturing the knowledge base of an economic system, as they reflect the set of activities or tasks that employees are paid to perform, and thereby the type of knowledge they actually apply at their place of work. Employees who perform the same tasks are classified to the same occupation, whether or not they are active in the same industry sector. If an individual has more than one occupation, it is classified in the occupation that requires the highest level of skills and expertise. If there is no clear difference in skill requirements, workers are included in the occupation in which they spend most of their time (OECD, 2007). We argue that occupation data provide a measure that is more appropriate than industry sector data when it comes to capturing actual skills and competencies applied at the workplace. Furthermore, we argue that educational data are not sufficient to capture the knowledge base of a person, because continuous learning and on-the-job training allow people to further develop their careers and carry out tasks that go beyond their certified level of education, and labour mobility can lead people to work with activities that have little to do with their formal area of education.

We claim that each type of knowledge base can be attributed to a set of different occupations, while we focus on occupation groups that are likely to contribute actively to innovation and knowledge creation. For example, persons working as physicists, mathematicians, life scientists or higher education professionals are expected to be conducive to analytical knowledge generation. A region with a high share of persons occupied in these areas can be considered as dominated by an analytical knowledge base. Correspondingly, a region with high shares of engineers, technicians and related professionals can be considered as synthetic based, and a region with a high share of occupations related to design, arts and culture can be considered as symbolic based. It is worth mentioning that some occupations that may well contribute to innovation can hardly be attributed to one of the three categories, such as managers or financial experts. Furthermore, a number of occupations are not likely to be involved in innovation activities, such as clerks and blue-collar workers, and are therefore excluded from the analysis. It is also worth mentioning that few occupations will depend merely on one of the three knowledge bases, while most will rely on a mix of two or more knowledge bases complementing one another.

The usefulness of such an approach is also dependent on the availability of data, where we use data on employees and their field of occupation provided by the Swedish statistical office (SCB).[3] To run the analysis, we use regionally aggregated occupation data and apply a classification brought forward by Asheim and Hansen (2009), who attribute different occupations to the three knowledge bases[4] (Table 2).

3.2 *Location quotient analysis*

To assess which region specializes on which knowledge base, we apply an LQ analysis, a classical technique in economic geography. It compares the local economy to a reference economy, in the process attempting to identify specializations in the local economy. Commonly, this technique is used to see whether certain industries have a smaller or larger presence in a local economy compared with the corresponding national economy, measured by employment active in industry sectors (MacLean & Voytek, 1992). In this article, our intention is to identify knowledge specializations rather than industry specializations. Therefore, we use data on employment in their field of occupation to find out whether particular occupations (which we have attributed to the three knowledge bases) have a relatively smaller or larger presence in the regional compared to the national economy.[5] An LQ above 1 indicates that the share of employment in the regional economy exceeds the share of employment in the reference economy. If it is below 1,

Table 2. Occupation groups with typical analytical, synthetic and symbolic knowledge base

Occupations group (SSYK code)	Number of employees (Sweden, year 2007)
Analytical (science-based occupations)	
211 Physicists, chemists and related professionals	7275
212 Mathematicians and statisticians	1901
213 Computing professionals	87,025
221 Life science professionals	4333
231 College, university and higher education teaching professionals	31,619
Synthetic (engineering-based occupations)	
214 Architects, engineers and related professionals	69,748
311 Physical and engineering science technicians	128,524
312 Computer associate professionals	38,361
313 Optical and electronic equipment operators	8822
314 Ship and aircraft controllers and technicians	6511
315 Safety and quality inspectors	6899
324 Life science technicians	9142
Symbolic (arts-based occupations)	
243 Archivists, librarians and related information professionals	9195
245 Writers and creative or performing artists	38,517
347 Artistic, entertainment and sports associate professionals	13,725

Note: SSYK nomenclature based on ISCO.
Source: modified after Asheim and Hansen (2009).

the share of employment in the local economy is smaller than in the reference economy. We consider an LQ of more than 1.25 as a sign for a strong regional specialization on the respective knowledge base, and an LQ of less than the 0.75 as a sign for weak presence of the knowledge base under consideration (MacLean & Voytek, 1992).

4. Empirical analysis and results for Swedish regions

To test the practicality of this analytical scheme, we apply it on a regional level in Sweden. The territorial focus is the county, or *län*, which is the first level administrative and political subdivision in Sweden. We perform the analysis for all 21 counties based on occupation data provided by the Swedish statistical office. The results are presented in the following sections.

4.1 *Analytical knowledge base*

Figure 1 displays the LQs for occupations attributed to the analytical knowledge base. A strong specialization on economic activities where scientific knowledge is important can be found in Uppsala county (LQ = 1.43) and Västerbotten county (LQ = 1.33). The reason why Uppsala is present in this category is without doubt its well-established higher education sector in the capital city of the region, but also a substantial industrial focus on medical research and biotechnology. Uppsala has a number of the country's largest biotech tools, medical technology and *in vitro* diagnostics companies, and is part

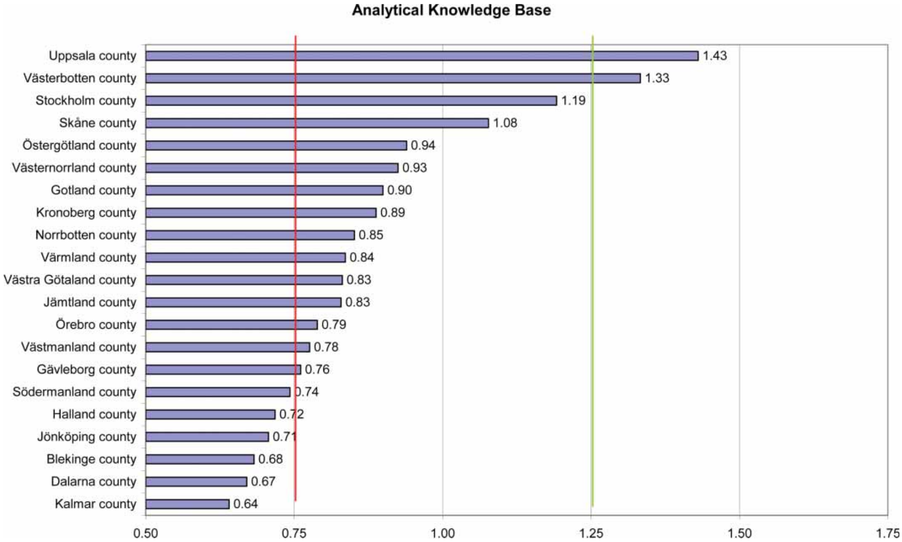

Figure 1. Analytical knowledge base.
Source: own draught.

of the larger Stockholm–Uppsala life science cluster (Sandström *et al*., 2011; Waluszewski, 2004). Västerbotten appears in the same category; its capital city Umeå has the fifth largest university in Sweden with particular focus on technical and medical research, collaborating with a number of small and research intensive companies in the region (Högskoleverket, 2011; Sandström *et al*., 2011). A significant analytical knowledge base can also be identified in Stockholm county (LQ = 1.19) and Skåne county (LQ = 1.08). Stockholm is characterized by a large service sector and a number of high-tech companies that cooperate with universities and other research organizations in the region. Organizations of higher education include Stockholm University, Stockholm School of Economics and The Karolinska Institute, one of Europe's largest medical universities. The life science industry in Sweden is mainly clustered around Stockholm and Uppsala, followed by Skåne region in southern Sweden. Skåne hosts Sweden's largest university in Lund and possesses a live science cluster with a strong and dedicated R&D infrastructure (Cooke, 2005; Moodysson, 2008; Moodysson *et al*., 2008). Typical science-based business segments in the region are drug development, biotech and *in vitro* diagnostics, with the large multinational companies Gambro, AstraZeneca and McNeil. Furthermore, the region has a tradition in agricultural biotechnology, with a number of companies in food, agricultural and environmental biotech (Nilsson, 2008; Sandström *et al*., 2011). For these industries, the absorption of scientific knowledge through industry–university collaborations is a precondition for economic success, and knowledge-creation is more formalized and scientifically grounded than in activities based on synthetic knowledge.

4.2 *Synthetic knowledge base*

Figure 2 visualizes the LQs for occupations attributed to the synthetic knowledge base. Their distribution across Swedish regions is more balanced than for other types of

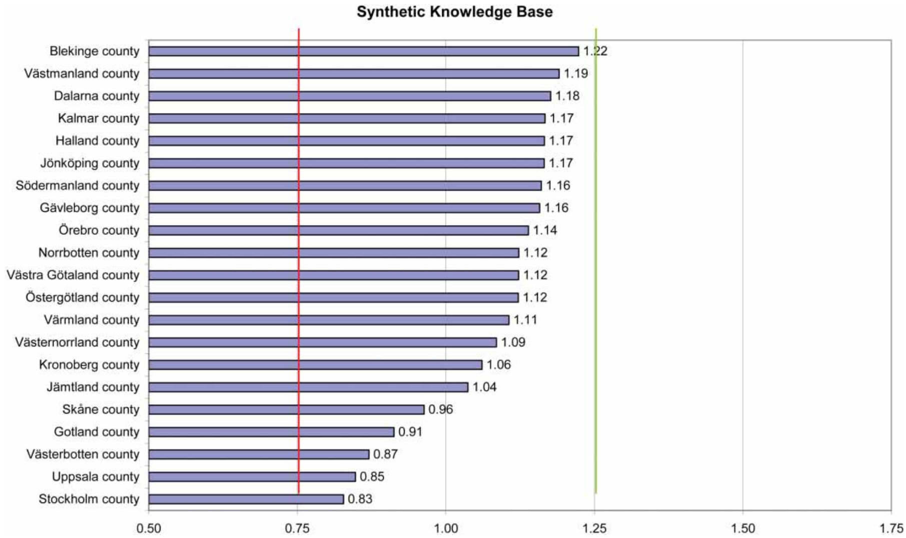

Figure 2. Synthetic knowledge base.
Source: own draught.

knowledge base, none of the regions stands out with a particular high LQ. However, there are some regions that rely more on synthetic knowledge creation then others, for instance Blekinge county (LQ = 1.22), Västmanland county (LQ = 1.19) and Dalarna county (LQ = 1.18). Blekinge possesses an academic environment with Blekinge Institute of Technology conducting research and education in the fields of engineering, humanities, healthcare and social science (Högskoleverket, 2011). Nevertheless, the analytical knowledge base does not outweigh the importance of synthetic knowledge creation, in which existing knowledge is combined in new ways involving practical skills and know-how. Västmanland, even though possessing a university in the regional capital city Västerås, is strongly shaped by its manufacturing sector; especially by the large engineering company ABB, operating in the power technology and industrial automation sector. Dalarna possesses a small university college, though the regional economy relies heavily on manufacturing industries with large companies such as SSAB and Avesta Sheffield, active in iron and steel production, and STORA Enso, fabricating paper, packing and wood products (Invest in Dalarna, 2011). In these sectors, knowledge creation is mostly engineering based and aims at solving concrete, technical problems.

4.3 *Symbolic knowledge base*

Figure 3 visualizes the LQs for occupations attributed to the symbolic knowledge base. The generation of artistic value in a course of cultural production is highly present in Gotland county (LQ = 1.60) and Stockholm county (LQ = 1.34).

Gotland is a small, island region and a prominent holiday destination in Sweden, with a regional economy mainly reliant on tourism. Its cultural and natural heritage attracts not only tourists, but also writers and painters who live and pursue their profession on the

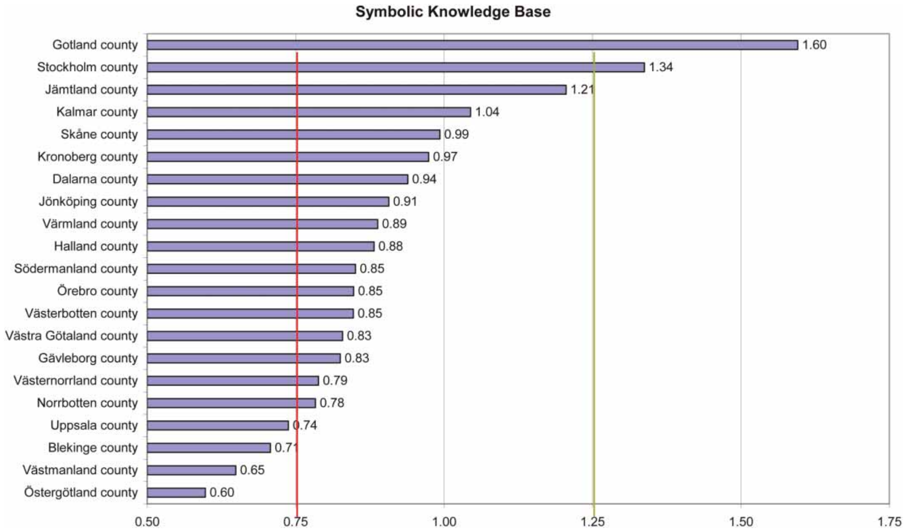

Figure 3. Symbolic knowledge base.
Source: own draught.

island. Apart from tourism, there is a number of small manufacturing businesses focusing on quality and design, especially in design-oriented furniture-making (Gotland, 2009). Accordingly, a symbolic knowledge base is strongly present in Gotland.

The metropolitan region of Stockholm is the centre of cultural production in Sweden. A remarkable case of symbolic knowledge creation in Stockholm is the national music industry (Power & Hallencreutz, 2002). By singing in English and following the mainstream music genres, Swedish artists create products with considerable commercial success, as they appeal to a large, international audience. Although most of the well-known Swedish groups originate from other cities than Stockholm, the capital region is the centre of the music industry and the place where most artists pursue their careers. Stockholm hosts a large number of local and international music companies, with around 200 record companies and approximately 70 music-publishing companies, which is roughly one-half of the national total (Power & Hallencreutz, 2002). Music is of course not the only form of symbolic knowledge generation in the capital region, where various kinds of media businesses are located: four nation-wide daily newspapers, the publicly funded radio (SR) and television (SVT) and all other major television channels have their headquarters in the region.

The cases of Stockholm and Gotland demonstrate that symbolic knowledge production is often dominant in metropolitan regions, but can equally occur in institutionally thin peripheral regions (Tödtling & Trippl, 2005). As the productive output of these industries occurs in form of images, sounds or symbols, it is not always clearly tangible, but can have a significant economic value contributing to regional economic growth.

4.4 *Combining knowledge bases*

The empirical analysis reveals that regional economies are not necessarily dominated by one single knowledge base, but can equally have a comparative advantage in two or more knowledge bases. In most regions, there is a clear dominance of one knowledge base, such as analytical knowledge in Uppsala and Västerbotten, symbolic knowledge in Gotland and synthetic knowledge in most other regions. Nonetheless, some cases are positioned at the intersection of two knowledge specializations, such as Stockholm with strengths in both analytical and symbolic knowledge, Kalmar and Jämtland with synthetic and symbolic knowledge, and Västernorrland with analytical and synthetic knowledge. A balanced mix of all three knowledge bases can be identified in Skåne, where analytical, synthetic and symbolic knowledge is similarly present. Figure 4 visualizes how differentiated knowledge bases can intersect and be combined in different regions.

So far, little can be said about the consequence a certain degree of specialization in the knowledge base may have on regional innovation and growth. There is an argument in the literature that it is in fact the combination of different types of knowledge and different modes of learning that leads to an optimal performance in terms of innovation and growth. Jensen *et al*. (2007), for instance, argue that companies that combine science-based STI (science, technology and innovation) and experience-based DUI (doing, using and

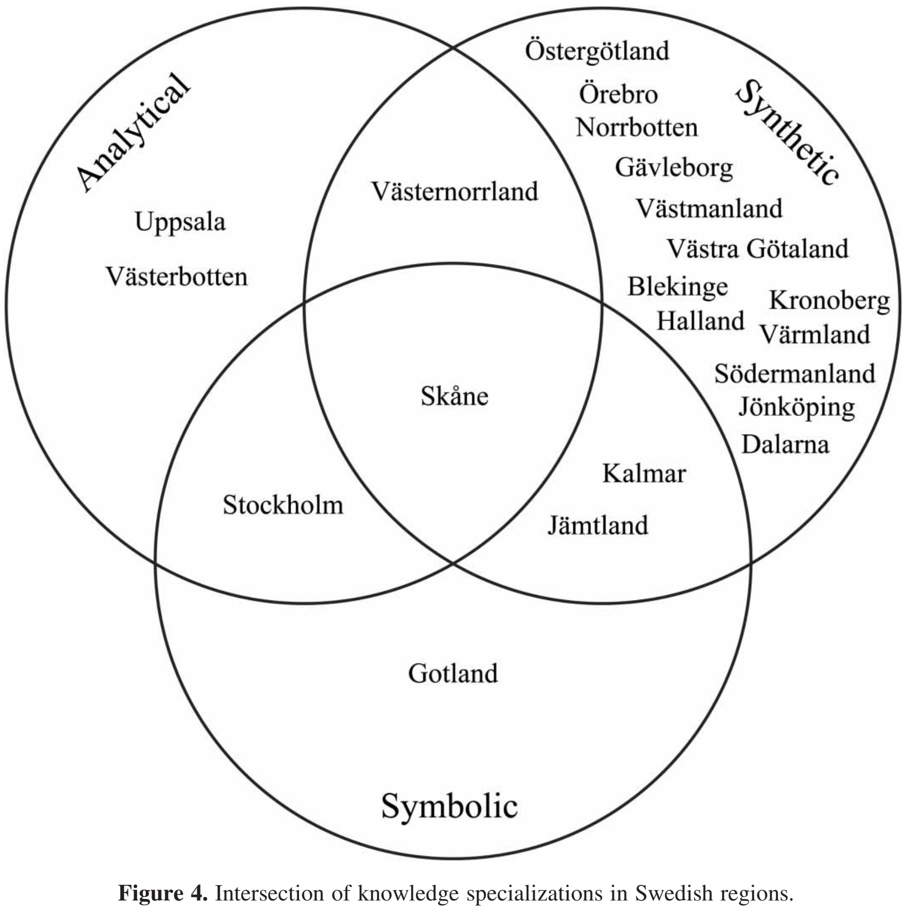

Figure 4. Intersection of knowledge specializations in Swedish regions.
Source: own draught.

interacting) modes of innovation tend to be more innovative than firms relying on only one mode. It remains open, though, to what extent this argument can be transferred to the realm of differentiated knowledge bases and regional innovation systems.

5. Conclusion

In this article, an attempt is made to develop an analytical scheme to empirically identify the knowledge base of a region. First, a review was given on the theoretical concept of differentiated knowledge bases. Second, the applied indicators and method for assessing knowledge bases were discussed. We used occupation data reflecting the tasks and duties undertaken by the local workforce, in association with an LQ analysis comparing the knowledge specialization of the regional economy to the national economy. To bring the scheme into practice, we applied it on the county level in Sweden. The results show an analytical knowledge base that is particularly strong in Uppsala and Västerbotten, a rather balanced specialization in synthetic knowledge across all Swedish counties and a strong specialization on symbolic knowledge especially in Gotland and Stockholm. The obtained results consist well with the characteristics of the regional industries identified by reviewing the literature. We conclude that the proposed scheme of analysis leads to fairly reliable results.

Therefore, we suggest bringing the method forward and extending the research agenda towards more advanced empirical work on differentiated knowledge bases. Building on the approach developed in this article, one could address further research questions. For instance, one could study whether a particular combination of knowledge specializations is favourable for innovation and economic growth. Are regions with strong analytical knowledge base more competitive than regions with a strong synthetic knowledge base, or is symbolic knowledge the critical driver for growth? Is it the combination of different types of knowledge base that leads to the best performance in terms of innovation? Furthermore, one could analyse whether particular knowledge specializations are associated with different types of growth, e.g. income versus employment growth, or different types of innovation, e.g. process versus product innovation. And finally, one could extend the analysis from a static to a more dynamic and evolutionary perspective, by observing different points in time and thereby exploring how knowledge bases transform with the evolution of a region.

It is important to stress that innovation and knowledge dynamics in a regional economy can be very complex and diversified, and can hardly be captured adequately by a set of quantitative measures. The approach promoted in this article aims at providing a first overview of the knowledge specialization of a region. Taking this aim into consideration, the developed scheme of analysis has shown to be fairly reliable and applicable for further empirically informed research on differentiated knowledge bases.

Notes

1. As far as we are aware, the first and only attempt to quantitatively assess the knowledge base of territorial entities has been made by Asheim and Hansen (2009).
2. The distinction between the three knowledge bases is intended as ideal-typical and as a mode of conceptual abstraction. In practice, most activities comprise more than one knowledge base, and the degree to which a certain knowledge base prevails can vary between industries, firms and different types of activities.
3. SCB follows a national classification system (SSYK), which is to a large extent matching the International Standard Classification of Occupation (ISCO).

4. We follow Asheim and Hansen's classification with minor modifications: instead of using not only writers and creative or performing artists to describe the symbolic knowledge base, but we also include archivists, librarians and related information professionals as well as artistic, entertainment and sports associate professionals, following Eurostat's cultural statistics (Eurostat, 2007).
5. After adapting the formula for location quotients (LQs), it can be written as LQ = $(e_i/e)/E_i/E$, where e_i the local employment with occupation attributed to knowledge base i; e the total local employment; E_i the reference area employment with occupation attributed to knowledge base i; E the total reference area employment.

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Article II

European Planning Studies Vol. 19, No. 7, July 2011

Innovation in Symbolic Industries: The Geography and Organization of Knowledge Sourcing

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(Received January 2010; accepted September 2010)

Abstract *This paper deals with geographical and organizational patterns of knowledge flows in the media industry of southern Sweden, an industry that is characterized by a strong "symbolic" knowledge base. The aim is to address the question of the local versus the non-local as the prime arena for knowledge exchange, and to examine the organizational patterns of knowledge sourcing with specific attention paid to the nature of the knowledge sourced. Symbolic industries draw heavily on creative production and a cultural awareness that is strongly embedded in the local context; thus knowledge flows and networks are expected to be most of all locally configured, and firms to rely on less formalized knowledge sources rather than scientific knowledge or principles. Based on structured and semi-structured interviews with firm representatives, these assumptions are empirically assessed through social network analysis and descriptive statistics. Our findings show that firms rely above all on knowledge that is generated in project work through learning-by-doing and by interaction with other firms in localized networks.*

Introduction

It is widely recognized, among researchers as well as among policy makers, that innovation is one of the key drivers behind sustainable regional economic growth. There is also consensus on the claim that such innovation-based economic growth not only emanates from those industries that traditionally have been referred to as science based and (high-) technology oriented, but from more or less all segments of the economy. As opposed to the linear view on innovation, in which new products or processes were perceived as natural outcomes of scientific breakthroughs (Bush, 1945), innovations are now largely understood as outcomes of interactive, non-linear, processes (Kline & Rosenberg, 1986; Pavitt, 2005). The trigger for renewal can thus in principle appear in any part of the problem solving

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ISSN 0965-4313 Print/ISSN 1469-5944 Online/11/071183–21
DOI: 10.1080/09654313.2011.573131

sequence, through crucial input from various types of actors. In the last couple of decades, this view on interactivity has been further pronounced, with increased attention paid to economic activities transcending established sector boundaries (Boschma & Iammarino, 2009). There is, however, 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 differ between different types of activities based on different types of knowledge.

So far, explanations of observed patterns of interactive knowledge creation are best described as dichotomous or, in more elaborated discussions, binary. On the one hand, geographical and organizational proximity[1] between interacting parties is seen as a crucial condition, enabler, or at least an important factor facilitating knowledge exchange between organizations and individuals (Torre & Gilly, 2000; Boschma, 2005). The tacit dimension of knowledge is usually stressed as the factor calling for proximity and direct face-to-face interaction since such knowledge cannot be detached from the knowledge holder's mind and expressed through words or symbols (Polanyi, 1967). On the other hand, proponents of a diminished role of geographical proximity for knowledge exchange have stressed that globalization and improved technological tools for interpersonal communication reduced these spatial barriers and the need for face-to-face interaction, thus enabling organizational proximity at distance (Gertler, 2008). The codified dimension of knowledge is stressed as the factor making most knowledge (sooner or later) ubiquitous and thereby less sensitive to space (Malmberg & Maskell, 1999; Gertler & Wolfe, 2006). However, none of these arguments are convincing on a stand-alone basis, especially not since proponents of both arguments also admit that all knowledge has, and always has had, both a tacit and a codified dimension (Nonaka & Takeuchi, 1995; Mokyr, 2003). In concrete studies of knowledge networks among firms and other organizations this becomes striking. Clusters of firms tightly knit together in various forms of (traded and untraded) interdependencies are at the same time also deeply involved in globally distributed knowledge networks (Hagedoorn, 2002; Gertler & Levitte, 2005). The conclusion from such studies would, if not further problematized, imply that geographical proximity seems to matter, but not always and not in all respects. Such a conclusion is highly unsatisfactory if not taken one step further in trying to specify when geography matters for knowledge exchange, in what respect, and why (Tödtling *et al.*, 2009).

This paper contributes to filling this gap by presenting new findings on the spatial, sectoral and organizational patterns of innovation among actors representing a subset of sectors here referred to as "symbolic". Instead of joining in on the binary arguments on the role of geography for knowledge exchange roughly outlined above, this paper aims to qualify the discussion by arguing that deeper insights in the crucial *knowledge base* of actors, specifying the nature of the knowledge they share in their processes of interactive learning (beyond the tacit-codified dichotomy), contribute to transcending these binary arguments, explaining when geography matters for knowledge exchange, in what respects, and why. The knowledge base approach (Asheim & Gertler, 2005; Cooke *et al.*, 2007) takes account not only of the different combinations of tacit and codified knowledge inherent in all knowledge and the various codification possibilities of different forms of tacit knowledge, but also, and more importantly, on the *contextual* dimension of knowledge and the underlying rationale for knowledge creation in various types of economic activities (Moodysson *et al.*, 2008). While "analytical" and "synthetic" knowledge differ primarily with regard to degree of tacitness, formalization and ultimate aim for knowledge creation, "symbolic" knowledge can be distinguished primarily based on its context specificity. Thus, while knowledge production in industries defined as ultimately drawing on symbolic knowledge may be heavily influenced also by elements of both analytical and synthetic knowledge (and the geographical preconditions these respective combinations imply), the symbolic element calls for localized learning since the meaning of symbolic knowledge is highly variable between place, class, gender and other contextually bound factors (Gertler, 2008; Asheim & Hansen, 2009).

These arguments are developed in the following, in which various reasons are brought forward to explain why geography matters for knowledge exchange, and why this is particularly true for symbolic industries. The main theoretical arguments refer to spatially bounded accessibility and transferability of knowledge as well as to trust and reciprocity that facilitates knowledge exchange within the local milieu. This leads to the claim that an awareness of the specific knowledge characteristics of an industry is decisive to understand differences regarding modes and preconditions for innovation, and that patterns of knowledge sourcing can vary substantially subject to the knowledge base of an industry. The paper addresses the empirical research question how geographical and organizational patterns of knowledge flows are shaped in industries that draw on symbolic knowledge. To shed light on this issue, empirical evidence is obtained from a case study on the moving media industry in Scania, the southernmost province of Sweden. The industrial cluster is composed of 71 mostly small and medium-sized firms with activities in the area of digital arts and design, ranging from film and TV production to computer games and graphical applications for hand held digital devices. Drawing on standardized and semi-standardized interviews with firm representatives, we question the local versus the non-local as the prime arena for knowledge exchange among firms and related actors, and examine the organizational patterns of knowledge sourcing. To illustrate the points, findings from the present study are put in perspective through comparisons with previous studies on patterns of innovation in subsets of other sectors referred to as analytical and synthetic, respectively (Asheim & Gertler, 2005).

Spatial and Organizational Preconditions for Knowledge Sourcing: A Review of Dichotomies

One widespread assumption among academics studying innovation processes and interactive learning has been, and largely remains, that knowledge sourcing tends to be facilitated by short geographical distance between the learning counterparts (Gertler, 1995, 2003). Knowledge is thus assumed to flow smoother within than across the territorial boundaries of regional clusters. This assumption is shared also by those scholars not particularly interested in innovation but searching more broadly for explanations to the phenomena of agglomerations (Storper, 1997; Storper & Venables, 2004). Also, in times when opportunities for individual and organizational mobility increase and the costs for transport and communication over long distances decrease, agglomeration tends to sustain. There are thus other factors than pure costs and time constraints in play sustaining local concentrations of similar and related actors. Cognitive and social preconditions for knowledge exchange are usually described as being among the most influential of such factors. External economies arising from shared investments in and easy access to localized resources (i.e. what Glaeser *et al.* (1992) refer to as static externalities) are thus no longer always as important as the localized learning taking place as a result of good relations between organizations in spatially concentrated networks (Malmberg & Maskell, 2006). Good relations are, in this context, defined as relations characterized by mutual trust and understanding.

These arguments are, to a large extent, based on Alfred Marshall's seminal work on industrial districts. The core of the argument is that geographical distance serves as a barrier for knowledge spillovers which actors embedded in a local milieu can benefit from without making particular investments. As Marshall (1920, p. IV.X.7) argues "(. . .) so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air". There are two main assumptions behind this argument. One has to do with accessibility and one with transferability. The accessibility assumption takes account of the actors' capacity constraints with regard to mobility and dissemination, while the transferability argument takes account of the nature and content of the knowledge that is to be exchanged. As already touched upon above, the mobility and dissemination argument has lost in importance as a result of globalization. Pure physical (Euclidian) distance is less a barrier for interaction today, partly due to improved means of transportation but also, and more importantly, due to improved means of communication at distance (e.g. the Internet).

The transferability argument though, very much persists. Despite wide possibilities to meet and communicate on a global scale, many of the most influential channels for transferring knowledge remain localized. One important reason for this is ascribed the tacit dimension of all knowledge (Nightingale, 1998). Even though *information* can be disseminated through various means of communication at distance, exchange of *knowledge* requires interaction collocated in time and space. This is due to the fact that the tacit element cannot be detached from the knowledge holders mind and expressed through words or other symbols. Transfer of tacit knowledge from one individual to another can thus only take place through demonstration and direct face-to-face interaction (Polanyi, 1967; Malmberg & Maskell, 1999). In addition to this transferability argument taking account of the nature of knowledge, there is also a trust and reciprocity based argument in favour of localized learning. Through a mingling of personal and professional relations in the local milieu, actors are assumed to be more inclined to trust each other and to engage in knowledge exchange with immediate neighbours than with actors located elsewhere (Gertler *et al.*, 2000). Some scholars take this argument even further, stating that actors learn from such "local buzz" more or less without intentions (Bathelt *et al.*, 2004). Knowledge is thus assumed to *spill over* between firms and individuals (Audretsch & Feldman, 1996).

There are, however, at least two reservations to these assumptions of local buzz and knowledge spillovers in clusters appearing in the literature. The first is based on a theoretical argument and takes account of the absorptive capacity of actors exposed to such spillovers. Even though there may be a relatively higher likelihood that collocated actors are exposed to knowledge flows between each other (for whatever of the reasons touched upon above), learning also requires that they are able to adopt and make use of these knowledge flows (Giuliani, 2007). Such absorptive capacity presupposes a certain degree of cognitive similarity to allow understanding and a certain degree of cognitive dissimilarity to avoid redundancy (Nooteboom, 1999). Such optimal cognitive scope is defined by the specific knowledge of the actors rather than their complementary engagement in friendship, family or organizationally defined relations. Actors who know, trust and like each other may be more inclined to share certain information, but they are not necessarily destined to learn from each other. The second reservation is based on an empirical argument and takes account of the surprisingly few concrete observations supporting the assumption on localized learning. Contrary to the theoretical arguments in favour of local knowledge spillovers as one of the key explanations to industrial clustering, many studies specifically oriented towards tracing knowledge flows between firms and related actors identify a low degree of local knowledge exchange in clusters compared to the global knowledge flows taking place (Hagedoorn, 2002; McKelvey *et al.*, 2003; Gertler & Levitte, 2005; Moodysson, 2008). In science-based (analytical) industries like biotechnology and some niches of ICT, the most crucial flows of knowledge seem to take place in globally configured epistemic communities rather than in locally configured, trust-based inclusive networks (Amin & Cohendet, 2004; Moodysson, 2008), but also in traditional (synthetic) manufacturing (Lagendijk & Boekema, 2008) and creative (symbolic) industries like media and film production, local clusters are highly dependent on input from non-local knowledge sources (Coe, 2001; Nachum & Keeble, 2003). The local environment is thus important, primarily as a source of specialized human capital, but knowledge exchange through bilateral collaboration (formal as well as informal) is, in some industries, relatively rare. Instead such intentional knowledge exchange is organized through "pipelines", i.e. thoroughly planned networks anchored in formal agreements (Bathelt *et al.*, 2004; Owen-Smith & Powell, 2004) or through interpersonal relations with peers (Knorr-Cetina, 1999; Powell & Grodal, 2005). These are built both on a local and a global scale, in some studies referred to as composing "Neo-Marshallian nodes in global networks" (Amin & Thrift, 1992).

This is obviously not to say that more or less unintentional knowledge spillovers do not take place. Buzz may very well serve as an important source of social capital formation in the local (or non-local) industrial environment, but the knowledge influencing innovation processes are usually sourced in a far more organized manner (Moodysson, 2008). The often-referred-to incidental meeting at the local pub or restaurant leading to breakthrough innovation is probably, at least in a Scandinavian context, nothing more than a fascinating story, maybe a onetime event that over the years has transformed into a widespread myth on how the seed for innovations usually occur. Nevertheless, the local environment sometimes offers advantages as source of knowledge, otherwise clusters would erode when the companies initially started as local spin-offs tap into international networks (or they would never have appeared in the first place). One such advantage is connected to the above-mentioned mingling of personal and professional relations, not necessarily because it facilitates interpersonal trust and incentives for sharing knowledge about product development and technologies, but because it facilitates the transfer of rumours and various forms of strategic information (Grabher, 2002). One form of such strategic information is what Johnson *et al.* (2002) coined "know-who" knowledge. This refers to knowledge about who knows what and what to do, i.e. insights into existing networks of competence and influence. In science-based industries such know-who knowledge is largely distributed in global communities (i.e. interpersonal professional networks), while there are reasons to believe that those networks are less geographically distributed in many other industries. Following our arguments on the context specificity of knowledge in symbolic industries there are reasons to expect that the moving media industry represents one such example. The argument is further developed in the next section, followed by an empirical assessment.

Transcending Dichotomies: The Knowledge Base as Decisive Factor

Despite the fact that innovation takes place, and is seen as equally important, in more or less all parts of today's economy, most attention among innovation researchers has so far been dedicated to high-technology sectors. Innovation in the service sector is given less priority, and to the extent that low-technology industries are analysed, the main focus has been on technological upgrading, for instance through new combinations of industries (e.g. production and ICT, food and modern biotechnology etc.). Nevertheless, the literature has highlighted the need to contextualize our understanding of preconditions for knowledge sourcing, and indicated that one of the most important explanations of differences between industries with regard to modes of and preconditions for innovation has to do with the specific knowledge base of companies composing the respective industry. Keith Pavitt's well-known taxonomy of industries (1984) largely takes account of the technological diversity of actors, distinguishing on the one hand between technology suppliers and acquirers, and on the other hand on the level of specialization/sophistication. Asheim and Gertler's (2005) alternative distinction, which is used as main point of departure in this paper, follows a different rationale. Instead of comparing industries based on the technological scope and sourcing, they take account of the *nature of knowledge* which is crucial for the sector, the knowledge the sector cannot do without or, phrased differently, the knowledge that defines the fundamental basis of the actors' competitiveness (Moodysson, 2007).

The literature specifies three different types of such "knowledge bases": analytical, synthetic and symbolic (Asheim *et al.*, 2007a; Cooke *et al.*, 2007). Innovation in industries drawing on an analytical knowledge base is largely oriented towards development and application of basic science. The crucial knowledge is to a high degree codified, meaning is relatively constant between places, and the transfer of such "propositional" knowledge from one organization to another is therefore less sensitive to geographical distance between the exchanging counterparts. The basic rationale for knowledge creation is to understand the constituting parts of functional systems (e.g. machines) and explain the structures and mechanisms behind their workings. It is thus such ability of understanding and explanation that defines the foundation of the actors' competitiveness in this type of industry. Synthetic industries, on the other hand, are primarily oriented towards solving concrete practical, functional challenges, not necessarily through understanding and explaining the structures and mechanisms behind them. The basic rationale for knowledge creation is thus to control functional systems. The crucial knowledge is to a much higher extent tacit, experience based and immediately connected to a specific application. For that reason the transfer of knowledge from one organization to another is highly sensitive to geographical distance. Knowledge exchange requires physical co-location, primarily because the limited transferability of such knowledge requires direct face-to-face interaction. Due to the tacit dimension of such "prescriptive" knowledge, meaning initially varies substantially between places (Asheim & Hansen, 2009), but through the process of diffusion, broadening the "metaset of feasible techniques" (Mokyr, 2003, p. 11), such context specificity becomes less pronounced over time. Innovation in symbolic industries, finally, draws on yet a different logic. The main purpose of these types of actors is to trig reactions in the mind of consumers. The innovation is not as much a product or a process as an idea and the impression that it carries. The basic rationale for knowledge creation is thus to shape meaning and desire through an affecting sensuous medium (Asheim *et al.*, 2007a). The transfer of such knowledge from one organization to another is not by definition sensitive to geographical distance, but due to the contextual nature of symbolic knowledge, the absorptive capacity of actors involved in knowledge exchange is highly localized, embedded in the socio-cultural milieu of the location of the firm.

It would, as mentioned above, be fair to claim that most attention in previous studies focusing on geographical preconditions for knowledge exchange in innovation processes has been dedicated to industries drawing on a combination of analytical and synthetic knowledge (Coenen *et al.*, 2006; Moodysson, 2008) where symbolic elements are secondary. Yet, in parallel with the immense attention to emerging industries in the intersection of science and industry (especially biotechnology and to some extent ICT), there is a growing interest among scholars to learn more about innovation in industries representing the convergence of industry and arts (Lorenzen *et al.*, 2008). These types of industries are sometimes referred to as "creative" (Caves, 2000) or "cultural" (Lash & Urry, 1994; Pratt, 1997; Scott, 2000; Power, 2002). Creative/cultural industries are, according to the classification introduced above, prime examples of industries drawing heavily on a symbolic knowledge base. The essence of a product or a process in these industries is an impression, an experience, an image or another type of intangible good whose prime function is materialized first when it enters the mind of the user (e.g. the consumer). The sign-value of intangible brands, impressions and (aesthetic) symbols is often superior to the actual use-value of tangible products in defining their success or failure (Lash & Urry, 1994). Since such sign-value is contingent on culturally defined values and schemes of interpretation, it is reasonable to expect that the learning processes that take place through interaction between firms and related actors in industries with strong symbolic components, as well as user-producer relations, are more localized than in analytical and synthetic industries where such schemes of interpretations are more universal (e.g. scientific laws, engineering principles). Local knowledge spillovers in the latter type of industries are thus more about social networking, gossip and orientation about what is going on in the industry and region than actual knowledge exchange feeding into product development within the firms.

The remainder of this paper deals with spatial and organizational patterns of knowledge flows in a specific subset of symbolic industries. The aim is to question the local versus the non-local as the prime arena for knowledge exchange among firms and related actors, and to examine the organizational patterns of knowledge sourcing. We enter into the question whether symbolic industries rely more on local than on non-local knowledge sources, and whether knowledge sources with lower degree of formalization are more important than sources with higher degree of formalization. Explanatory factors are thus not sought in the tacitness of knowledge (as most traditional approaches have done), but in its contextual specificity. Based on the preliminary theoretical considerations outlined above, we would expect knowledge sourcing in symbolic industries to be above all a local phenomenon, and thus knowledge sources in spatial proximity to the firms analysed to be of prime importance for their innovation activities. As regard the organizational patterns, we would expect a dominance of various forms of knowledge sourcing through interaction between firms and related actors and through users-producer relations, and a minor role of formalized knowledge stemming from universities and other scientific organizations.

Empirical Assessment: Knowledge Sourcing Among Moving Media Firms in Sweden

Research Design

This study addresses these expectations through a combined survey and interview-based study of actors specialized in moving media, located in Sweden. The moving media industry cannot be identified and delimited through established industry classification systems (e.g. NACE) but spans a range of organizationally distinct, but functionally related, activities. The degree of relatedness should be large enough to allow for cooperation and knowledge exchange between actors, yet small enough to cover a variety of skills and competences that can complement one another. Real opportunities for learning can occur if the relatedness of activities is neither too small nor too large (Nooteboom, 1999; Boschma & Iammarino, 2009). Concrete examples in the case of moving media 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. What these activities have in common is that they all display strong symbolic components as regards their output and that they all, as regards key competences required in the innovation process, draw heavily on artistic skills as crucial complements to more traditional qualifications in fields like engineering, science and management. The study pays main attention to the organization and spatial distribution of knowledge flows among organizations (firms) engaged in such development and production. The analysis is based on a multilevel approach, combining a micro-perspective on activities and a system-perspective on the configuration of interacting actors. Detailed innovation biographies, drawing on a combination of in-depth interviews with key stakeholders and document studies, are used to illustrate the specificities of knowledge creation. An attempt is thereby made to fill the gap in the literature as regards preconditions for innovation in these industries. The assumptions/expectations on the spatial and organizational preconditions for knowledge sourcing in symbolic industries (specified in the previous section) are empirically assessed through social network analysis on firms composing the moving media cluster in southern Sweden.

The study adopts an inclusive approach to knowledge sourcing, covering bilateral collaboration as well as indirect interaction through mobility of key personnel (e.g. recruitment of staff), and monitoring of actors through various forms of interaction at arm's length (e.g. fairs and exhibitions, books, journals and magazines, surveys, the Internet). In addition to the spatial dimension, distinguishing regional, national and international knowledge sourcing, the study also reveals organizational and sectoral patterns of knowledge sourcing by measuring the extent to which knowledge exchange among the new media firms composing the source population takes place with actors representing: (1) universities, (2) other firms from the same industry, and (3) other firms from other industries. While the first assessment (the spatial dimension) primarily targets the discussion on localized learning, the second (the organizational and sectoral dimension) takes account of the issue of cognitive scope and absorptive capacity. As touched upon above, these two dimensions are inseparable in an analysis of interactive innovation.

Descriptive statistics, and network diagrams accompanying them, form the basis for an analysis of the spatial preconditions for innovation in symbolic industries; how innovation processes are organized and to what extent and under which geographical conditions knowledge flows between firms and related actors. Interpretation of the quantitative data is influenced by insights from in-depth interviews with innovating firms in which the innovation process as such was discussed in an open manner, without specific questions on geographical and sectoral distribution of knowledge networks. Instead, the interviewees were asked to describe their innovation processes, to explain the main rationale for activities carried out, what type of challenges they faced in different stages of the innovation process and how they handled these challenges.

Our main source of data draws on structured interviews with 37 firms situated in the region of Scania. The interviews were conducted between May and September 2008. The number of firms in the sample represents 52.1% of all moving media firms located in the region by that time. Since the majority of the firms working with moving media represent small and specialized niches of other more generic sectors (like ICT, advertising, software development, etc.) it was not possible to use official statistics to identify the source population. This was instead done through a dialogue with a regional support organization specialized in moving media. Based on an inclusive list of actors whom this support organization had identified as being involved in, or related to, activities classified as moving media, a manual selection process was carried out. Inactive firms and firms that only have sales departments in the region were excluded. So 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 companies. Most of them are small firms, the majority with less than 10 employees.

Introduction to the Case

The moving media industry in Southern Sweden (epicentre in the city of Malmö) represents a new niche in a regional economy historically based on heavy manufacturing. The growth of the industry took off in the late 1990s/early 2000s, a period in which the local university (Malmö University) also grew rapidly. Malmö University decided to employ a strategy focusing their research and educational activities on applied science and "creative" activities (arts, design, moving images, etc.), partly as an attempt to distinguish themselves from the larger and more established Lund University with a strong focus on educations in science and engineering. The majority of the firms composing the media cluster are located in the western part of Malmö. This was the site of shipping and heavy processing industries until the close down at the turn of the century. The neighbourhood is now being heavily transformed. Regional authorities (Region Skåne and the Municipality of Malmö) have an explicit ambition to make this area the new landmark of the city. With regard to industrial activities, moving media covers the scope from traditional film and broadcasting to digital design and computer games software. A common feature of all these activities, despite their broad scope with regard to applications, is that they ultimately draw on a symbolic (artistic) knowledge base (Asheim *et al.*, 2007a). Another shared feature, partly coming as a natural consequence of the crucial knowledge base, is that they are geared towards creating images and experiences rather than production. Project organization and informal networking are important, formalized networks less frequent. Public policy support is perceived as very important for the future growth of this industry, not only by providing resources (e.g. subsidies and grants) but also by catering for the long-term supply of qualified labour (e.g. education policy) and for the formation of attractive living conditions for this type of workforce (Florida, 2002). However, the most highly profiled policy support program targeting this industry, Moving Media Southern Sweden, is more concerned with network promoting activities than supply and sustainment of human capital in the region. The question is whether these activities reflect the real needs of the industry.

Illustrative Case: Innovation in a Moving Media Company

The illustrative case for a typical innovation process in this subset of symbolic industries is taken from a company working with development of user-friendly graphical interfaces for hand-held digital devices (e.g. mobile telephones). The company was founded by a group of six young designers; four engineers, one industrial designer, and one with a background in cinema studies. Their diverse educational backgrounds where unified through a shared interest in digital arts. After organising a series of art exhibitions in the early 2000s they were approached by a company developing computer games asking for their services. This, in turn, led to further jobs developing games for mobile telephones, and eventually to the formation of a company specialized in graphical interfaces. The company was based on a philosophy of design as something primarily targeting human interpretation, not visual performance. The design orientation in combination with cutting edge technology solutions shaped a winning formula. Today the company employs around 140 staff with development offices all over the world. The main unit for development is still located in Malmö. The problem-solving sequence involves three main challenges, here revealed in order of importance from the company's perspective: (1) to differentiate and enhance the user experiences of portable devices, (2) to control the display (on a computer monitor) that allows the user to interact with the system, (3) to reveal the mechanisms defining the workings of data-enabled operating systems. By attacking these three challenges, drawing on a combination of engineering and art skills, however with core competence in digital design, the company now creates solutions applied by most major mobile telephone producers in the world.

Linking this illustration to the classification of knowledge bases introduced above, it is clear that all three knowledge bases, and the modes of knowledge creation characterising them, appear in this company's innovation processes. It is, however, the symbolic knowledge base that defines the fundamental basis of the firm's competitiveness, shaping the core of the innovation. The analytical challenge, revealing the mechanisms defining the workings of data-enabled operating systems, could in principle be carried out by any advanced service supplier specialized in data-enabled operating systems. The technological solution would not need to be tailor-made for this specific application. Also the synthetic challenge, controlling the display of the device (in a functional sense), could be outsourced to a subcontractor. The symbolic challenge on the other hand, differentiating and enhancing the user experience of portable devices, constitutes the core of this company's innovation. The former would be of no specific use without the latter. Table 1 illustrates the innovation process of the company.

While this company is illustrative for symbolic industries also drawing on the other two knowledge bases, it is not necessarily the most representative case for the cluster under study. Due to the sectorally diverse composition of the cluster it is hard, not to say impossible, to find such a representative case. Besides technology-intensive symbolic companies like the above example and the firms developing computer games software and the like, a large share of the companies in the cluster draw almost unilaterally on symbolic knowledge with more limited influences of analytical and synthetic knowledge. Among those

Table 1. Knowledge bases involved in the innovation process of a moving media firm

	Analytical	Synthetic	*Symbolic*
Rationale for knowledge creation	Reveal the mechanisms defining the workings of data-enabled operating systems	Control the display (on a computer monitor) that allows the user to interact with the system	*Differentiate and enhance the user experience of portable devices* (*e.g. mobile phones*)
Modes of knowledge creation	Interpretation of existing systems by unravelling their structures	Experimentation, trial and error	*Advanced design based on visual experience and artistic skills* (*creative process*)
Knowledge characteristics	Formalized scientific knowledge (advanced mathematics)	Experience-based practical/ technical knowledge	*Knowledge adapted to* (*territorially confined*) *cognitive institutions* (*language, perception, etc*)

Source: own draft.

are a large group of traditional film and TV producers. Most innovation processes are initially organized through projects, in large part building on informal networks of key personnel forming temporary alliances on an ad hoc basis (Grabher, 2004; Isaksen & Asheim, 2008). This is partly because the industry operates in a constantly changing market, even more sensitive to trends than most industries (maybe the financial sector excluded). Thus, flexible work-forms are needed to permit fast reaction on latest trends in shifting markets conditions. Projects are flexible since firms can acquire additional competences for a specific task without binding in long-term contracts (Lundin & Söderholm, 1995). Actors with specialized knowledge come together and carry out innovation though short-term cooperation. Consequently, knowledge about potential collaborators with complementary skills ("know who") is essential for these industries. The local pool of human capital suitable for such temporary alliances is therefore crucial for the performance of the companies. When it comes to the more long-term established alliances between organizations in later stages of the development process, shared socio-cultural schemes of interpretation are decisive for the selection of partners. Returning to the example of the digital design company referred to above, they have, for this specific reason, established development offices in various parts of the world instead of only sales departments as most companies do. By being close to the market, sharing the culturally defined interpretive schemes of potential customers and partners, they are able to adapt to the specific demands of their respective regions instead of providing standard solutions applicable to the entire global market.

Knowledge Sourcing in the Moving Media Industry

Below follows a descriptive account on patterns of knowledge sourcing in the moving media industry through *monitoring*, *mobility* and *collaboration*. Monitoring refers to search for knowledge outside the organizational boundaries of the firm, but without direct interaction with these external sources. Mobility refers to retrieving knowledge input through recruitment of key employees from other organizations (e.g. firms, universities). Collaboration refers to exchange of knowledge through direct interaction with other organizations. Firms were asked to indicate the importance of those various sources of knowledge 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 of course a range of possible sources of knowledge. Other firms doing similar things (competitors), universities and firms working with related and supporting activities (suppliers), and actors representing the users of the moving media firms' products or services (customers) are probably the most obvious primary sources of knowledge. However, in this section on monitoring, the main attention has been paid to the "secondary" sources, or intermediaries, carrying knowledge from these primary sources. Examples of such are scientific journals reporting results from basic research, surveys in form of questionnaires or interviews carried out and published by various types of business and support organizations, magazines specialized in issues connected to certain industries and/or technologies, and fairs and exhibitions focusing on the specific interests of the moving media industry or related fields. Due to the symbolic nature of moving media it is reasonable to expect a low importance of scientific journals as a source of knowledge input. Due to the informal and ad hoc oriented type of project organization dominating innovation activities where know-who knowledge is considered far more important than know-what, it is also reasonable to expect a fairly low importance of the type of surveys described above. On the other hand, it is, for similar reasons, reasonable to expect a high importance of fairs, exhibitions and other types of organized meeting places aiming to stimulate inter-organizational network formation. Since the moving media industry is strongly oriented towards creating and affecting perception, and since such perception is highly influenced by the socio-cultural context, yet supposed to evolve in line with current trends and fashion, it is also reasonable to expect that specialized magazines reporting such trends are considered important. In addition to distinguishing between these different sources of knowledge in our analysis, we also divide the findings into two different types of knowledge sourced through these means: technological knowledge which is required as direct input in the development of new or improved products and processes, and market knowledge which is knowledge about new trends and developments on the market. With the exception of fairs and exhibitions it would be reasonable to expect a generally lower importance of these types of secondary sources for market knowledge since this to a large extent is retrieved through interpersonal networks.

The results (Table 2) are, however, similar for the two knowledge types, but differ considerably between various types of sources. Specialized magazines are the most important source for both technological and market knowledge. 50.0% of the interviewed firms consider magazines as important or very important for technical knowledge, 44.4% for market knowledge. Fairs and exhibitions rank second; they are considered important or very important for technological knowledge by 25.7% of the firms and for market knowledge by 36.1% of the firms. Whereas magazines and fairs seem to be essential, journals and surveys play a minor role for most companies. The share of firms considering scientific journals as important or very important is only 19.4% for technological knowledge and

Table 2. Relative importance of various sources for gathering technological and market knowledge through monitoring

	Technological knowledge				Market knowledge			
%	Fairs	Magazines	Surveys	Journals	Fairs	Magazines	Surveys	Journals
Very high	17.1	13.9	5.6	5.6	13.9	22.2	2.8	5.6
High	8.6	36.1	8.3	13.9	22.2	22.2	22.2	11.1
Moderate	42.9	22.2	25.0	25.0	30.6	25.0	25.0	25.0
Low	14.3	13.9	25.0	22.2	16.7	13.9	16.7	25.0
Very low	17.1	13.9	36.1	33.3	16.7	16.7	33.3	33.3
Total (%)	100	100	100	100	100	100	100	100
$n =$	35	36	36	36	36	36	36	36

Source: own survey.

16.7% for market knowledge; the result for surveys is similar. 33.3% of the interviewed firms explicitly attribute a very low importance to those sources of knowledge. These forms of knowledge disseminated through scientific journals and surveys are, as compared to the knowledge retrieved through specialized magazines and fairs and exhibitions, far from concrete application. Their meaning is universal and relatively constant between places. The moving media industry is in contrast, as touched upon above, very much dependent on more specific forms of knowledge generated through creative activities and interactive learning. Production processes are directed towards goods and services that include a high degree of aesthetic value, symbols and images that are very much context specific. For that reason, the moving media industry relies on information sources that are less formalized, but much more flexible, dynamic and just-in-time. It has turned out in the interviews that the actors above all rely on two additional knowledge sources. One of them is the Internet, where information on the latest products, developments and trends is available. In this context, it can be seen as an intermediary knowledge source that does not necessarily require personal interaction. However, since actors take active part in writing blogs, using twitter and cultivating their social networks over the Internet, it is very much used as a medium for direct and interactive knowledge exchange. This leads to a second additional knowledge source which is crucial for firms in the moving media industry: personal contacts and personal networks.

Knowledge Sourcing Through Mobility

As regards *mobility* of highly skilled labour, the primary sources of knowledge specified above (firms, universities) can be accessed directly, i.e. without going through an intermediary medium transferring the knowledge. By asking from where they recruit their highly skilled employees, the relative importance of these various sources is assessed. Due to the symbolic nature of the crucial knowledge base for moving media it is reasonable to expect a low importance of universities and technical colleges for recruitment of key employees since these are very much oriented towards education in science and technology. One should, though, keep in mind that some universities also provide educations in arts and design, which may be relevant for some of the moving media firms. One should also remember that the innovation activities in moving media, as discussed above, *also* draw on scientific and engineering skills (e.g. informatics, computer programming, etc). Finally, one should bear in mind that formal educations do not necessarily reflect the actual skills of employees, especially in an industry largely drawing on artistic skills often retrieved in an informal manner during life. It is thus possible that universities and technical colleges contain large pools of qualified workers in totally different fields than what the educations as such would imply. However, this potential bias in the data should not be overestimated. Due to the specialized nature of knowledge required in this type of activities (as was also indicated in the analysis of knowledge sourcing through monitoring) it is also reasonable to expect a high importance of firms in the same industry for recruitment of key employees.

As regards the spatial dimension in connection to recruitment from these various sources, it is reasonable to expect that the region and the nation stand out as more important than the rest of the world. This is partly due to the role of the socio-cultural context for the activities as such, and partly to the importance of personal networks based on know-who knowledge. Distinguishing between the various sources it is, though, also reasonable to expect that this importance of the local is more pronounced for firms in the same industry since these, at least according to our theoretical arguments, would be specialized in similar types of development and production. Complementary skills from universities, technical colleges and firms in other industries may be easier to find elsewhere since they are more universal by nature and less context dependent.

Table 3 displays the relative importance of these various sources for the recruitment of highly skilled labour. The results show that supply of skilled workforce arises primarily from the moving media industry itself. 83.3% of the interviewed firms consider recruitment from the same industry as an important or very important part of their employment strategy, whereas recruitment from other industries is regarded as important or very important by only 25.0%. Higher education facilities play a minor role is this respect: universities are seen as important or very important by 40.0% and technical colleges by only 17.1% of the interviewed firms. A substantial share of the interviewed firms explicitly attributes a very low importance to labour flows from universities and technical colleges. These results are in line with our expectations and point in the direction that analytical and synthetic competences generated in the higher education sector are not of predominant importance for artistic based industries such as moving media. Among the firms in the

Table 3. Relative importance of various sources for recruitment of highly skilled labour

%	Recruit from universities	Recruit from technical colleges	Recruit from same industry	Recruit from other industries
Very high	20.0	2.9	58.3	2.8
High	20.0	14.3	25.0	22.2
Moderate	14.3	20.0	13.9	27.8
Low	25.7	31.4	2.8	27.8
Very low	20.0	31.4	0.0	19.4
Total (%)	100	100	100	100
$n =$	35	35	36	36

Source: own survey.

source population there are examples of employees with a background as dancers and performance artists now working as programmers and designers. There are also examples of employees with a background in humanities and the social sciences working with highly technical tasks, as well as engineers working with external communication and other non-typical tasks for a trained engineer.

Additional insights derived from a distinction between geographical locations (Table 4) go fairly well in line with our expectations based on the theoretical discussion on the context dependency of certain skills and the universal nature of others. Comparing the relative importance of labour flows stemming from different spatial levels, we observe that firms attribute more importance to the regional and less to the national or international level. A large share of the interviewed firms consider other companies in the same region and industry as the most important source for the recruitment of highly skilled labour (64.7%). In contrast, many firms regard foreign universities (45.2%), technical colleges (53.3%), and other industries (45.2%) outside the country as very little important. Taking the variable "recruitment from companies in the same industry" as an example, we observe that 64.7% of the interviewed firms consider the region as very important, while 40.6% do so for the national and 35.5% for the international level. We conclude that the regional milieu plays a major role for supplying the moving media industry with highly skilled labour. Competences that are needed to create new or improve existing products and processes in the media industry have a strong localized nature; they barely cross sectoral and regional boundaries. Therefore, labour flows occur mostly between companies that are part of the moving media industry of southern Sweden. Some of the firms would, however, have liked to broaden their geographical recruitment focus if these (perceived or actual) cultural, cognitive and physical barriers had not made it too costly and risky.

Knowledge Sourcing Through Collaboration

Bilateral *collaboration* is another fundamental way of gathering knowledge for symbolic industries. It encompasses various types of knowledge that are exchanged between actors

Table 4. Relative importance of sources and their spatial level for recruitment of highly skilled labour

%		Very high	High	Moderate	Low	Very low	Total (%)	*n* =
Regional	University	35.5	22.6	6.5	12.9	22.6	100	31
	Technical college	10.0	16.7	16.7	20.0	36.7	100	30
	Same industry	64.7	17.6	14.7	0.0	2.9	100	34
	Other industries	12.1	24.2	24.2	12.1	27.3	100	33
National	University	19.4	19.4	16.1	19.4	25.8	100	31
	Technical college	0.0	13.3	30.0	26.7	30.0	100	30
	Same industry	40.6	9.4	31.3	3.1	15.6	100	32
	Other industry	3.1	12.5	37.5	12.5	34.4	100	32
International	University	12.9	12.9	22.6	6.5	45.2	100	31
	Technical college	0.0	3.3	33.3	10.0	53.3	100	30
	Same industry	35.5	12.9	22.6	6.5	22.6	100	31
	Other industry	3.2	9.7	29.0	12.9	45.2	100	31

Source: own survey.

through an intentional process of direct interaction. This can be both technological knowledge required as direct input in the development of new or improved products and processes, and knowledge about new trends and developments on the market. It is, as already discussed, reasonable to expect geographically dense local networks, especially between the moving media firms and their customers. As regards suppliers involved in the exchange of knowledge one could expect somewhat more geographically distributed networks, partly because these can be assumed to supply the companies with more universal (i.e. less context dependent) knowledge than the customers, and because they may serve as crucial sources of knowledge for firms aiming to enter new, international, markets. For the same reason one could expect knowledge exchange between moving media firms in Scania and competitors to be more internationally oriented.

Figure 1 visualizes knowledge sourcing through collaboration. Taking a look on the *structure* of the network, some characteristics of the moving media industry become clear. The network constitutes of a considerable number of actors and exchange relations; overall we count 349 nodes and 405 links. It is obvious that the majority of companies are engaged in intensive exchange of knowledge with other actors inside and outside the region. Almost all firms are part of one single network and either directly or indirectly

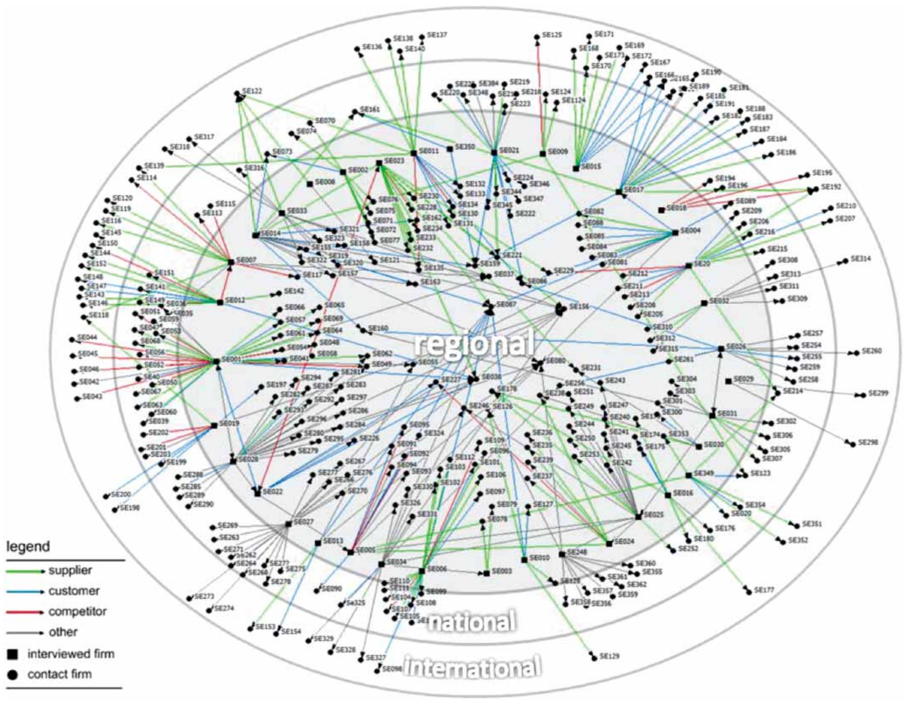

Figure 1. Knowledge flows through collaboration.
Source: own survey. Graphical illustration inspired by Plum and Hassink (2011).
Note: The network is composed of nodes and links. Nodes represent actors, links represent knowledge flows. The node shape indicates whether the actor is part of the interviewed group. The link colour indicates the type of relation (supplier, customer, competitor and other companies). The node location reflects the spatial dimension (regional, national, international).

connected to each other. Exceptions are two companies (SE029, SE032) and their partners which are not explicitly linked to the major network. There are no isolates; all actors are more or less deeply integrated into the network, whereas most firms communicate with numerous different partners.

On the one hand, some firms have a variety of knowledge sources to rely on; they consider a large number of firms to be valuable exchange partners (e.g. SE001, SE028). Those companies rely heavily on collaboration as an essential source of knowledge. On the other hand, some actors are mentioned repeatedly as important partners. These organizations are central knowledge sources and can be considered as key players in the moving media industry. These are foremost the Municipality of Malmö (SE087), Malmö University (SE080) and Media Mötesplats Malmö (SE156), which is an intermediate organization aiming at strengthening the regional moving media industry. As regards the expected differences between relations with customers, suppliers and competitors, one can see that most of the knowledge flows occur along the supply chain with suppliers (30.0%) or with customers (22.6%). Competitors account for only a small share of all knowledge flows (8.7%) whereas the largest share is other companies that do not fall in the previous categories (38.7%). Going more into details of the network structure, one can see that the majority of firms share knowledge both with their customers and their suppliers (e.g. SE015, SE017). The expected patterns of a larger share of international linkages for exchange of knowledge with competitors and suppliers could not be confirmed.

Considering the *spatial location* of actors and exchange relations, one can see that contact partners are situated both inside and outside the region: out of all 349 actors included in the sample, 51.9% are situated in the functional region of Scania, 28.1% in other parts of Sweden and 20.1% outside the country. We regard Copenhagen as part of the same functional region, since the Danish capital city is only a short train ride away from Malmö and intensive commuting takes place between the two cities[2]. Of all 181 actors considered as part of the functional region of Scania, 16 are actually situated in Copenhagen. Regarding the geographical pattern of knowledge flows, we count 405 links, of which 54.8% occur within the functional region of Scania, 24.4% within the country and 20.7% cross national boundaries. Although national and international linkages are considerably present, intra-regional knowledge exchange is prevailing. This empirical observation is in line with our expectation that knowledge exchange and interactive learning are most effectively conducted through direct face-to-face interaction, therefore firms tend to cooperate primarily with actors located in geographical proximity. This is also confirmed in discussions with firm representatives. Not only does time constraints matter, but also the trust and mutual understanding which only can be achieved through repeated physical meetings.

Conclusions and Implications for Further Research

In this paper, we studied the moving media industry of Southern Sweden as an example of economic activities that are to a large extent based on symbolic knowledge, to shed light on the organizational patterns of knowledge sourcing in this type of industry and to address the question of whether local or non-local is the main locus for knowledge exchange among firms and relates actors. The aim was to examine the organization of innovation processes with a specific focus on the geographical distribution of knowledge networks and the distinctive nature of knowledge flows in symbolic industries. The notion of knowledge flows was captured from three different angels: *monitoring*, *mobility* and *collaboration*. Our main finding can be summarized as follows. As regards monitoring, e.g. knowledge sourcing through intermediaries, we found that less formalized knowledge sources such as fairs, exhibitions, specialized magazines and the Internet are considered more important than surveys and journals representing scientific knowledge and principles. As regards mobility of key employees, e.g. exchange of knowledge embodied in human capital, we found that knowledge sources in geographic proximity are predominant. The interviewed firms recruit primarily from organizations situated in the same region. Most important in this respect are not local universities or other higher education facilities, but other firms in the same industry. As regards collaboration, e.g. direct interaction between actors, we found that firms are connected to each other in a dense network. Knowledge flows are very much locally configured and occur above all within the regional boundaries.

These observations are in line with our preliminary theoretical considerations. It lies in the nature of symbolic knowledge to be 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.*, 2007b, 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.). The meaning and value associated with symbolic knowledge can thus vary considerably between social groupings and places. Therefore, knowledge flows are more likely to occur if the involved partners share the same socio-cultural background and are part of the same regional environment, which has been emphasized in this paper. Concrete examples of strategies trying to deal with this are firms establishing sub-units in different countries and on different continents even when it, from a technical and practical point of view, would have been possible to deal with worldwide operations from one location.

Likewise, our theory-led expectations concerning the organizational patterns of knowledge sourcing have been confirmed. Scientific principles and knowledge stemming from universities and other scientific organizations tend to be of minor importance. This holds especially for codified knowledge written down in scientific journals and for other monitoring activities drawing on scientific principles. As phrased by Asheim *et al.* (2007b): "the acquisition of essential creative, imaginative, and interpretive skills is less tied to formal qualifications and university degrees than it is to practice in various stages of the creative process" (p. 665). What drives innovation in symbolic industries is above all knowledge acquired through various forms of learning-by-doing and on the job training, as well as through face-to-face interaction between firms and other actors in the (regional) industry. Yet, universities may still be important for future employees targeting this industry, not least through fostering norms, habits, and interests among students and through providing a platform for interpersonal contacts and network formation.

The present study indicates a potential need for further research. A first step would be to contrast the results obtained from the moving media industry with industries that are characterized by a different, i.e. an analytical and a synthetic knowledge base. Whereas symbolic industries have turned out to be above all locally based, we expect synthetic industries to rely partly on codified knowledge and thereby not necessarily locally configured networks but networks configured on any territorial scale within which such knowledge are valid (e.g. principles and technical standards on a national or European level). Analytical industries, in contrast, deal with scientific knowledge and principles that are relatively constant between places, thus knowledge flows and networks are expected to be significantly more globally configured. Providing empirical evidence for these assumptions would underline the importance of the local sphere for symbolic as opposed to other industries. A second step would be to derive implications for fine-tuned regional innovation policy. It is reasonable to argue that industries that are based on symbolic knowledge will need different policy mixes and measures than those primarily based on analytical or synthetic knowledge. Our findings on the moving media industry reveal that economic activities in artistic-based industries are very much locally configured and draw on knowledge that is generated through cooperation and interaction between firms and related actors in the region. Thus, one could expect that polices aiming at networking activities on the subnational level will have a positive impetus on the development of these industries, whereas similar strategies might prove as failure in the case of analytical or synthetic-based industries. These expectations could be further elaborated on the basis of interviews with policy makers and firm representatives. To sum up, we believe that a sound awareness of differentiated knowledge bases can be helpful both for policymakers aiming at sustainable regional economic growth and researchers striving towards a nuanced understanding of the geography for innovation.

Notes

1. Organizational proximity includes various sub-dimensions such as social, cultural, institutional and, probably most important in the context of knowledge exchange and learning, cognitive proximity.
2. Commuting between Malmö and Copenhagen has become a major issue with the opening of the Öresund Bridge in year 2000. At the end of year 2007, 15,300 persons commuted daily between the two sides of the bridge (Trendsoresund, 2008).

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Article III

Article

EUROPEAN URBAN AND REGIONAL STUDIES

European Urban and Regional Studies
1–18

DOI: 10.1177/0969776411427326
eur.sagepub.com
SAGE

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.

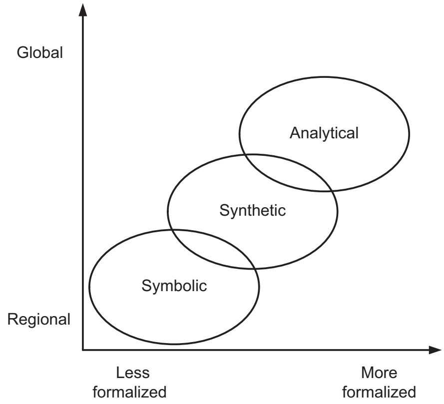

Figure 1. Expected patterns of knowledge sourcing
Source: Author's own figure.

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 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 rate[5]). 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).

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.

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 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 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.

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.

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 Rabellotti, 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

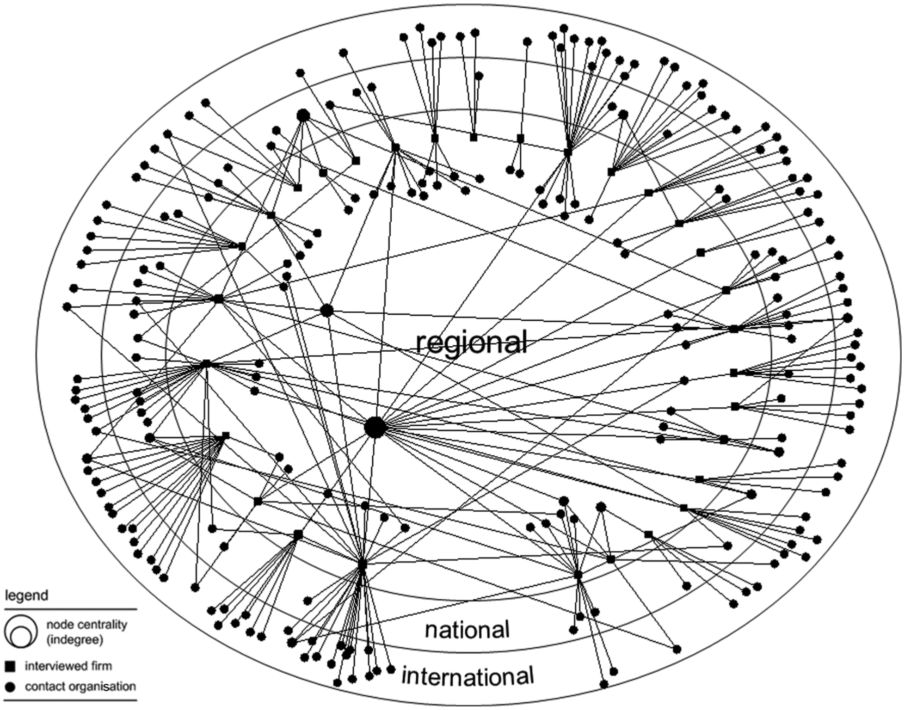

Figure 2. Knowledge sourcing through collaboration in the life science industry
Note: Nodes represent actors and links represent knowledge flows. The shape of the node indicates whether the actor is part of the interviewed group, the size of the node indicates the importance of the actor in the network (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 since 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

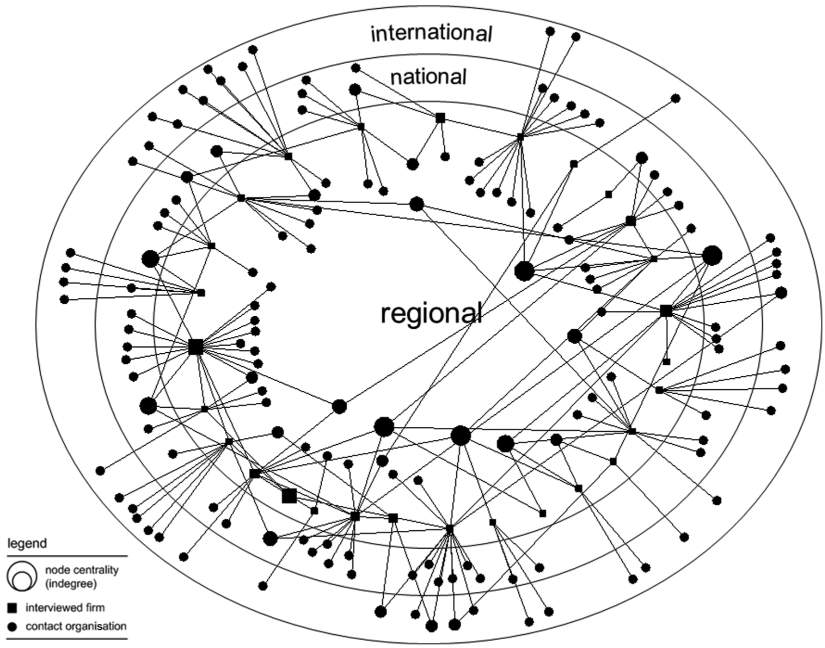

Figure 3. Knowledge sourcing through collaboration in the food industry
Source: Author's own figure.

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

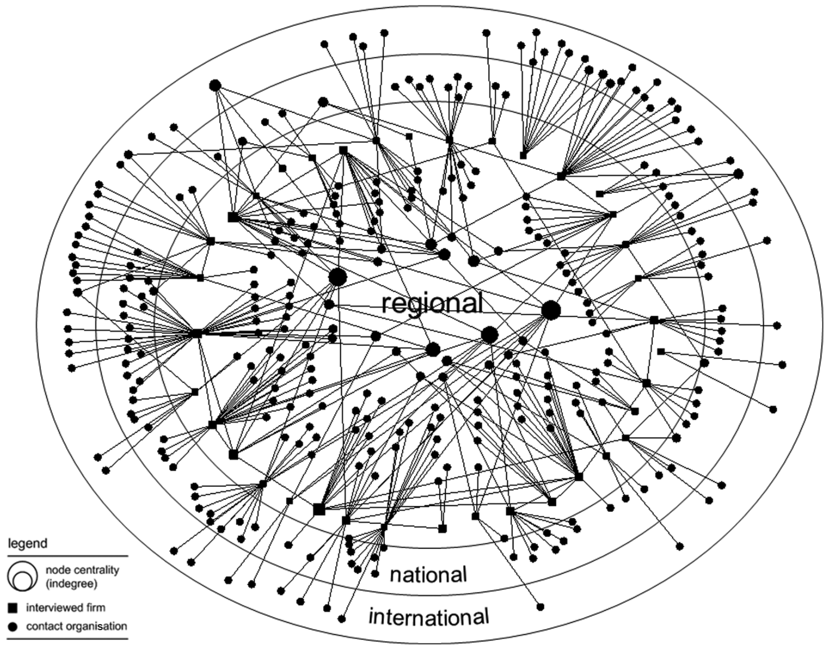

Figure 4. Knowledge sourcing through collaboration in the moving media industry
Source: Author's own figure.

important exchange partners are the Municipality of Malmö (9), the University College of Malmö (7) and Media 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 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 essentiality 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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Article IV

J Knowl Econ (2011) 2:550–568
DOI 10.1007/s13132-011-0067-2

Regional Innovation Policy Beyond 'Best Practice': Lessons from Sweden

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Received: 29 September 2011 / Accepted: 30 September 2011 /
Published online: 12 October 2011

Abstract This paper deals with policy measures in the regional innovation system of Scania, Southern Sweden. Focus is on the innovation policy requirements of actors representing industries that draw on different knowledge bases. Previous studies have identified profound industry-specific differences concerning the organisation of knowledge sourcing between firms and other actors. In correspondence with these findings, industries are also expected to vary with regard to how policy measures aiming to support innovation are perceived and implemented. Still, there is a tendency among regional policy programmes to base their strategies on one 'best practice' model, inspired by successful (or sometimes less successful) cases in other parts of the world. Here, regional policy initiatives targeting three distinct industries in Scania, namely life science, food and moving media, are discussed, in particular their ability to meet the specific needs and demands of firms in these industries. The findings reveal that the existing initiatives are customized on a rather generic level and not sufficiently fine-tuned to the particular needs and demands of the respective actors. Policies are recommended to take the specific characteristics of the industrial knowledge base into account in order to provide appropriate support and to become an effective part of the institutional framework of the regional innovation system.

Keywords Innovation policy · Regional innovation systems · Knowledge bases · Sweden

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Introduction

This paper deals with policy measures in the regional innovation system of Scania, Southern Sweden. Particular focus is devoted to assessing the needs and demands made on innovation policy by actors representing different industries and the extent to which existing regional policy programmes have managed to meet these needs and demands.

Previous studies have identified profound differences in the modes of innovation among industries that draw on different knowledge bases [5, 34]. In correspondence with these findings, industries are also expected to differ with regard to how policy measures aiming to support innovation are perceived and implemented. Summarizing the differences in the modes of innovation, it can be said that knowledge sourcing and inter-organisational collaboration in geographical proximity are especially important for industries that rely on a synthetic or symbolic knowledge base since interpretation of the knowledge they deal with tends to differ substantially from place to place. This is less the case for industries drawing on analytical knowledge since such knowledge is codified, abstract and universal. Knowledge sources related to scientific knowledge and principles are particularly important for analytical industries, whilst synthetic industries rely more on experience-based learning and applied R&D, and symbolic industries on creativity and non-scientific knowledge [3].

We argue that regional innovation policies should take these differences seriously into account in order to provide appropriate support and shape good conditions for innovation to take place. However, there is a tendency among regional policy programmes to base their strategies on one ‘best practice’ model, neglecting such industry-specific needs and preconditions [20]. This paper presents three existing regional innovation policy programmes supporting three different industries located in the same region and analyses to what extent these have been fine-tuned to the needs and demands of the respective industries. The knowledge-base approach serves as a conceptual framework and principle for the selection of cases. The main questions addressed in the paper are thus (1) how needs and demands on policy support differ between industries that draw on different knowledge bases, (2) whether and how the existing regional policy support programmes meet these distinct needs and demands, and, partly as a consequence of the previous two, and (3) whether and how the existing policy measures have a real impact on the behaviour of their target population and succeed in becoming an integral part of the institutional framework of the regional innovation system.

Conceptual Framework

With the aim of generating economic growth, regional authorities are more and more engaged in designing framework conditions to support innovation [16]. This emphasis on innovation in regional policy was initially triggered by the recognition that regions can no longer compete merely by offering basic technical infrastructure, skilled labour and financial incentives to attract investors. Policies following such a traditional approach have been proven to be rather ineffective when it comes to solving problems of unfavoured regions today. A central problem of many old industrial and declining regions is the low performance with regard to innovation and a reluctance to change, which leads to a certain risk of locking into a development path that, although perhaps previously successful, holds little promise for the future. In order to create sustainable economic growth, regions need to redefine themselves continuously and move towards more auspicious trajectories [21].

The literature on regional development highlights different aspects of regional infrastructure in the process of redefinition. Storper [42] emphasizes the importance of region-specific assets such as norms, habits and conventions which add to regional uniqueness, creating competitive advantage. This idea is also supported by Swyngedouw [43] who argues that the economic success of cities and regions is highly dependent on the local sectoral and institutional configuration and on the framework of governance in which regional and urban economies are embedded. However, due to increased economic reflexivity [42], concrete patterns of competitive advantage are constantly changing, requiring the economic actors to catch up. Therefore, an institutional framework and governance that facilitate learning are necessary for survival in contemporary capitalism. Those that can learn faster or better are more competitive [1]. As a response, regional policy makers are typically advised to promote and support interactive learning and cooperation in the local sphere.

This is in line with one of the key arguments in the literature on regional innovation systems; that is, regional growth and competitiveness are dependent on the ability of local actors to exchange knowledge and build networks. The important actors in this respect are private firms, governmental agencies, as well as universities and other public research [5]. The regional innovation systems approach thereby emphasizes the importance of networking and considers the firm as having the leading role in innovation [8]. Missing or inappropriate institutions supporting innovations or missing or inappropriate interactions of the actors in the system are among the most common failures preventing the fluent functioning of innovation systems [11]. Very much related, the triple helix model describes a spiral trilateral interaction of the academia, industry and government, and thereby stresses the role that universities can play for economic development beyond being organisations for education and knowledge generation. Universities, government and industry are learning to promote economic growth within a specific local context through the development of what is called 'generative relationships', that is loosely arranged reciprocal relations between actors that persist over time [15].

Both the RIS and the triple helix approach emphasize the crucial role of networks and relations between learning counterparts. The importance of networking for innovation is also supported by Lambooy and Boschma [26] who define two objectives for regional policies—efficient capital markets and good access to information and stimulation of economic actors' innovative capabilities through networking and interactive learning. This is in line with Schwerin and Werker's [39] argument that innovation policy should support knowledge networks in a non-selective manner. As a consequence, regional polices tend to focus strongly on designing framework conditions for knowledge exchange as their main measure of innovation support. However, what is often missed in theoretical discussions is that actors within these networks differ depending on the industry to which they belong, partly as a consequence of their specific knowledge-base characteristics [5]. This implies different barriers to innovation, and it follows that, in order to succeed, policies need to account for such specific needs and characteristics of their target industry.

Regional Policy and Institutional Framework Conditions

Despite wide acceptance among researchers as well as policy makers that societal institutions matter in economic operations, there is neither consensus on what is meant by institutions, nor how institutions matter more precisely [24, 38]. To begin with, institutions and organisations are not the same. Institutions are considered to be the rules of the game, relatively enduring features of political and social life that shape, constrain and structure the behaviour of organisations (universities, firms, governmental agencies, etc.) and individuals [28, 36]. Sheingate [41] argues that institutions are *constraining* insofar as they establish parameters for action, but they are also *empowering* for individuals to develop innovation in practice. Such rules are essential for the systematic actions of organisations and individuals.

Many studies of institutional change analyse the possibilities for institutional innovations resulting from the interpretation and application of existing rules [29]. This is also the context in which Sheingate [41] grounds his arguments. However, in the case of innovation policies, institutions might have a direct impact on innovative actions. One example of the ambiguous relations between constraining and empowering institutions is the system for public funding of new research activities. By giving priority to some research areas or collaboration, the funding system contributes to shaping the development of research. On the one hand, the funding system thus constrains the paths that research might take by excluding certain areas and organisational forms at the same time as empowering those that are found strategically important. From a policy point of view, such efforts might be necessary to create a critical mass and contribute to shaping possibilities for more efficient research.

On a more general level, North [36] classifies institutions into formal (i.e. officially stated) and informal. The latter are not necessarily explicitly communicated but rather shaped by common social context and implicitly perceived by the actors. Scott [40] specifies institutions in even more detail and separates regulative, normative and cognitive ones. Regulative institutions represent rules and laws that work as coercive mechanisms and are legally sanctioned. Normative institutions are values, norms, codes of conduct, not legally sanctioned but morally governed. Cognitive institutions are beliefs and models of reality taken for granted and supported by culture and everyday practices. These should thus be understood as interdependent and mutually reinforcing pillars, which, seen as a whole, define the institutional framework within which economic actors function and interact [32]. The three industries analysed in this paper are obviously embraced by regulative frameworks at a national as well at a supranational (e.g. EU) level, and to some extent, these regulations can be described as sector-specific (e.g. formalized standards, safety regulations, etc.). However, and more importantly in the context of this study, everyday practices, norms and routines of industries, which can be referred to as constituents of cognitive and normative frameworks, also differ.

Before moving on to a discussion of the relations between policies and the formation and development of institutional frameworks, it is worth clarifying what is meant by regional innovation policy in this paper. A full account of existing regional innovation policies would include a wide range of measures promoting innovation not only at regional but also at national and supranational levels (to the extent that these have an impact on innovation in regions, which they almost by definition have). Concrete examples of the latter would be EU structural funds (notably the European Regional Development Fund) and various national funds in support of innovation (e.g. those provided by VINNOVA in Sweden). Although acknowledging their potential impact on innovation in regions (either directly or indirectly), it would go beyond the scope of this paper to include all such general framework conditions in the actual analysis. Following Edquist's [13] definition of innovation policy as actions by public organisations to influence innovation processes, we therefore refer to regional innovation policies as concrete support programmes targeting innovation in specific regions (in this case Scania). Since our aim was to assess the abilities to fine-tune policy for specific industries, we focus on sector-specific examples of such regional initiatives and analyse by what means and to what extent they add to the creation of a regional institutional framework supporting innovation in their target industries.

This choice of focus is partly influenced by the governance structure in Sweden in which regional authorities have a quite limited direct influence on economic policies. They are responsible for promoting regional development and planning in the areas of industry, communication, culture and cooperation with other regions within and outside Sweden. In this way, they influence to some extent the preconditions for the economic performance of the region and contribute to creating normative—constraining and enabling—institutions for many activities [14]. Their efforts might also, in an indirect manner, influence the regulative framework, but most concrete measures are ultimately handled either by the central (state) government or the local (municipality) authorities. For this reason, most regional innovation policies (defined as above) are carried out in collaboration with local and national stakeholders. Among the most influential and visible regional innovation policy constructs are the type of consortia analysed in this paper in which regional, national and local representatives, from public as well as private sectors, join forces in dedicated efforts to influence the regional institutional framework. Most of those target specific sectors.

As noted by Mahoney and Thelen [29], institutions are not just designed but also have to be applied and enforced. It follows that institutions 'work' only if the actors whom they target comply with them [25]. Cognitive institutions are perceived unconsciously; thus, actors do not think about not complying [29]. In the case of regulative institutions, compliance is enforced by law and the perception of non-compliance might be very costly. However, normative institutions come into being only if actors perceive that certain norms and codes of conduct are beneficial for their performance and meet conventional conceptions of fairness [19]. The central challenge for regional innovation systems policy is thus to promote such compliance with the rules, regulations, norms and patterns of cognition defining the institutional framework of the system at the same time as stimulating the change towards innovation. Regional innovation system policies will thus feed into the institutional framework in a fruitful way only if they meet practical, appropriate and sensible requirements [6].

According to Helgoy and Homme [22], authorities might use two types of policy tools to influence institutional change. The first type is input regulations which include legislation, organisational frameworks and funding possibilities. The other category is made up of accountability tools which include information, training, education and value-based marketing of policy programmes. These tools attempt to influence behaviour through the transfer of knowledge and through persuasive reasoning. Relating to Scott's [40] typology, we argue that the input regulation tools primarily address change in the regulative institutional framework, whilst accountability tools can potentially influence the normative and cognitive institutions (to the extent that policy has an impact at all). Regional innovation policies primarily aim at changing normative institutions within the region by promoting collaboration, learning and knowledge exchange [35]. In other words, since regional policy makers have quite limited access to input regulation, they primarily use accountability tools to introduce the change. We illustrate below how preconditions for such policy impact differ from industry to industry, even though they are part of the same regional innovation system.

Industry Needs, Demands and Crucial Knowledge Bases

Demands for policy support from firms might be assessed in an indirect manner through studying the actual involvement of industry representatives in various forms of activities initiated by the support structure of the regional innovation system. Another, in our view more fruitful approach, would be to assess the demands in a more direct way, simply by asking the firms what they demand from policy. Identifying the real needs is more complicated. As noted by Edquist [13], needs are not the same as demands—they have to be translated into articulated demand. It follows that companies do not necessarily know what their real needs are, and the translation process into articulated demand might suffer from bias. Consequently, only satisfying the explicitly communicated demands of target groups might lead to fatal mistakes in which the policy support programme contributes to creating a lock-in situation.

To deal with this (potential) problem, the empirical assessment of firm demands is enriched by a theoretically based assessment of needs derived from the main arguments of the differentiated knowledge-base concept [5]. We argue that this concept, through clarifying different preconditions for innovation in different industries, can serve as a heuristic model for designing fine-tuned regional innovation policy. To explain patterns and modes of innovation in different regions, industries or firms, three different types of knowledge base are distinguished, namely analytical, synthetic and symbolic. It is important to say that this distinction is intended as a mode of conceptual abstraction. In practice, most activities will comprise more than one knowledge base, and the degree to which a certain knowledge base prevails can vary substantially between different activities [2, 4]. Nevertheless, the distinction has been proven to be suitable for specifying and explaining the differences of economic activities in an ideal-typical manner. The main characteristics of the respective 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 primarily based on formal models, codified science and rational processes [5]. Examples mentioned in the literature are genetics, biotechnology and information technology [10]; this paper focuses on the life science industry. For analytical industries, basic as well as applied research is an important activity, and new products and processes are developed in a relatively systematic manner. Firms usually have their own R&D departments, but also rely on knowledge generated at universities and other research organisations. For that reason, the linkages between private firms and public research organisations are considered as particularly important and take place more frequently than in other industries. Since analytical industries deal with scientific knowledge stemming from universities and other research organisations, they depend to a large extent on codified forms of knowledge contained in scientific publications and patents. These forms of knowledge are relatively easy to share and exchange over long distances. Therefore, knowledge sourcing in these industries is assumed to take place on a wide geographical scale, often within globally configured networks.

A synthetic knowledge base prevails in industries that create innovation through the use and new combinations of existing knowledge with the intention of solving concrete practical problems [5]. Examples mentioned in the literature are plant engineering, specialized industrial machinery and shipbuilding; this paper 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 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, practical work or computer-based simulation. Knowledge that is required for these activities is partially codified, but the crucial form of knowledge is in many cases tacit due to the fact that new knowledge often results from experience gained through learning by doing, using and interacting. In comparison with analytical industries, knowledge networks are assumed to be less globally configured, and much knowledge sourcing takes place within national or regional boundaries, be it through the mobility of employees or cooperation with other firms. At the same time, many synthetic firms are involved in international user–producer relations, which provide knowledge linkages not to be neglected.

The symbolic knowledge base is a third category that is receiving increasing attention in the scientific discourse in view of the growing importance of cultural production [4]. It is present within a variety of industries such as film, television, publishing, music, fashion and design, whereas the example in the present study is the moving media industry. All these activities have in common the fact that they are devoted to the generation of aesthetic value and images and less to physical goods. Symbolic knowledge can be embedded in material goods such as clothing or furniture, but the impact on consumers and the economic value as such 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 produce through short-term contracts and within small project teams, knowledge about possible partners for cooperation and knowledge exchange (know-who) are particularly important. 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" [4]. Therefore, the meaning and the value associated with symbolic knowledge vary considerably from one place to another. This also reflects the spatial dispersion of knowledge networks, which are, due to the context specificity of symbolic knowledge, predominantly locally configured [31].

Empirical studies have confirmed the theory-led expectations of the distinct geography and organisation of knowledge sourcing of industries drawing on different knowledge bases [30]. The exchange of knowledge in geographical proximity is particularly important for symbolic industries since the interpretation of knowledge they deal with tends to vary. Accordingly, cooperation and knowledge exchange occur above all within locally configured networks. Models and principles stemming from academia have little importance since innovation is driven by creativity rather than the application of scientific laws. Synthetic industries deal to a higher extent with codified knowledge, which is less context-specific; however, the dominating form is still tacit. Therefore, cooperation and knowledge exchange occur primarily among partners in the same functional region, but actors on the national and global levels also play considerable roles, not least in user–producer relations [7]. Analytically based industries rely on scientific knowledge that is codified, abstract and universal, and are therefore not very sensitive to geographical distance. In line with this, knowledge exchange occurs in globally configured epistemic communities rather than in locally configured, trust-based networks [17, 33].

Survey and Analysis

The three industries under study are (1) the life science industry, (2) the food industry[1] and (3) the moving media industry. The empirical cases are clusters of firms, representing these three industries, located in the southernmost province of Sweden. The main method for data collection was structured interviews with representatives of the firms. A total of 95 structured interviews were conducted: 30 for the life science industry, 28 for the food industry and 37 for the moving media industry. This corresponds to a response rate of 72% for the life science cluster, 80% for the food cluster and 50% for the moving media cluster.[2] The main aim of these interviews was to identify the type of support, according to the perception of the firms, that is needed by them and the type of support that is provided by the existing policy programmes.

To find out in more detail what the existing policy programmes claim to provide in terms of support, document studies were combined with in-depth interviews with key individuals representing the regional policy programmes. A total of 15 such

[1] The study is limited to a specific sub-segment of the food sector, including firms working specifically on the development of new products and/or processes related to food production. A large number of food-producing companies are hence excluded from the sample.

[2] A desktop-based non-response analysis has revealed no systematic differences in terms of size, age and type of activities between responding and non-responding firms.

interviews with policy makers were conducted. These interviews allowed us to make an in-depth assessment of the actual activities carried out in the policy programmes despite the fact that most of the documents are fairly vague when it comes to specifying the concrete activities. Additional input for assessing the policy programmes was received through participation in focus group meetings involving representatives of the regional council, one of the main stakeholders responsible for the design and implementation of the programmes. These meetings allowed us to discuss the stakeholders' views on the workings of their activities as well as the main challenges and achievements in the course of the programmes. Eight such meetings were held during the period from February 2009 to March 2010. Through this combination of different strategies for data collection, we aim at assessing the correspondence between the required and provided policy support from the point of view of both the target population (the firms) and the policy stakeholders.

Overview of the Three Industries Under Study

As stated above, all three cases analysed in this study are located in the region of Scania, southern Sweden. The actors are clustered in (or close to) two cities, Malmö and Lund. Malmö is the third largest city of Sweden and Lund hosts the largest university of the country. All three industries are considered to be of high importance for regional development by the regional governmental body Region Skåne [23].

The cluster of life science, the third largest in Sweden (after Stockholm and Västra Götaland), is a heterogeneous sector in terms of size and areas of activity. It contains about 30 research-based biotechnology companies focusing on new pharmaceuticals and medical R&D, and about the same number of medical biotechnology and equipment-oriented companies. However, the regional value chain of this sector is quite limited in scope; pure production is not well developed. The majority of biotechnology companies have been established after 1995 and are clustered around Lund University and in the Ideon or Medeon science parks. Most of the companies are spin-offs from Lund University or large pharmaceutical companies that have been present in the region for many decades. The companies are small and most often unprofitable, measuring their success in terms of R&D investments rather than economic revenues. The life science industry in Scania is part of a larger cross-border cluster named Medicon Valley, which also includes life science companies and research institutes in the Danish capital Copenhagen and its surroundings.

Scania has a strong national position in food production. One quarter of the country's food industry is located in the region, employing about 25,000 people. The majority of companies are clustered in the western part of the region. Their activities cover the whole food production value chain from primary production to storage, transport, and packaging and processing. Global competition accelerated as a consequence of Sweden's accession to the European Union in 1995, which increased the pressure on the Scanian food industry to develop towards higher value-added niche products involving greater knowledge content. Examples of such renewal towards knowledge-intensive activities are the developments of the so-called convenience food, functional food and specific niches of healthy food. The food cluster under study in this paper is composed of such innovative companies which build their competitive advantage on the ability to produce new and better products through new and better processes in areas such as dairy, bakery, meat and fish processing, juice production and the like. The case study thus covers a specific knowledge-intensive subset of the food industry in the region.

The concept of moving media is used to describe the intersection of industries such as film, television, computer games, mobile technology and other types of graphical design applications. Drawing on its roots in traditional media and ICT, this sector, a relatively new niche in the regional economic structure, experienced strong growth in the beginning of the last decade. Most of the companies within the region are young and small. They are located in Malmö's Western Harbour, the same location of large parts of the publicly administered knowledge and support infrastructure targeting this industry.

Overview of the Three Regional Policy Support Programmes

There are three main regional policy support programmes specifically targeting these different industries. All three are organised as consortia in which public and private organisations representing different spatial administrative levels (local, regional, national) join forces in support of their target industry. Medical Valley Alliance (MVA) aims at promoting the life science industry (drawing on an analytical knowledge base). Skåne Food Innovation Network (SFIN) focuses on the food industry (drawing on a synthetic knowledge base) and Media Evolution (ME) provides support to the moving media industry (drawing on a symbolic knowledge base). More detailed accounts of each policy initiative, with a focus on what they (claim to) provide to the respective industries, are provided below.[3]

MVA started in the middle of the 1990s as a cluster initiative with the aim of stimulating industry–university linkages and binational (Swedish–Danish) interaction in the field of life science. It was a result of an EU Interreg project in which Lund University and the University of Copenhagen took the lead, joined by three of the region's largest pharmaceutical companies and a number of public actors responsible for regional development in Sweden and Denmark (within the framework of the Öresund Committee, a platform for cross-border policy cooperation). Initially, the main focus of this initiative was to increase the economic integration of the cross-border region and to stimulate cooperation between companies and universities. With time, the focus of the initiative transformed and broadened; MVA now has several initiatives with possible benefits for their member companies. Some activities, such as the MVA annual meeting, MVA golf championship and MVA executive club, primarily aim at social networking of members in the cluster. The MVA Life Science Ambassador programme and the Meeting MVA initiative aim at global knowledge exchange among life science companies. It is implemented by exchanging ambassadors between Medicon Valley and clusters in Japan, Canada and South Korea whose task is to assist foreign firms

[3] In the remainder of this paper, we also refer to these policy support programmes, and the activities they claim to provide, in the section discussing the benefits perceived by the firms. It is important though to note that some of these activities are provided through synergies with the broader support structure of the regional innovation system, such as more generically focused science parks, incubators and business support organisations.

to get in touch with local companies or organise seminars and conferences on how to do business in the respective areas. Thus, together with strengthening cross-border relations and local cooperation in MVA activities, there has been a shift towards international marketing of the region and global networking.

SFIN was created in the middle of the 1980s in order to increase the food sector's international competitiveness, mainly through connecting the food industry with other relevant industries such as packaging, machinery, logistics and academia. SFIN is involved in human capital and competence development within the industry through presenting the food sector to students during career days, specially organised tours and internship programmes. The initiative also assists in opening new innovative markets and supports the development of innovations by facilitating connections with academia and, to some extent, providing financial support for R&D. It is also engaged in the design and development of higher education programmes at Lund University. However, the main focus of the initiative is networking and communication among the actors. It runs a 10-year development project called Food Innovation at Interfaces, funded by a consortium of state actors (primarily VINNOVA), Region Skåne, Lund University and some food companies in Scania. The overall objective is to improve cooperation within the food industry and between food companies and academia, thereby stimulating innovation and economic growth.

ME is a continuation of a policy initiative named Media Mötesplats Malmö, a project which started in 2004. It was initiated by Region Skåne, Region Blekinge, the City of Malmö and Scandvision, which is one of the larger companies in the sector. ME is an umbrella organisation unifying several small initiatives that were present in the region. A key task of the initiative is to strengthen links between traditional and new media for moving images and to serve as a meeting place for actors focused on the production, distribution and consumption of new media. More concretely, the initiative claims to support the development of the industry by providing knowledge about new market possibilities and initiating collaboration projects among the actors in the region (e.g. living labs); competence development and social networking (e.g. fairs, conferences, seminars); entrepreneurial consultations, contact and business development (e.g. incubator); and access to venture capital. ME also strives to promote the linkages between industry and academia, partly through providing platforms for interaction, lobbying and information campaigns about the university sphere.

The following section outlines the results from the structured interviews with firms belonging to the moving media, food and life science clusters in Scania. Firm representatives were asked to specify the type of policy support they require and perceive as relevant for their innovation activities and to describe how they benefit from existing policy programmes available in the region (i.e. ME, SFIN and MVA).

Demand for Policy Support

There is a set of policy measures that can be implemented in order to stimulate innovation in the regional economy. Typical support measures are financial provisions in the form of grants for R&D and innovation activities, support for knowledge exchange through various forms of networking, human resource development in the form of seminars and training courses, and improved access to knowledge related to technologies or to new developments on the market. The companies were asked what types of policy support they require and perceive as relevant for their innovation activities.

Table 1 summarizes the types of policy support demanded by firms and reveals both a general trend and industry-specific differences. Irrespective of what sector they belong to, firms request policy support programmes to identify and mobilise additional sources of funding. Monetary support seems to be important in general, even though there are observable differences between industries. Public funding is particularly demanded by firms in the life science industry (73.3%), whilst this is less so for the moving media (64.9%) and even less so for the food industry (53.6%). Innovation in the life science industry is often carried out in R&D laboratories with rather sophisticated and expensive technical equipment. Only companies with sufficient financial assets can afford their own equipment, whereas young and small firms need to rent facilities and machinery. The importance of public funds can also be explained by the risky nature and lengthy time horizon of innovation projects in life science in which the transformation of scientific research into commercial products can take several years [9, 18]. Innovation in the food industry, in contrast, is less dependent on high-cost technical equipment and time-consuming trials; it is instead driven by the know-how, craft and practical skills of people. Firms in the food industry need, above all, a workforce with good practical training, which is reflected by a high demand for policy initiatives addressing staff training (53.6%).

Very clear differences can be observed when it comes to networking of industries, e.g. policies facilitating the search for new partners. Whilst firms in the moving media (51.4%) and life science industry (56.7%) have a high demand for networking, only a few firms in the food industry (17.9%) are interested in such support. In the media industry, innovation activities are often carried out in flexible and short-term alliances involving various partners. Thus, access to a wide range of possible collaborators is important. Previous research has shown that collaboration in the moving media industry occurs predominantly with other firms in the same region, whereas collaboration with universities and actors outside the region plays a minor role [30]. Similar to moving media, actors in the life science industry are continuously seeking partners for cooperation, but such alliances often occur within globally configured networks between firms and various research organisations [17]. In contrast to this, the food industry is less engaged in the search for new partners; it

Table 1 Policy support demanded by firms in different industries

	Life science (n=30)	Food (n=28)	Moving media (n=37)	Total (n=95)
Financing (%)	73.3	53.6	64.9	64.2
Networking (%)	56.7	17.9	51.4	43.2
Staff training (%)	50.0	53.6	48.6	50.5
Information about market (%)	46.7	14.3	29.7	30.5
Information about technology (%)	16.7	35.7	40.5	31.6

Source: Own survey

is a rather mature industry with a long history in the region, which implies that partnerships have developed and persist for a long time. However, the industry is increasingly exposed to international competition; thus, firms need to reconfigure their established networks and improve their access to technological knowledge. This is in line with the observation that a large share of firms demands policy support regarding access to information on technologies (35.7%), whereas only a few demand support for access to information on markets (14.3%). The opposite can be observed for the life science industry in which few firms require help to find information about technologies (16.7%), whilst a larger share demands access to market information (46.7%).

Perceived Benefits from Existing Policy Support Programmes

The previous section presented the kind of support that is perceived as important by companies' representatives. This section elaborates on the benefits that companies perceive they have achieved through their respective policy support programmes (Table 2).

To begin with, there are large differences between the food industry (28.5%) and the two other industries (69.4% and 80.0%) regarding the share of the companies that could identify benefits from any type of policy support. As mentioned above, the food industry has had a long history in the region, with established routines and partnerships for its business activities. Food companies thus do not express any demand for external help to find partners (see Table 1). A policy initiative like SFIN, primarily focusing on promoting networking between companies or between companies and the university, can hardly attract firms to participate in its activities since the immediate benefits are not obvious to the firms. Part of the challenge for policy makers is thus to translate the identified needs for network renewal to an offer meeting the demands articulated by the companies. Due to low participation in the policy initiative, the results of the various types of benefits are not comparable with the results for the other two industries. The remainder of this section will thus primarily discuss the results for the life science and media industries.

Both the media and the life science industries perceived that they benefited most by receiving support for getting access to market knowledge. Around half of the

Table 2 Benefits achieved by firms in different industries

	Life science (n=30)	Food (n=28)	Moving media (n=37)	Total (n=95)
Financing (%)	6.6	10.7	5.4	7.3
Networking (%)	36.6	17.8	54.0	37.9
Staff training (%)	23.3	14.2	13.5	16.8
Information about market (%)	46.6	10.7	48.6	36.8
Information about technology (%)	23.3	17.8	18.9	20.0
Any type of policy support (%)	80.0	28.5	69.4	60.0

Source: Own survey

moving media (48.6%) and life science (46.6%) firms indicated this as a concrete benefit from their respective policy support programmes in the region. Since information about markets is one of these industries' most clearly identified demands (see Table 1), it is likely that the firms consciously use these policy programmes to improve their competitive advantage. It has to be said, however, that fewer moving media firms expressed a demand for market knowledge compared with life science firms. Despite the big demand for financing (see Table 1), very few firms in the media (5.4%) and life science (6.6%) industries indicated that they acquired any financial support from existing policy initiatives. This is not surprising since regional policy programmes of the type analysed in this paper generally aim for indirect support targeting the system level rather than direct support targeting individual firms. The contribution to financial capital mobilisation in the region is thus indirect, mostly through attracting investors and providing information about venture capitalists and various sources of R&D support, primarily administered at the national and international levels [37].

The firms in both industries got only moderate support regarding access to technology knowledge and staff training. However, some differences should be addressed. More life science firms (23.3%) indicated that they received help with human resource development than media firms (13.5%). One potential explanation for this could be that staff training in symbolic industries is less related to formal education and codified knowledge, whilst tacit understanding of local culture and personal abilities to create artistic artefacts are crucial. Both these are hard to provide from outside, and even if achieved through interactions with other companies during social events and workshops, organised by policy support programmes, they are not necessarily consciously perceived by companies' representatives. In the case of codified knowledge exchange and formal education, the support is easier to notice and evaluate. This is also in line with the main focus of Swedish innovation policy in which most attention is paid to support for R&D and higher education [12, 27].

The findings on access to technological knowledge are interesting in relation to demands on the policy initiatives by companies. As mentioned above, support for access to technological knowledge is perceived as moderate in both industries. About 18.9% of the moving media firms and 23.3% of the life science firms indicated this as a concrete benefit. However, the life science industry does not demand it (see Table 1), possibly because technological knowledge defines the core competence of these firms and, therefore, largely managed internally. The media companies, on the contrary, display a high demand for technological knowledge. Symbolic industries do not produce new technologies; however, they use them in the creation of cultural artefacts. Technological knowledge is thus needed for competitiveness of the firms, but it is not at the core of their competence. Thus, in order to access it, they might need external support. Important to note, though, is that technological knowledge does not necessarily equal scientifically based knowledge, which is indeed strongly prioritized in Swedish and European innovation policies [12, 20, 27]. The media companies are clearly more in need of experience-based practical knowledge such as craftsmanship, which can help them materialize their ideas and communicate their symbolic knowledge, than scientific and engineering-based knowledge as input for product or process innovations. Such support is rare, if not nonexistent, in Swedish and European innovation policies.

The results with regard to how the firms perceive the benefits in terms of support for networking activities of the industries reveal observable differences. More than half of the companies in both industries expressed a high demand for help to find partners (i.e. network promotion). Nonetheless, the share of firms that benefited from support in networking activities was much larger in the moving media industry (54.0%) than in life science (36.6%). This result is most likely a consequence of the different modes of innovation characterizing the different industries. Firms in symbolic industries mostly collaborate and exchange knowledge locally, whilst knowledge exchange in analytically based industries is embedded in globally configured professional knowledge communities [17, 31, 33].

Naturally, regional policy support programmes have better capacity to promote local than global networking, and a vast majority of the network promoting activities initiated by the regional policy support programmes are geared towards intra-regional networks. There is also a tendency among these activities to prioritize university–industry networks, whilst the firms' demands are more in favour of networking in the same or related sectors. Furthermore, and somewhat paradoxically given the focus on industry–university networks, the support programmes mostly promote networking through various forms of social events. In symbolic industries, it might be appropriate to acquire 'know-who' information about each other and to discuss possible collaboration. In analytical industries, on the other hand, research is very specialized and social events are not sufficient to exchange knowledge of scientific and technological 'know-why'. There is thus a double mismatch connected to network promotion through such industry-specific regional policy support programmes in Scania. In terms of geographical scope, there is a mismatch between needs/demands and received policy benefits primarily for life science and partly for food industries, whilst in terms of scope, there is a mismatch between needs/demands and received policy benefits for all three sectors.

Discussion and Conclusions

This paper addresses three main research questions. Firstly, how needs and demands for policy support differ for industries that draw on different knowledge bases; secondly, whether and how the existing regional policy support programmes meet the needs and demands; and, thirdly, whether and how the existing policy measures have a real impact on the behaviour of their target population and succeed in becoming an integral part of the institutional framework of the regional innovation system.

To sum up the findings in relation to the first and second questions, the three industries have both similarities and differences. All three demand financial support; however, this is the demand least met by regional policies. About half of the interviewed companies in all three industries demand labour training activities, but, similarly to financial support, only a minority of the companies identify any such benefits from existing policy support programmes. Important to note in this connection is that labour training does not necessarily equal formal education. Such training (i.e. higher education) might be of importance for the life sciences and, to some extent, the food industry, whilst the media industry requires different types of training such as on-the-job training, tutorials and guidance for various forms of experience-based learning. Support in the form of information on new technologies is primarily demanded by the moving media and food industries, but is of little interest to actors in the life science industry. This demand is largely neglected by all the policy support programmes, and to the extent that it is promoted, scientifically based knowledge is strongly predominant. This is somewhat paradoxical since such knowledge is most relevant to the actors not demanding it (i.e. the life sciences), whilst the actors demanding it (food and media) can neither absorb it nor let it feed into their current innovation and product development strategies, which are largely based on non-scientific knowledge. Finally, industries differ a lot in the geography and organisation of their networking activities. More than half of both media and life science companies demand policies that help them find partners, whilst only a few food companies do so. So far, policy measures targeting the moving media industry have been more successful in promoting network activities than measures targeting the life science and food industries. This is due not only to the predominant focus on informal networks in the current regional policy programmes but also to the geographical intra-regional scope, which suits the media industry better than life science. The strong emphasis on industry–university relations, also characterizing the network promotion activities in all three policy support programmes, is less well suited to the media industry.

The aim of all three policy support programmes was to be adopted and 'internalized' by their target population, empowering the firms to conduct innovative actions in order to foster regional development. With regard to the third research question of whether the existing policies render a real impact on the behaviour of the target population (the firms) and thereby succeed in becoming an integral part of the institutional framework of the regional innovation system, the findings are less convincing. As suggested by institutional theory referred to in the conceptual framework, for a new initiative to be adopted, it must meet regulative as well as normative and cognitive requirements. All three policy support programmes are in line with existing regulations, primarily set on an administrative level beyond the region (i.e. national, international). However, profound differences with regard to the needs and demands and the perceived benefits among the actors representing the three industries reveal that normative patterns among the actors are hardly taken into account. Furthermore, in the case of the food industry, there seems to be a mismatch between needs and demands. Network stimulation from outside is not demanded by the companies, but increased collaboration is indeed needed to break path dependency and stay competitive on an increasingly global market. It follows that in order to introduce new norms, policy makers should first address the cognitive framework of the industry. As mentioned in "Conceptual Framework", cognitive patterns are primarily addressed using accountability tools such as spread of information and marketing of policy programmes. This could possibly happen through collaboration with pioneering industry representatives, widely distributed successful examples, and other communication and information tools policy makers could use to contribute to translating the need into an articulated demand.

The results from the survey carried out in this study are thus clearly in line with the theoretically derived assumptions following the knowledge-base approach to innovation studies, highlighting profound differences among industries drawing on different knowledge bases. However, rather than addressing the needs and demands in customized ways and taking the differences of the industries into account, the policy support programmes appear to be very similar in scope. They provide more or less generic support in line with best practice models, which have had a strong impact on the predominant policies defining the Swedish and European research and innovation policy agenda over the past decades. Typical activities defining those are regional industry–university network promotion, technology transfer support through incubation, human capital development through higher education, and regional branding in attempts to attract venture capital and nationally and internationally governed funds for R&D.

These best practice models, with the exception of their predominant geographical scope, seem to be most well suited to industries drawing primarily on an analytical knowledge base. This is also reflected in the analysis of perceived benefits presented in this paper. A large share of firms representing the life science industry (drawing on analytical knowledge) identify benefits from existing policy programmes, whilst firms in the food industry (drawing on synthetic knowledge) clearly refuse to comply with attempts to change the institutional framework for their activities. However, regional policies fail to be fully institutionalized even in life science as support related to financial capital, global networking and human resource development is limited. We argue that regional innovation policy ought to take this complexity and diversity into account and resist the temptation of implementing universal 'one-size-fits-all' formulas [44]. Such fine-tuned policies would require new policy support instruments that are not necessarily part of the policy makers' current portfolio. They would also require new ways of communication to enhance compliance and participation among the target population. Both a fine-tuning of activities and a more target-oriented way of communicating these are necessary components in a strategy to make such policies really influence the institutional framework of the regional innovation system.

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Article V

Article V

Differentiated Knowledge Bases and the Nature of Innovation Networks

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Forthcoming in European Planning Studies
(Accepted: Aug 6, 2012)

Abstract: It is argued in this paper that the nature of innovation networks can vary substantially with regard to the type of knowledge that is critical for innovation. Subject to the knowledge base of an industry, networks between companies can differ in various aspects, such as their geographical configuration, their structure, the type of actors holding a strategic position and the type of relations between actors. The paper comprises a conceptual discussion on social capital theory and networks, followed by a theoretically informed discussion on differentiated knowledge bases and innovation networks, which is subsequently illustrated with empirical material. The empirical analysis is based on social network analysis in association with exclusive data about patterns of cooperation and knowledge exchange in a number of regional industries located in different parts of Europe. The findings suggest that networks in analytical industries are not much constrained by geographical distance; knowledge is exchanged in a highly selective manner between research units and scientists in globally configured epistemic communities. Synthetic industries source knowledge within nationally or regionally configured networks between suppliers and customers, and within communities of practice. Symbolic industries rely on knowledge that is culturally defined and highly context specific, resulting in localised networks that are temporary and flexible in nature.

Keywords: differentiated knowledge bases; regional innovation systems; social capital; social network analysis

1. Introduction - networks and the geography of innovation

The spatial concentration of innovation activities is a matter of extensive academic debate, where increasing attention has recently been devoted to the notion of networks. The origin of this discussion refers back to Marshall (1920), who began to explore the spatial clustering of small manufacturing companies in northern England in the late 19th century and argued that their considerable economic performance results from a favourable local industrial atmosphere composed of an intensive and often unintentional exchange of ideas in the region. Within an industrial district, Marshall (1920, IV.X.7 §3) states, "[t]he mysteries of the trade become no mysteries; but are as it were in the air". The argument on the importance of the local milieu has been developed further in several territorial innovation models (Moulaert and Sekia 2003), notably in the literature on regional innovation systems (RIS) (Cooke, Uranga and Etxebarria 1998; Cooke, Heidenreich and Braczyk 2004; Asheim and Gertler 2005). In this stream of literature, a recent shift in attention can be observed from characteristics of the local industrial milieu towards strategies of innovating companies and how they can acquire new knowledge (Moodysson, Coenen and Asheim 2008). There is agreement that the unintentional roaming of ideas described by Marshall (1920) remains a seldom exception, at least when it comes to economically valuable knowledge. Even though there may be a higher probability that spatially collocated actors are exposed to knowledge flows amongst each other, spatial proximity is not a sufficient precondition for effective knowledge exchange (Torre and Gilly 2000; Gertler 2003; Boschma 2005). In fact, actors must be able to adopt and make use of the knowledge available in their surroundings, requiring a sufficient level of absorptive capacity for interactive learning to take place (Cohen and Levinthal 1990; Giuliani 2005). Such absorptive capacity involves a certain degree of cognitive similarity to enable mutual understanding, but also a certain degree of cognitive dissimilarity to evade redundancy and resemblance of thoughts and ideas (Nooteboom 1999). Consequently, knowledge is not equally accessible to all actors in the local milieu, innovation related knowledge is rather diffused and exchanged in a highly selective and uneven way (Giuliani 2007). Large parts of innovation related knowledge are exchanged amongst business partners (i.e. between customers and suppliers or users and producers), but hardly ever by pure incidence. Rather, knowledge is sourced and exchanged through *networks* that knit together companies and other organisations at different geographical locations (Gertler and Levitte 2005; Powell and Grodal 2005). The embeddedness in inter-firm networks is considered as critical for successful innovation in all sectors of the economy, and this holds for analytical, synthetic and symbolic industries (Asheim, Boschma and Cooke 2011). However, it remains unclear in the literature whether knowledge networks are equally designed in all sectors, and, more specifically, why and in what respect the nature of networks differ between industries that rely on different types of knowledge bases.

This study deals with the questions if and in what respect the nature of innovation networks varies between industries which are based on different types of knowledge. On the level of networks, a distinction is made between three dimensions, namely the structure, the type of relations and the geographical configuration of networks. On the level of industries, a distinction is made between three types of knowledge bases, namely analytical (also called 'science-based'), synthetic (also called 'engineering-based') and symbolic (also called 'art-based') industries (Asheim and Gertler 2005; Asheim, Boschma and Cooke 2011). The paper begins with a conceptual discussion on networks grounded in social capital theory, followed by a theoretically informed discussion on differentiated knowledge bases and innovation networks. This conceptual framework is subsequently illustrated with empirical data on patterns of cooperation and knowledge exchange in a number of regional industries situated in different parts of Europe.[1]

2. Social capital and the nature of networks

Innovation related knowledge is neither travelling freely in the air nor simply accessible to everyone, but is very often sourced from, and exchanged in, defined networks of actors. A typical network consists of nodes and linkages, and while nodes represent actors (i.e. persons, companies and other organisations), linkages represent different types of relationships. Networks can be knit together by formal relationships, for example, in the case of contract-based cooperation. Likewise, networks can be based on informal linkages, such as joint membership of a business association or belonging to the same knowledge community (Lave and Wenger 1991). Networks can be created for a specific purpose and with the intention to carry out a particular task, or they can gradually grow out of previous and on-going social relationships based on social or cultural communality. They can be of a strategic nature and aim at the realisation of concrete business opportunities, or they can be of a social nature and be embedded in on-going inter-personal relationships. However, as networks evolve over time, it is unlikely that relationships will always remain in one of these categories. Rather, strategic relationships can become increasingly embedded

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[1] The data are drawn from an EU collaborative research project entitled 'Constructing Regional Advantage (CRA)'. All project partners are gratefully acknowledged for collecting and providing the data.

in social relationships, while social and trust-based cooperation can eventually lead to strategic and contract-based collaboration (Powell and Grodal 2005).

A central body of literature which stresses the importance of networks for innovation is related to the notion of social capital. The literature on social capital offers on the one hand a theoretical argument on the role of networks for innovation, and provides on the other hand a number of network dimensions that can be taken into consideration when studying the geography of innovation (Loury 1977; Bourdieu 1980; Coleman 1988; Rutten, Westlund and Boekema 2010).

2.1. The structural and relational dimension of social capital

According to Bourdieu (1980, 1986) and Coleman (1988), two of the main protagonists in social capital theory, social capital is closely associated with the formation of networks.[2] Bourdieu (1986, 51) defines social capital as "the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalised relationships of mutual acquaintance or recognition", and thereby explicitly refers to networks and their significance for economic activities. Coleman (1988, 98) defines social capital by its function as "a variety of different entities, with two elements in common: they all consist of some aspect of social structures, and they facilitate certain action of actors - whether persons or corporate actors - within the structure". Although both agree on the importance of networks, each takes a different perspective when it comes to the functioning of networks. Bourdieu regards social capital as a resource which is generated through the linkages to the nodes, whereas Coleman's standpoint is that social capital consists of the linkages between the nodes (Westlund 2006). These different perspectives reflect a distinction between a structural dimension of networks on the one hand, where social capital is seen as the number of connections that an actor possesses in a network, and a relational dimension of networks on the other hand, where social capital is seen as being generated through the process of interaction, and particular attention is for that reason devoted to the nature and quality of relationships. A structuralist approach to networks suggests that an actor with numerous connections has more social capital than an actor with fewer connections, since linkages provide potential access to valuable resources and opportunities. A relational approach, in contrast, implies that social capital is only the result of successful interaction. The value of a connection arises from its actual use, and accordingly, specific attention

[2] The term 'social capital' occurs first in an article by Loury (1977), who criticises the dominant neoclassical theory to be incapable of taking social context into account.

should be devoted to the nature, quality and frequency of interactions and to the institutions (e.g. norms, values, trust) that govern social interaction (Rutten, Westlund and Boekema 2010).

Bourdieu's (1980, 1986) and Coleman's (1988) treatment of the social capital concept emphasises the economic benefits occurring to individuals by investing in networks. Networks are in this context seen as outcomes of individual investments and efforts oriented to the institutionalisation of relationships that can be used in a later stage to generate additional benefits (Portes 1998). Different arguments can be brought forward to explain how investments into social networks can generate economic benefits for individuals or organisations (Portes 1998; Lin, Cook and Burt 2001; Inkpen and Tsang 2005). First, and particularly relevant in the context of innovation activities, network embeddedness facilitates the flow and access to information and knowledge. Connections with other actors, in particular when they are situated in strategic or hierarchical positions, can provide access to economically valuable knowledge, for instance about technologies or market opportunities. Second, relationships can exert influence on decision making agents, e.g. managers in a company or policy-makers in a government. Some agents, due to their strategic position in the network, can transmit more and higher valued resources and accordingly exercise greater power on decision making agents. Third, embeddedness is often understood as a sign of the social credentials or status of an actor, reflecting its access to resources through social networks and relationships. Individuals who are strongly embedded in networks can provide other actors with resources that go beyond their individual capital. Finally, embeddedness in social networks reinforces identity and common norms and rules, since membership in a group with similar interests and resources can provide acknowledgement on one's claim on specific resources (Lin 2001).

2.2. The geographical dimension of social capital

While these arguments mainly explain benefits from social networks gained by individuals or organisations, it was with Putnam's (1993; 1995) work that the concept of social capital became closely linked to performance of regional economic systems (Portes 1998). Putnam et al. (1993) study regional governments in Italy and argue that their relative success (or failure) depends on the existence of strong horizontal networks in the society, that is, networks between individuals that are actively engaged in local clubs and associations. These networks encourage civic engagement, which goes hand in hand with more responsive regional governments and, eventually, with well-performing and prospering regional economies. In their study, they argue that northern Italian regions typically possess active civic societies with people involved in associations, clubs and various types of collective activities, stimulating interaction amongst each other and with the regional administration and ultimately leading to good and effective governance. The south of Italy, as stylised contrast, is characterised by a virtual absence of social capital, going hand in hand with corrupt regional governments and economic deprivation (Putnam, Leonardi and Nanetti 1993). In Putnam's work, social capital, defined as networks between individuals governed by common norms and mutual trusts, is seen as a necessary precondition for the economic prosperity of a regional economy.

Following these ideas, a number of studies empirically examine the importance of social capital for economic growth (Westlund and Adam 2010). Some of these explicitly deal with regional innovation (Adam 2011). With a few exceptions (e.g. Fromhold-Eisebith 2004; Lorenzen 2007), these studies tend to apply econometric methods that generate rather ambiguous results, partly due to a lack of consensus on an operational definition of social capital. Beugelsdijk and van Schaik (2005), for instance, study the effect of social capital on economic growth in European regions. They apply regression models using data from a large scale survey on basic human values and find that social capital does indeed explain differences in regional growth. It is however not the mere existence of network linkages, but the active involvement in these relations that matters (Beugelsdijk and van Schaik 2005). Hauser et al. (2007) use the same survey data to study the impact of social capital on regional patenting outcomes. They test the effect of various proxies for social capital on patenting activities and find that not all, but at least some dimensions of social capital can explain varieties in regional knowledge production. However, the authors recognise that a multidimensional concept such as social capital is difficult to capture in a small set of econometric measures (Hauser, Tappeiner and Walde 2007). Barrutia and Echebarria (2010) study the impact of social capital on innovation outcomes in Spanish and Italian regions and compare two different approaches to social capital: a rational choice-driven approach where social capital is seen as investments into social relations of an individual, and a sociologically driven approach where social capital is seen as the amount of trust and reciprocity in a community. The two approaches provide contradictory results: while investments into social relations seem to have some explanatory power, trust and reciprocity do not explain the observed variance in innovation outcomes (Barrutia and Echebarria 2010).

Even though they provide partly ambiguous results, these empirical studies all point in the direction of positive effects on various measures of network embeddedness on various measures for regional innovation outcomes (Westlund and Adam 2010; Adam 2011). The existing literature on social capital and regional innovation offers a detailed insight into various network dimensions, but it has a tendency to treat regional economies as homogenous entities without looking deeper into the sectorial composition, with the result that little can be said about industry-specific variation in the nature of innovation networks.

3. Knowledge bases and the nature of innovation networks

In the recent literature on regional innovation systems, increasing attention has been paid to industry specific differences in the geography of innovation. In this context, a distinction can be made between industries that build on different types of knowledge bases, namely analytical, synthetic and symbolic (Laestadius 1998; Asheim and Gertler 2005; Cooke and Leydesdorff 2006; Asheim, Boschma and Cooke 2011). These knowledge bases differ in various respects, such as the rationale for knowledge creation, the dominance of tacit and codified knowledge content and the dominance of different modes of innovation and learning. In this paper, it is argued that industries with different knowledge bases differ not only with regard to the type of knowledge which is involved in innovation activities, but also with regard to the nature of innovation networks, that is, their structural, relational and geographical dimension. In the following paragraph, the theoretical arguments underlying the differentiated knowledge bases concept are synthesised with regard to the notion of networks, which leads to a number of theoretically informed postulations on the nature of networks in analytical, synthetic and symbolic industries. Some of these expectations are subsequently illustrated with survey data on knowledge networks in different regional industries in Europe.

3.1. The nature of innovation networks in analytical industries

An analytical knowledge base prevails in industries where scientific knowledge is important, and where innovation is mainly based on formal models, codified knowledge and rational measures. Typical analytical industries mentioned in the literature are biotechnology, life science and some segments of information and communication technology (ICT) (Moodysson, Coenen and Asheim 2008; Plum and Hassink 2011a). A defining feature of these industries is that they aim at the development of new knowledge about natural systems by applying scientific laws. Innovation and knowledge creation follow a deductive logic of reasoning through application of scientific knowledge and models (Asheim, Boschma and Cooke 2011).

What does this imply for the nature of networks in analytical industries? It is argued in the following that innovation involves a relatively small number of actors and an intensive collaboration between those actors. This can be explained by the dominant mode of innovation and learning in analytical industries, which is science, technology and innovation (STI) (Jensen et al. 2007). The prevailing type of innovation is formal R&D, often taking place in company-owned research units and with the intention to protect (rather than to share) new research findings. Knowledge exchange is however not absent, but occurs very selectively, either through formal collaboration between organisations, or, less formalised, within communities of scientists knowledgeable in a particular issue-area.

Analytical industries deal with scientific knowledge which is typically accessible in codified form, for instance, in scientific publications or patent databases. Results from public research at universities are usually disclosed in scientific publications and thus openly available to the public, while the results from private research carried out within companies are either kept secret or protected by patents or other copyrights. Patents are the classic instrument used to protect intellectual property in analytical industries, while at the same time constituting a source of information relating to innovation activities undertaken by competitors and other actors in the market. Codified forms of knowledge accessible through publications and patent databases are particularly important for analytical industries; nonetheless, obtaining and decoding the information often goes hand in hand with interactive learning and exchange of more tacit forms of knowledge between scientists. Interactive learning and knowledge exchange with customers, suppliers and other actors is accordingly not absent, but occurs in a very selective manner.

In analytical industries, innovation is usually geared towards a very particular field, in which only a limited number of professionals share the specific language and understanding relevant to the issue-area. Knowledge exchange, therefore, takes place within small communities of knowledgeable individuals sometimes labelled as 'epistemic communities' (Haas 1992; Knorr-Cetina 1999; Amin and Cohendet 2004). Epistemic communities can be seen as networks between scientists and other professionals, who may well originate from a range of academic backgrounds, but are associated by a set of unifying characteristics, such as a shared set of normative and principled beliefs, shared causal beliefs and shared notions of validity (Haas 1992). Members of an epistemic community share similar patterns of reasoning, common causal beliefs and common discursive habits, as well as a shared commitment to the application and production of knowledge. They work on a commonly recognised subset of knowledge issues and accept common procedural authority as essential to their knowledge-building activities (Moodysson 2008). While the notion of epistemic communities is not limited to science based industries, it is useful for understanding patterns of collaboration and knowledge exchange in those industries (Knorr-Cetina 1999; Gittelman 2007; Moodysson 2008). Moodysson (2008), for instance, shows that the biotech industry in southern Sweden that most of the interactive knowledge exchange is embedded in globally configured epistemic communities and attainable only by a small number of eligible professionals.

Relationships between members of epistemic communities are typically cultivated and maintained for an extended period of time, which points in the direction of a long term stability of networks. Innovation networks are either based on long term and trust-based cooperation between key individuals in epistemic communities, or on long term and contract-based R&D cooperation between small numbers of specialised companies and research organisations. As analytical industries deal with scientific knowledge that is not dependent on a particular geographical or social-cultural context, cooperation and knowledge exchange can take place between scientists and research units that are widely dispersed across great distances. This implies that innovation networks can be globally configured, and that intensive knowledge exchange is not always restricted to a specific geographical area.

3.2. The nature of innovation networks in synthetic industries

A synthetic knowledge base prevails in industries that innovate through use and recombination of existing knowledge, with the intention to solve concrete, practical problems. Examples mentioned in the literature are automotive, aviation and shipbuilding (Broekel and Boschma 2011; Plum and Hassink 2011b). One of the main characteristics of synthetic industries is that innovation is driven by the recombining of existing knowledge and the application of engineering skills. Innovation and knowledge creation are typically aimed at concrete problem solving and custom production (Asheim, Boschma and Cooke 2011).

What does this imply for the nature of knowledge networks? It is argued in the following that networks involve a relatively small number of actors who cooperate along the supply chain or exchange knowledge in communities of practice. These networks are predominantly nationally or regionally configured. Synthetic industries are constantly engaged in resolving engineering problems, which require know-how and practical skills. In search for solutions to concrete technical problems, the dominant mode of innovation is doing, using and interacting (DUI) (Jensen et al. 2007). DUI subsumes three interrelated ways of learning, namely learning-by-doing, learning-by-using and learning-by-interacting (Arrow 1962; Rosenberg 1982; Lundvall 1988). The importance of learning-by-doing for engineering based industries is stressed by Arrow (1962), who argues innovation to be a result of practical experience and to take place by resolving concrete problems in the work place. Then again, essential forms of learning do not only occur during the course of production, but also while a product is in use by the customer, which leads to the notion of learning-by-using (Rosenberg 1982). Learning-by-doing and learning-by-using do not necessarily imply a need for knowledge sharing with other actors. However, the notion of learning-by-using suggests that learning does not take place in isolation, but very often in close connection between users and producers. As Lundvall (1988, 352) points out, "the knowledge produced by learning-by-using can only be transformed into new products if the producers have a direct contact to users". Important forms of learning occur in collaboration and close contact between users and producers and are consequently labelled as learning-by-interacting (Lundvall 1988). By means of cooperation, producers can benefit from insights into user needs and requirements and can adjust their products accordingly, while the users can increase their understanding about the use-value characteristics of a new product (Lundvall 1988, 350-352).

Interactive learning between users and producers is not the only way in which synthetic industries collaborate in networks. Important forms of cooperation can evolve between individuals engaged in solving similar or interrelated technical problems. A concept that describes this form of cooperation is 'community of practice' (Lave and Wenger 1991; Hildreth and Kimble 2004). Communities of practice refer to groups of people who share an interest, a craft, or a profession, and who communicate regularly with one another about their activities (Lave and Wenger 1991). Individuals in communities of practice share their expertise and knowledge, learn from each other and foster new approaches and solutions to problems. Communities of practice can exist within the boundaries of a firm, or they can develop between associates in different companies and different places. They can for instance emerge, as described by Wenger and Snyder (2000), between technicians who seek to improve a production flow within their company, or between engineers who cooperate between companies to improve a particular technology. Those persons are bound together by common expertise and passion for a joint undertaking, and they learn from each other by sharing knowledge about advancements and obstacles related to their work (Moodysson 2008).

Innovation networks in synthetic industries involve a relatively small number of actors, while most of the knowledge exchange occurs between suppliers and customers along the supply chain, or between the members of a community of practice with a mutual interest for a specific product or technology. Interactive learning between customers and suppliers is likely to end after a limited period of time; for instance, when the support contract between supplier and customer has ended. Communities of practice can be seen as more durable, as they involve a mingling of professional and personal relationships. Although companies deal to some extent with codified knowledge, the most essential type of knowledge is tacit, since innovation is driven by leaning-by-doing, -using and -interacting. The importance of tacit knowledge and interactive ways of learning implies that spatial proximity plays an important role for collaboration and knowledge exchange. Although international cooperation is not absent and knowledge exchange may well happen over longer geographical distances, companies are more likely to engage in intensive cooperation with suppliers and customers which are located within the regional or national milieu, where a common institutional framework facilitates interactive learning and knowledge exchange

(North 1990; Johnson 1992). Consequently, knowledge networks in synthetic industries are expected to be primarily nationally or regionally configured.

3.3. The nature of innovation networks in symbolic industries

The symbolic knowledge base is a third category which is present within a set of cultural industries, such as film, music, television, animation or video games, in which innovation is based on creativity and cultural knowledge (Garmann Johnsen 2011; Martin and Moodysson 2011; Sotarauta et al. 2011). The defining feature of symbolic industries is that innovation is geared towards the creation of meaning, desire, aesthetic qualities, effects, symbols and images. Innovation and knowledge creation are creative processes involving artistic skills and imagination (Asheim, Boschma and Cooke 2011)

What does this imply for the nature of knowledge networks? It is argued that networks in symbolic industries involve a large number of actors engaged in knowledge sharing and project-based cooperation within highly localised networks. Innovation in symbolic industries is dominated by creativity and artistic skills, while the dominant mode of innovation is flexible and based on temporary and project-based cooperation. In this context, a project can be understood as "a temporary organizational arena in which knowledge is combined from a variety of sources to accomplish a specific task" (Grabher 2004, 104). Individuals come together and work in project teams that may dissolve after the particular problem is solved or redefined (Gibbons et al. 1994, 6). Innovation is based on temporary projects because trends and fashions tend to change rapidly, which leads to a continuous variation in the skills and competences required for innovation. Product development often involves a large number of small companies and freelancers, that is, independent contractors who join into a project for a limited period of time (Garmann Johnsen 2011). Individual producers need access to a range of potential cooperation partners, so that interpersonal networks and knowledge about possible partners for cooperation and knowledge exchange are particularly important. Know-who and to some extent also know-how are highly relevant, while know-why is of minor importance. Although learning by doing, using and interacting does obviously play a role, it is argued that project-based industries are characterised by an alternative form of learning, sometimes labelled as 'learning by switching ties' (Dornisch 2002; Grabher 2004, 2005). Innovative actors are tied together for the limited period of a project before they switch to other projects and another set of connections. Repeated collaboration is often based on the reputation which an actor gains (or loses) in earlier projects. Through collaboration in previous projects, actors build up a pool of resources to draw on for future projects, and these connections can evolve into considerably large networks of cooperation and knowledge exchange. Most linkages in the network remain latent and hidden for most of the time, until they come to be reactivated for the limited period of a project (Grabher 2002).

Apart from cooperation between companies within projects, knowledge is also sourced and exchanged between individuals who share similar interpretation of the aesthetic properties of a product (Scott 2006). A group of individuals who share a common way of understanding a cultural product can be labelled as an 'interpretive community' (Fish 1980). Fish (1980) argues that a cultural product such as literary work will be interpreted differently by different persons; however, there exist communities of like-minded individuals who share similar perceptions about how a text should be read. Members of the same interpretive community are likely to use the same interpretive strategies. Conversely, disagreement about the interpretation of a cultural product is more likely to arise among members of different interpretive communities (Dorfman 1995). Interpretive communities are not necessarily bound to a specific location, though they tend to concentrate in places where people share similar socio-cultural experiences and backgrounds. Regions, and in particular metropolitan regions as centres for cultural production, can host a number of interpretive communities whose members interact and exchange knowledge on a regular basis (Berkowitz and TerKeurst 1999).

Innovation in symbolic industries is driven by creativity, interpretation and cultural awareness that can vary considerably between various regional and national settings. Companies tend to work with partners who have the same perception of the aesthetic qualities and design value of a product, which is typically the case for partners with a similar socio-cultural background. The importance of cultural knowledge and sign values suggests that cooperation and knowledge exchange takes place first and foremost within the regional milieu, while national or international collaboration is less frequent. Innovation in symbolic industries is strongly governed by the local context, and companies tend to cooperate primarily within regionally or locally configured networks (Martin and Moodysson 2011).

4. Empirical illustration – the nature of knowledge networks

The theoretical arguments made on the nature of innovation networks can be illustrated with empirical material collected in the European collaborative research project 'Constructing Regional Advantage (CRA)'. Over the course of the project, research has been carried out on a number of regional industries located in different parts of Europe, which can typically be attributed to one of the three knowledge bases. Information has been collected on various characteristics of the companies that make up a regional industry, in particular on their relations to other organisations in the (regional) innovation system. Managing directors or other firm representatives were interviewed about their companies' strategies and practices to collaborate and exchange knowledge with other organisations. More specifically, they were asked with whom they cooperate and exchange knowledge with relevance for their companies' innovation activities, either related to technological development or to market opportunities, and where these cooperation partners are located in relation to each other. The resulting survey data includes information about the companies that constitute a particular regional cluster and about their patterns of cooperation and knowledge exchange, which can be analysed by means of social network analysis.

The analytical industries in the sample comprise biotechnology in North Rhine-Westphalia (Germany), space in The Netherlands and life sciences in Scania (Sweden). The synthetic industries in the sample comprise ICT in Moravia-Silesia (Czech Republic), electronics in South Moravia (Czech Republic), automotive in Southwest Saxony (Germany), food in Scania (Sweden) and aviation in The Netherlands. The symbolic industries comprise video games in Hamburg (Germany) and moving media in Scania (Sweden).[3]

4.1. The structure of knowledge networks

As described above, industries with different knowledge bases are expected to differ with regard to the structural dimension of knowledge networks. In the following, particular attention is devoted to two network measures which are related to the structure of networks, namely degree centrality and component size (Wasserman and Faust 1994). The first measure, degree centrality, reflects the number of *direct* contacts an actor possesses in the network. In this case, it reflects the number of cooperation partners a company can draw on in order to access new knowledge. Cooperation partners can include other companies in the same or related fields, suppliers, customers or competitors, public or private organisations engaged in research and education, or policy initiatives and other organisations with relevance for innovation activities. The measure provides an indication of the extent of immediate knowledge exchange between companies by capturing the number of actors who are directly connected to one another. The second measure, component size, goes beyond the previous by taking into account the direct and *indirect* contacts an actor has in the network. This implies that companies can access knowledge not only through direct

[3] Studies on the individual cases are published, amongst others, in the European Planning Studies special issue 'Constructing Regional Advantage: Towards State-of-the-Art Regional Innovation System Policies in Europe?' (Asheim, Moodysson and Tödtling 2011)

interaction with other organisations, but that they can also indirectly benefit from knowledge that is available and transmitted from one organisation to another through intermediate organisations which act as knowledge brokers (Granovetter 1973; Burt 1992; Walker, Kogut and Shan 1997).

Obviously, not all companies in a regional industry are directly linked to one another. Some companies have a large number of direct exchange partners but are weakly integrated in the overall network. They form network components that may be strongly connected amongst each other, but disconnected from the rest of the network. Other companies have only a few direct exchange partners; however, as those are strategically positioned in the network, they can connect different components of the network and provide indirect access to a large number of organisations. Based on the theoretical discussion on the structural dimension of networks, one would expect knowledge exchange in analytical and synthetic industries to take place between a relatively small number of organisations, and symbolic industries to be constituted of a large number of collaboration partners.

Table 1: Structure of knowledge networks in analytical, synthetic and symbolic industries

			Degree centrality (direct linkages)	Component size (indirect linkages)
Knowledge base	analytical	Median	8	202
		N	74	74
	synthetic	Median	6	124
		N	183	183
	symbolic	Median	11	337
		N	57	57
Total		Median	7	178
		N	314	314

Source: own calculations

The results from the overall network analysis are fairly well in line with these expectations (see table 1). Degree centrality, reflecting the number of direct contacts, is considerably higher in symbolic industries (11) compared to analytical (8) and synthetic (6) industries.[4] This demonstrates that companies in symbolic industries rely

[4] Numbers in brackets display median values. Median values are used in order to account for the skewed distribution of the network measures.

on a larger number of partners for direct cooperation and knowledge exchange than companies in analytical and synthetic industries. Further insights can be gained by looking not only at the direct, but also at the indirect connections an actor possesses in the network. The component size is considerably lower in analytical (202) and synthetic (124) industries, while the largest component size can be observed for symbolic industries (337), confirming the theory led argument on the structural dimension of networks.

Table 2: Structure of knowledge networks in different regional industries

			Degree centrality (direct linkages)	Component size (indirect linkages)
Regional industry	Biotech in North Rhine-Westphalia (DE)	Median	11	202
		N	23	23
	Space in The Netherlands (NL)	Median	5	49
		N	21	21
	Life Science in Scania (SE)	Median	8.5	242
		N	30	30
	ICT in Moravia Silesia (CZ)	Median	6	17
		N	19	19
	Electronics in South Moravia (CZ)	Median	4	124
		N	28	28
	Automotive in Southwest Saxony (DE)	Median	11.5	545
		N	58	58
	Aviation in The Netherlands (NL)	Median	3	84
		N	50	50
	Food in Scania (SE)	Median	7.5	178
		N	28	28
	Video Game in Hamburg (DE)	Median	11	189
		N	20	20
	Moving Media in Scania (SE)	Median	11	337
		N	37	37
Total		Median	7	178
		N	314	314

Source: own calculations

A more detailed picture can be gained by breaking up the aggregated values and concentrating on specific regional industries (see table 2). The lowest component sizes can be identified in the Dutch aviation industry (3), the electronics industry in South

Moravia (4), the Dutch space industry (5) as well as in the ICT industry in Moravia Silesia (6). These four industries are typical examples of a synthetic or analytical knowledge base. Component sizes in the middle range can be identified in the food industry in Scania (7.5), which is an example for a synthetic industry, and in the life science industry in Scania (8.5), an example for an analytical industry. The largest component sizes can be identified in the two symbolic industries, namely video games in Hamburg (11) and moving media in Scania (11), but also in biotech in North Rhine-Westphalia (11) and automotive in Southwest Saxony (11.5).

While the results from the overall network analysis closely match the expectations regarding knowledge bases and network structures, the industry specific analysis reveals that not all variation in the network structure can be explained by differences in the industrial knowledge base. The extent and frequency of collaboration and networking is not only dependent on the knowledge base of an industry, but also on other factors such as the institutional setting in the respective regional innovation system (Tödtling and Trippl 2005; Tödtling et al. 2011), the characteristics of the national system of production, innovation and competence building (Lundvall et al. 2002; Asheim and Coenen 2006) and the stage of the development and evolution of the regional industry (Boschma and Frenken 2011; Martin and Sunley 2011). As this analysis encompasses a variety of industries situated in different regional and national settings and passing through different stages of development, the result points in the direction that the knowledge base is one important determinant among several factors which can explain the structural dimension of innovation networks.

4.2. The geography of knowledge networks

Another notion of networks which can be illustrated with the empirical material is the geography of knowledge networks. The companies where asked to indicate with whom they exchange knowledge and where these exchange partners are located. Accordingly, a distinction can be made between cooperation partners situated in the same regional milieu, cooperation partners located outside the region but within the national boundaries, and international cooperation partners situated outside the country.[5]

The empirical results are in line with the discussion on the geographical dimension of innovation networks (see table 3). In analytical industries, the largest share of all

[5] The space and aviation industries in the Netherlands were excluded from the geographical analysis, as the research design did not distinguish between regional and national collaboration.

exchange relations is international (40.6%), while national (25.3%) and regional (34.1%) collaboration is less frequent. This illustrates the dominance of international collaboration and globally configured networks in science based industries. In synthetic industries, most of the exchange relations occur within the national boundaries (45.6%), followed by regional collaboration (35.7%), while international collaboration is less common (18.7%). This shows that engineering based companies interact and exchange knowledge mainly within the national or subnational context. In symbolic industries, the majority of all exchange relations occurs within the regional milieu (50.6%), while national (25.3%) and international (24.1%) collaboration is less frequent, demonstrating the regional and localised nature of networks in artistic based industries.

Table 3: Geography of knowledge networks in analytical, synthetic and symbolic industries

			Contact location			Total
			regional	national	international	
Knowledge base (KB)	analytical	Count	182	135	217	534
		% within KB	34.1%	25.3%	40.6%	100%
	synthetic	Count	432	552	227	1211
		% within KB	35.7%	45.6%	18.7%	100%
	symbolic	Count	334	167	159	660
		% within KB	50.6%	25.3%	24.1%	100%
Total		Count	948	854	603	2405
		% within Total	39.4%	35.5%	25.1%	100%

Source: own calculations

A more detailed picture can be gained from distinguishing between regional industries (see table 4). The international level plays an important role in both analytical cases, in particular in the life science industry in Scania (47.3%), but also in biotechnology in North Rhine-Westphalia (32.6%). Among the synthetic cases, a clear dominance of the national level can be observed, in particular in the electronics industry in South Moravia (44.9%) and the automotive industry in Southwest Saxony (50.2%), while cooperation networks in the ICT industry in Moravia-Silesia and the food industry in Scania are nationally and, to some extent, also regionally configured. The two symbolic cases, which are video games in Hamburg (44.0%) and moving media in Scania (54.8%), are clearly dominated by regionalised cooperation networks, supporting the theoretical argument on the importance of the regional milieu for artistic based industries.

Table 4: Geography of knowledge networks in different regional industries

			Contact location			Total
			regional	national	international	
Regional industry (RI)	Biotech in North Rhine-Westphalia (DE)	Count	105	58	79	242
		% within RI	43.4%	24.0%	32.6%	100%
	Life Science in Scania (SE)	Count	77	77	138	292
		% within RI	26.4%	26.4%	47.3%	100%
	ICT in Moravia-Silesia (CZ)	Count	60	45	10	115
		% within RI	52.2%	39.1%	8.7%	100%
	Electronics in South Moravia (CZ)	Count	46	71	41	158
		% within RI	29.1%	44.9%	25.9%	100%
	Automotive in Southwest Saxony (DE)	Count	241	368	124	733
		% within RI	32.9%	50.2%	16.9%	100%
	Food in Scania (SE)	Count	85	68	52	205
		% within RI	41.5%	33.2%	25.4%	100%
	Video Game in Hamburg (DE)	Count	113	69	75	257
		% within RI	44.0%	26.8%	29.2%	100%
	Moving Media in Scania (SE)	Count	221	98	84	403
		% within RI	54.8%	24.3%	20.8%	100%
Total		Count	948	854	603	2405
		% within total	39.4%	35.5%	25.1%	100%

Source: own calculations

5. Conclusion - knowledge bases and the nature of networks

As stressed in this paper, important forms of knowledge which are required for innovation are not simply accessible to everyone in the local milieu, but are sourced and exchanged within defined networks between economic actors. Insights from social capital theory suggest that innovation networks can differ in various dimensions, such as their structure, the nature of relationships and their geographical configuration. Embeddedness into networks can have positive effects on innovation outcomes as they facilitate the flow of information and knowledge and provide access to tacit forms of knowledge which are elsewhere not available. Most of the existing studies on social capital and innovation networks treat regional economies as homogenous entities without taking into account essential differences in the regional industrial composition (Lin 2001; Westlund 2006; Adam 2011). In this respect, a distinction between knowledge bases is useful in order to conceptualise industry specific differences in the geography of innovation by referring to the nature of knowledge that underlies innovation activities.

As put forward in this paper, the structural, relational and geographical nature of innovation networks can vary substantially between industries which innovate based on different types of knowledge (see table 5).

Table 5: Knowledge bases and the differentiated nature of innovation networks

	Analytical	Synthetic	Symbolic
Structural dimension	Small number of actors; high network density	Small number of actors; low network density	Numerous actors; low network density
Relational dimension	Knowledge exchange in epistemic communities; long term cooperation between research units	Knowledge exchange in communities of practice; cooperation along supply chain	Knowledge exchange in interpretive communities; cooperation in short-term projects between companies
Geographical dimension	Knowledge exchange in globally configured networks	Collaboration in nationally and regionally configured networks	Prevalence of regionalised/localised networks

Source: own draft

In analytical industries, cooperation and knowledge exchange takes place in a highly selective way between small numbers of research units as well as between individual scientists in globally configured epistemic communities. Because networks are based on trust and reciprocity between experts in a very particular issue area, they tend to remain stable for a long period of time. Analytical industries deal with codified knowledge that is highly abstract and universally valid and therefore little bound to a specific geographical context, which implies that innovation networks are globally, rather than nationally or regionally configured.

In synthetic industries, cooperation and knowledge exchange occurs between users and producers or between members of communities of practice. Networks can remain stable for a period of time, since communities of practice are based on a common personal or professional interest for a specific product or technology, while formal cooperation between users and producers can dissolve quickly when a product is no longer in use, or when a support contract between supplier and customer has ended. Companies deal to some extent with codified knowledge, though, as innovation is driven by learning by doing, using and interacting, the most important type of knowledge is tacit. The importance of tacit knowledge and interactive learning implies that relatively little collaboration takes place across greater geographical distance, while knowledge networks are primarily nationally or regionally configured.

Innovation in symbolic industries is even more governed by the local context, and companies cooperate primarily within close geographical proximity and with a number of altering partners. Symbolic industries innovate within short-term projects, and companies change their cooperation partners frequently. They are tied together for the short period of a project before they switch to other projects and other sets of connections. Innovation in symbolic industries is driven by creativity, interpretation and cultural awareness that can vary considerably between various regional and national contexts. Companies exchange knowledge with associates in interpretive communities who share a similar perception of the aesthetic qualities and design value of a product. The importance of cultural knowledge implies that cooperation and knowledge exchange takes place first and foremost within regionally configured networks, while national or international collaboration is less frequent.

The literature on social capital provides valuable insights into the notion of networks by explaining the economic benefits generated by engagement into networks. Furthermore, it stresses a number of network dimensions, such as structure, relations and geography, all of which are important in understanding the differentiated geography of innovation. Then again, the literature on regional innovation systems and in particular on differentiated knowledge bases emphasises the need to consider industry specific differences in innovation, as the nature and geography of innovation can vary substantially between industries which are based on different types of knowledge. These industry specific differences are well reflected in the structural, relational and geographical dimensions of networks. Combining a nuanced view on networks with a differentiated perspective on knowledge bases can help to further advance our understanding of the nature and geography of innovation.

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Lund, 14th June 2012

To whom it may concern

The authors hereby certify that the paper entitled "Innovation in Symbolic Industries: The Geography and Organization of Knowledge Sourcing", which is published in *European Planning Studies* 19(7), pp. 1183-1203, is based on equal contribution by the respective authors Roman Martin and Jerker Moodysson.

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The authors hereby certify that the paper entitled "Comparing knowledge bases: on the geography and organization of knowledge sourcing", which is forthcoming in *European Urban and Regional Studies*, is based on 70% / 30% contribution by the respective authors Roman Martin and Jerker Moodysson.

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The authors hereby certify that the paper entitled "Regional Innovation Policy Beyond 'Best Practice': Lessons from Sweden", which is published in *Journal of the Knowledge Economy* 2(4), pp. 550-568, is based on equal contribution by the respective authors Roman Martin, Jerker Moodysson, and Elena Zukauskaite.

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