

The logo for CIRCLE, featuring the word "CIRCLE" in a bold, sans-serif font. A thin gold arc is positioned above the letters, starting from the top of the 'C' and ending at the top of the 'E'.

C I R C L E



Papers in Innovation Studies

Paper no. 2015/36

Regional Innovation Systems: Past - Presence - Future

Björn Asheim (bjorn.asheim@circle.lu.se)
CIRCLE, Lund University; UiS Business School/Centre for Innovation
Research, University of Stavanger; BI Norwegian Business School, Oslo

Markus Grillitsch (markus.grillitsch@circle.lu.se)
CIRCLE, Lund University

Michaela Tripl (michaela.tripl@circle.lu.se)
CIRCLE, Lund University

This is a pre-print version of a book chapter in: Doloreux D.; Shearmur R.; Carrincazeaux (eds) 'Handbook on the Geography of Innovation', Edward Elgar

This version: September 2015

Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
Lund University

P.O. Box 117, Sölvegatan 16, S-221 00 Lund, SWEDEN

<http://www.circle.lu.se/publications>

Regional Innovation Systems: Past - Presence - Future

Björn Asheim, Markus Grillitsch, Michaela Trippi

Abstract

Since its development in the 1990s, the Regional Innovation Systems (RIS) approach has attracted considerable attention from economic geographers, innovation scholars and policy makers. The RIS approach figures prominently in the scientific discourse about the uneven geography of innovation and the factors that shape the knowledge generation and innovation capacities of regions. The aim of this paper is to reflect about the emergence of the RIS approach, the current debate as well as future challenges. This reflection paper is guided by four overarching research questions: What are the origins and theoretical foundations of this approach? What has the RIS approach contributed to innovation studies and economic geography? What are the implications for innovation policy? And what are the recent lines of research and key research challenges in the future? We argue that the contributions of the RIS approach have been substantial. Still the approach has often been applied in a rather static way, more as a heuristic than a coherent theory. The key challenges for current and future research therefore are to move towards a more theory-based, dynamic perspective on RIS, dealing with new path development and the transformation of RIS.

JEL codes: O30, O38, P48, R10, R58

Keywords: regional innovation system, regional innovation policy, regional industrial change, transformation of innovation systems, research challenges

Disclaimer: All the opinions expressed in this paper are the responsibility of the individual author or authors and do not necessarily represent the views of other CIRCLE researchers.

Regional Innovation Systems: Past - Presence - Future

Björn Asheim, Markus Grillitsch, Michaela Trippel

1 Introduction

There is a widespread consensus in academic and policy debates that knowledge and innovation are eminently important for securing competitiveness, dynamic growth and prosperity of regional economies. The regional innovation system (RIS) approach figures prominently in scholarly discussions about the uneven geography of innovation and the factors that shape the knowledge generation and innovation capacities of regions. Since its development in the 1990s, it has attracted considerable attention from economic geographers and innovation scholars. Protagonists of the RIS notion have convincingly argued that the question of geographical scale is essential for understanding new knowledge creation and its economic exploitation.

This chapter reviews and discusses the conceptual cornerstones of the RIS notion and takes stock of some of the core contributions made by the pioneers of this approach. Section 2 offers an overview on the antecedents of the RIS approach and its theoretical foundations, exploring the grounding of the concept in the innovation systems literature and its connections to other territorial innovation approaches. In section 3 we discuss scholarly work on the variegated nature of regional innovation and the typologies that have been suggested to grasp the sources of differences in innovation capacity across regions. This is followed by an assessment of the attempts that have been made to apply the RIS concept to developing countries and regions and cross-border areas. This chapter also contains a review of the conceptual advances offered by the knowledge base approach, which has led to a significant further development of the RIS literature in the past decade. Furthermore, the notion of RIS as open systems and its links to the debate on the nature and geography of knowledge flows that underpin the innovation dynamics of regions are discussed.

Section 4 sheds light on the role of public policy and takes account of the inputs provided by the RIS literature to the discussion about the nature of modern innovation policy approaches. We demonstrate that the RIS notion has essentially informed this debate, providing a framework for designing and implementing regional innovation strategies across the globe and paving the way for customized, broad based innovation system policies. Finally, section 5 seeks to identify some of the most important current and future lines of research on RIS. We argue that in particular recent foci on the capacity of RIS to support new regional industrial path development and the transformation of RIS themselves as a precondition and consequence of regional industrial change deserve more attention in future work.

2 Origins of the RIS concept and its theoretical foundations

The RIS concept appeared in the 1990s and has since then attracted widespread interest from scholars and policy makers alike (Cooke 1992; Cooke and Morgan 1994; Asheim 1995; Asheim and Isaksen 1997; Asheim and Isaksen 2002; Asheim and Gertler 2005; Autio 1998; Cooke 1998; Howells 1999; Cooke 2001; Doloreux 2002). The RIS concept combines insights from the literature on innovation systems (Lundvall 1992; Nelson 1993; Freeman 1995; Edquist 1997) with the simultaneously burgeoning contributions on territorial

innovation models (Moulaert and Sekia 2003). The theoretical antecedents of the RIS concepts are discussed in two sub-chapters below zooming in on the innovation systems approach as well as on the reasons why a regional perspective on innovation systems is still legitimate and relevant.

2.1 Innovation Systems Approach

The innovation system approach was born in an OECD project on ‘Science, Technology and Competitiveness’ in the beginning of the 1980s. It builds on the premise that innovation is the key for competitiveness in a knowledge economy. Moving away from price-competition and a focus on comparative advantages, the future for advanced economies was seen in introducing new and improved products and processes, organisational routines and marketing strategies by promoting increased learning and innovation capacity. Innovation, interpreted in a Schumpeterian sense, was given highest priority in order to promote the recombination of knowledge and resources in novel ways that create higher value.

Innovation, however, was long perceived as a linear process where input in R&D leads to new inventions that then are commercialised. The innovation system approach moves away from a linear model and recognises that innovation typically results from complex, interactive and cumulative knowledge and learning processes in which a variety of actors participate. Clearly, investments in R&D will not stimulate economic growth if the generated knowledge cannot be appropriated in firms and translated into for instance products and processes that are introduced to the market. Furthermore, not all innovation, and competitive advantage based on product differentiation and Chamberlian monopolistic competition is the result of R&D. Innovation is far more varied and can be based on learning by doing using and interaction (DUI) as well as science and technology (STI) (Jensen et al. 2007).

The innovation system approach thus recognises that innovation comes in multiple forms and results from interdependencies between a variety of actors. This new understanding of innovation had profound policy implications. Innovation policy should not emphasise primarily the strengthening of R&D capacities but also support the circulation of knowledge between all the actors that are involved in generating innovations. This requires a shift of the policy focus from a few selected types of actors to a broader approach that pays particular attention to the networks between for instance universities, research organisations and firms, as well as the institutional environment in which these interactions are embedded. An active policy push is required not only to elevate market failures but also to promote the functioning of the system, this is to say knowledge exchange and learning between the actors.

At the same time, innovation systems have always been viewed as open system. This is because economies are not self-sustaining in the generation of knowledge. Economies, technologies and related institutions constantly evolve in all parts of the world. Ignorance of this fact and potential sources of new variety created elsewhere would turn any innovation system sooner or later into a dinosaur. The dynamic of innovations systems therefore depends on actors that are able and willing to tap into globally distributed knowledge sources. The absorptive capacity of actors in innovation systems, however, is to a large extent determined by the quality of human capital and organisational competencies, which in turn is influenced by the regional and national knowledge infrastructure such as universities or the education system. It can be argued therefore that competitiveness in the knowledge economy depends on the configuration and interdependencies in innovation systems, a high degree of openness, and the intersections between innovation systems and global innovation networks.

2.2 Regional Innovation Systems

Simultaneously to the emergence of the innovation systems approach in the 1980s, the concept of industrial districts was rediscovered and used to explain the success of post-Fordist regions characterised by flexible production systems and tight inter-firm networks giving rise to external economies of scale (Brusco 1982; Pyke, Becattini, and Sengenberger 1990; Asheim 2000). It was a revival of Marshall's (1920) ideas on the importance of local and regional context for the exchange of knowledge, the development of a local labour market and supplier industries. A large body of related work contributes to unveiling how regional context conditions shape innovation performance, including research on learning regions (Asheim 1996), innovative milieu (Camagni 1995; Maillat 1998; Crevoisier 2004), and clusters (Swann and Prevezer 1996; Baptista and Swann 1998; Porter 1998, 2000; Maskell 2001).

Common to these territorial innovation models (Moulaert and Sekia 2003) is a systemic perspective according to which innovation results from interactive learning processes between different types of actors. The systems approach therefore offers a unifying framework for these models despite the specificities of each (Asheim, Smith, and Oughton 2011). Innovation systems are per definition open systems (see also above), which raises the question how to delineate innovation systems and how to draw boundaries. The rationale for applying a system perspective at the regional level lies in particular in the importance of geographic proximity for knowledge exchange and interactive learning as well as the role of the region in meso-level governance.

The RIS approach emphasises the importance of geographic proximity for knowledge transfer and learning and thereby legitimises the regional perspective on innovation systems. Knowledge is partly tacit and thus difficult to transfer over distance (Polanyi 1958). Maskell and Malmberg (1999, p. 180) maintain that the proximity argument relates to the 'time geography' of individuals. Everything else being equal, interactive collaboration will be cheaper and smoother, the shorter the distance between the participants." Furthermore, tacit knowledge is embedded in a social, cultural and institutional context and as Gertler shows in his empirical investigation of German manufacturers operating in the US, tacit knowledge may lose its value when applied in other contexts (Gertler 2004). Geography is also important due to the spatial bias of social networks facilitating the circulation of knowledge (Granovetter 1973, 2005). The main reason for the spatial bias is that geographic proximity is important to establish social networks (Agrawal, Cockburn, and McHale 2006). This is intensified by the low mobility of labour. Breschi and Lissoni (2009, p. 460) find evidence that "[t]he fundamental reason why we observe geographical localization of patent citations is the low propensity of a special category of knowledge workers and providers of knowledge-intensive services (the inventors) to relocate in space." Furthermore, the dominant geographic scale for sourcing knowledge through recruitment is regional (Grillitsch, Tödting, and Höglinger 2013; Plum and Hassink 2013).

The region often also represents an important level of governance situated between the local and municipal level, as well as the national and the international level. According to Howells (1999, p. 72) three dimensions define the importance of the regional level, namely: "1 the regional governance structure, both in relation to its administrative set-up and in terms of legal, constitutional and institutional arrangements; 2 the long-term evolution and development of regional industry specialisation; and 3 additional core/periphery differences in industrial structure and innovative performance." The relative independence and strength of

regional government like in Austria or Germany, or the weakness of national government like in Italy can be important drivers for the emergence of RIS (Asheim and Isaksen 1997). The success of Baden-Württemberg's technology policy was to a large extent contingent on the federalist form of governance in Germany, which provides for independence, resources as well as high competencies of the regional government. However, even without legislative autonomy and funding opportunities, regions can play an important role in coordinating innovation activities and supporting the local industry, exemplified by Emilia-Romagna in Italia (Bianchi and Giordani 1993).

Consequently, an innovation system perspective is often justified at the regional level. This, however, does not yet tell us much about what RIS actually are. RIS understood in a narrow sense comprise two sub-systems, one capturing actors exploring and generating new knowledge and another one encompassing firms engaged in the exploitation of innovations. The knowledge exploration sub-system typically refers to universities, public and private research organisations, technology mediating organisations, workforce mediating organisations and educational organisations. The knowledge exploitation system relates to firms, often organised in one or several clusters potentially with horizontal networks between competitors and collaborators and vertical networks along the value chain. In a broad sense, RIS encompass all regional economic, social and institutional factors that affect the innovativeness of firms (cf. Lundvall 1992). The broad perspective views the two sub-systems as being embedded in an institutional and organisational support infrastructure for innovation. (Autio 1998; Cooke 1998; Tödtling and Trippl 2005; Asheim 2007).

Moreover, RIS are systemic due to the networks and interactions between the actors. Hence, it is questionable to speak about a regional innovation *system* if there is a lack of interactions of regional actors within and between the two sub-systems. These interactions are perceived to be socially embedded. Thus, the two dimensions of social capital, i.e. social networks and shared norms, values and a culture of trust (Putnam 1995; Burt 2000), are assumed to contribute to interactive learning and thus the functioning of RIS. Accordingly, the RIS approach places a stronger emphasis on informal institutions as compared to the national variant. However, common to both, the national and regional innovation system approach, is the central role of innovation policy for shaping the conditions for innovation and thus for constructing regional advantage (Asheim, Moodysson, and Tödtling 2011; Tödtling, Asheim, and Boschma 2013).

From the above, a clear distinction can be made between the RIS approach and its antecedents like industrial districts, innovative milieus or industrial clusters. From the start, these concepts zoomed in on interrelated firms in one or related industries that are co-located in space. As the cluster literature evolved, the importance of knowledge exploration to promote innovativeness has surfaced. The RIS approach, however, is more general and encompassing insofar as it looks at the systemic integration of these elements in a region, including the institutional and organisational support structures. A RIS furthermore can capture one (e.g. in a specialised region) or a variety of clusters in different stages of development (Trippl & Tödtling 2008). This implies, furthermore, that RIS are arguably more relevant units of analysis for structural change (even if the existing literature suffers often from a static perspective) than for instance industrial clusters. The reason is that new path development often results from the combination of related or unrelated industries, knowledge bases, and economic activities, thus from combinations that transcend cluster boundaries as we will discuss more in section 5.

3 Contributions of the RIS approach to Innovation Studies and Economic Geography

Over the past two decades, a flourishing literature on RIS has made essential contributions to the fields of innovation studies and economic geography. In this section we identify and discuss several of the most important core themes.

3.1 Types of RIS

The RIS approach has essentially contributed to a better understanding of the uneven geography of innovation. Its advocates have offered rich explanations for the sources and dimensions of the variegated nature of regional innovation, that is, why and in what respects innovation activities differ between regions. These endeavours have been accompanied by the development of a number of RIS typologies. The dimensions according to which RIS typologies were developed focus on i) key actors and governance (Cooke 1998; Asheim and Isaksen 2002), ii) the strengths in radical versus incremental innovations (Cooke 2004), and iii) RIS failures (Isaksen 2001; Tödting and Trippel 2005).

The typologies of Cooke (1998) and Asheim and Isaksen (2002) are based on the actors and modes of governance constituting RIS. In ‘grassroot RIS’ or ‘territorially embedded RIS’ innovation is driven by geographical proximity and interactions of firms located in the region. Typical examples are the Italian industrial districts, dominated by small firms that compete through flexible forms of production often in traditional industries. Governance is largely bottom-up, embedded in the social networks of the local actors. In ‘regionally networked innovation systems’ linkages between firms, R&D bodies and other supporting organizations can be observed and are often organized in deliberate ways. Such RIS are characterised by multi-level governance with a strong involvement of the regional level like in Baden-Württemberg. ‘Dirigist RIS’ or ‘regionalised national innovation systems’ differ substantially from the other two types. Localized learning and geographical proximity are less relevant. Firms mainly benefit from knowledge provided by national and international organizations as well as from proximity to universities and research institutes. Thus while the first two RIS types draw to a large extent on endogenous development potentials; the third one builds more on an exogenous development model. Furthermore, local and regional levels of governance play a substantially smaller role than national and international levels.

RIS scholars have also engaged in efforts to explain why some regions are able to generate high rates of radical innovation whilst others appear to do much better in producing innovations that are more incremental in nature. These differences have been portrayed as outcome of particular RIS configurations referred to as institutional RIS (IRIS) and entrepreneurial RIS (ERISs) (Cooke 2004). IRIS are well-suited to promote incremental innovations in traditional sectors due to system features such as strong user-producer interactions, supporting regulatory and institutional frameworks, public investment in (applied) R&D, the prevalence of patient capital and longer-term perspectives of a broad group of stakeholders. ERIS, in contrast, offer good conditions for radical innovation and new industries to flourish. Their dynamism is based on (local) venture capital, entrepreneurship, scientific excellence, market demand, (local) venture capital and short-term profit boosting of shareholders. The distinction in ERIS and IRIS shares some striking similarities with the varieties of capitalism approach and its distinction between liberal and market economies (Asheim and Coenen 2006; Asheim 2007) and regional versions of it (Ebner 2015). Furthermore, Asheim and Coenen (2006) argue that the national institutional framework has a

strong impact on the development of RIS. They argue that ERIS prevail in liberal market economies such as the US and the UK while IRIS are more common in coordinated market economies like the Germany or Scandinavian countries.

Another important argument brought forward in the RIS literature is that different types of regions often face typical systemic challenges (Isaksen 2001; Tödting and Tripl 2005). A distinction has been made between metropolitan agglomerations, old industrial regions and peripheral regions. Agglomerations are usually well endowed with a variety of organisations contributing complementary knowledge to innovation processes such as firms, universities, educational facilities, public innovation support facilities and policy makers. Also, different industries building on different knowledge bases are present. Headquarters of large organisations are usually located in cities, and with it knowledge intensive business services. Agglomerations are thus well equipped for combining different types of knowledge and consequentially innovate. A typical system failure for agglomerations, however, is fragmentation, which relates to a lack of networks and knowledge exchange between different sub-systems of the innovation system, such as between firms and universities (Fritsch 2003). Peripheral regions, in contrast, typically phase the system failure of organisational thinness, i.e. too few organizations that could stimulate the above-mentioned localized learning processes. In particular, such regions depend on external networks in order to compensate for a lack of learning opportunities locally (Fitjar and Rodríguez-Pose 2011; Tödting, Grillitsch, and Höglinger 2012; Grillitsch and Nilsson 2015). Finally, specialised regions, with strong organisations in a specific industry and an institutional framework supporting the specialisation, may face difficulties to adapt to changes in market or technological conditions. Then, the former success factors may become constraints and create negative lock-ins, a typical system failure in specialised regions (Tödting and Tripl 2004; Hassink and Shin 2005; Tripl and Otto 2009).

3.2 Applications of the RIS approach to other contexts

The RIS approach has also been applied to a variety of macroeconomic contexts comprising the Global North and South, and lately also to cross border areas. This has led to some extensions and re-conceptualisations of the notion. There are several aspects that surfaced from this literature: i) how to understand incomplete or emergent RIS, ii) how and why RIS emerge and strengthen over time, and iii) how to compare RIS across fundamentally different institutional and economic contexts.

In emerging and developing countries in particular, it may be questioned whether RIS do exist. Important elements of the RIS may be missing such as capable organisations in the knowledge exploration or exploitation sub-systems, the regional actors may be poorly networked and institutions may rather constrain than foster innovation. Accordingly, Radosevic (2002) was critical as to whether RIS could be observed in Central and Eastern Europe and suggested that the key focus should be on the factors determining the emergence of RIS, which according to him depends on the interplay between national, regional, micro-specific and sector-specific determinants. Against the backdrop of post-socialist transformation at the regional level, RIS should be analysed from a multi-level perspective. Evidently, even though Radosevic concluded that Central and Eastern European countries still have a formidable task ahead to establish strong RIS, the approach has been useful to identify the systemic deficiencies that hamper innovation, which relates less to the presence of RIS organisations but to their quality and the local collaborative networks.

The value of a more dynamic application of the RIS approach has also been underlined for development countries (Asheim and Vang 2006; Chaminade and Vang 2008), which closely resonates with the current efforts of introducing a more dynamic perspective to the RIS literature as discussed in sub-chapter 5. In developing countries, RIS typically are characterised by a low level of capabilities of indigenous firms, labour, but also knowledge generating organisations such as universities and research organisations. Thus, RIS located in the global periphery depend to a large extent on the inflow of knowledge, human and financial capital from external sources, such as through multinational co-operations. Typically, it is understood that firms in RIS perform low-value activities and thus compete on factor cost and could in the best case be understood as specialised hubs in global value chains. The crucial question then is how innovation policy can support the development of traded and untraded interdependencies (Storper 1995) between indigenous firms and subsidiaries of multinational co-operations and enhance the absorptive capacity. However, the picture might also be more blurred as even in the global periphery, there might be some strong firms that trigger foreign direct investments and could be the source for further upgrading (Mudambi and Santangelo 2015). Hence, more research on these dynamics is certainly required.

However, the RIS approach and the developed typologies as outlined in the previous subsection have also proven valuable in different contexts and for the purpose of comparing regions located in substantially different institutional and economic context conditions. For instance, Blazek and Zizalova (2010) apply the typology grounded on system failure for the Prague. The metropolitan area of Prague had been described as fragmented but they find that the RIS is in itself very diversified with some elements being fragmented while the biotechnology industry, one specific cluster within the RIS, is well networked. Tödting et al. (2013) compare the role of the ICT sector to renew two RIS dominated by traditional industries but embedded in different national contexts, concretely Austria as an advanced high-income market economy and the Czech Republic which has transformed from a state planning economy to a free market economy in the early 1990s. The article shows how the configuration of networks, organisational capabilities, and innovation performance plays together with the national context conditions. And Chaminade (2011) uses the RIS approach to investigate the geography of knowledge flows in Great Beijing region China and Pune in India for the automotive and software industries. The main finding is that networks differ more between the regions than between industries, thus underlining the importance of the geographic context. However, Chaminade (2011) also pointed out that the demand side of innovations as well as firm strategy have received too little consideration.

The RIS concept has also been applied to cross-border areas (Tripl 2010, Lundquist and Tripl 2013), that is, to regions that are made up of adjacent territories which belong to different nation states. Well-known examples are the Öresund region (situated at the intersection of Denmark and southern Sweden) the Euroregion Aachen, Liege, Limburg and the Centrope area (consisting of two capital cities Vienna and Bratislava, and neighbouring regions in Austria, the Czech Republic, Slovakia and Hungary). Various factors, most notably regionalization processes across the globe, the political and economic transformation of former communist countries and the enlargement of the European Union, have led to a rise in importance of cross-border regions, challenging the exclusive focus on RIS situated within a single national context. Scholarly work on cross-border RIS has thus far devoted particular attention to investigating critical preconditions for the emergence of integrated innovation spaces in trans-border settings and to identifying various stages of their evolution. Lundquist and Tripl (2013) advanced the idea that the rise and dynamic development of cross-border RIS requires to reduce distance on various dimensions, ranging from cognitive, functional, social and institutional ones. Empirical studies have given particular emphasis on the latter

aspect, that is, the institutional dimension. Departing from a broad definition of institutions that includes both formal institutions (such as laws and regulations) and informal institutions (like norms, values and routines), various scholars have found that many cross-border regions feature high levels of institutional distance, providing evidence that the lack of a common language, shared trust, beliefs and values, a common law system and so on often form powerful barriers to innovation-driven integration processes in trans-boundary regions (Van Houtum 1998, Krätke 1999, Hall 2008).

3.3 Knowledge bases

Innovation processes involve the novel combination of knowledge and have become increasingly complex and open. This is reflected in on the one hand a large body of literature dealing with the different types of knowledge involved in innovation processes and on the other hand in contributions scrutinizing knowledge flows within and between organisations.

Moving beyond the dichotomy of tacit versus codified knowledge as well as the focus on scientific knowledge, on which the linear view on innovation is grounded, the differentiated knowledge base approach has been an important advance in the RIS literature (Asheim and Gertler 2005; Tödtling, Lehner, and Trippel 2006; Asheim 2007). This approach builds on an ontology that consists of three innovation-relevant knowledge types: analytical, synthetic and symbolic knowledge. The knowledge types differ in the way knowledge is created, who is involved in the knowledge creating processes, the importance of tacit versus codified knowledge, as well as what types of innovations are created.

The analytical knowledge base draws largely on scientific knowledge created through deductive processes and formal models. Much of this knowledge is codified for instance in patents or research publications. Innovations bring new knowledge to the market resulting from collaborations between firms and research organisations. In contrast, applied, problem-related (engineering) knowledge is at the core of a synthetic knowledge base. New knowledge is typically created through inductive processes stimulated by interactive learning processes often involving clients or suppliers. Tacit knowledge plays an important role due to more concrete know-how, craft and practical skill. Innovation is more incremental and the result of the application or novel combination of existing knowledge. Symbolic knowledge represents the ability to understand and interpret the habits and norms of popular culture. Innovations result from the creation of meaning and desire through the generation of new designs, aesthetics and intangible, cultural attribute of products. This type of knowledge exhibits a high cultural embeddedness and is typically created by exchange in informal and professional communities, often in a local context.

The differentiated knowledge base literature has shown that the relative importance of each knowledge base varies significantly across industries and regions (Plum and Hassink 2011; Aslesen and Freel 2012; Martin 2012). Moreover, the geography of innovation differs markedly depending on the dominant knowledge base (Moodysson, Coenen, and Asheim 2008; Martin 2013; Herstad, Aslesen, and Ebersberger 2014). While the transfer of analytical knowledge appears to be least restricted by geographic distance, symbolic knowledge is most sticky, which has to do with the relative importance of tacit and codified knowledge as well as the cultural and institutional embeddedness of knowledge (Gertler 2003). Recently, the focus shifted from industry and region level analyses more towards firm level studies and innovation biographies showing that innovations, and in particular the more radical innovations, are often the result of combinations of knowledge bases (Manniche 2012; Strambach and Klement 2012; Grillitsch and Trippel 2014; Tödtling and Grillitsch 2015).

3.4 RIS and the geography of knowledge flows

The RIS approach was inspired by examples of successful regions with strong endogenous development potential, interregional networks embedded in an institutional environment conducive for knowledge exchange and interactive learning like Emilia-Romagna (Piore and Sabel 1984), Baden-Württemberg (Cooke and Morgan 1994), or Silicon Valley (Saxenian 1994). This, however, should not hide the fact that RIS have always been conceptualised as open systems. Systems that are embedded in national innovation systems, linked to other RIS, and that overlap with technological systems of innovations (Carlsson and Stankiewicz 1991; Markard and Truffer 2008) and sectoral systems of innovation (Malerba 2002, 2005). Well-developed RIS are characterised by strong embeddedness and networks within but also with actors located outside the region.

Theoretically, this idea was captured by the discussion on different dimensions of proximity (for a literature review see Knoblen and Oerlemans 2006). Geographical proximity facilitates face-to-face meetings, which play an important role for interactive learning processes; tends to coincide with the embedding of actors in a similar institutional framework; and can be conducive for the development of social ties. However, geographic proximity “per se is neither a necessary nor a sufficient conditions for learning to take place: at most, it facilitates interactive learning, most likely by strengthening the other dimensions of proximity.” (Boschma 2005, p. 62). Other dimensions of proximity such as cognitive, social, institutional and organisational can complement but also substitute geographical proximity. Interactive learning and even the transfer of tacit knowledge are made possible in organisational arrangements such as temporary work teams, collaborations, or strategic alliances (Powell, Koput, and Smith-Doerr 1996; Amin and Cohendet 2005).

The appreciation of the importance of extra-regional knowledge is not new in the RIS approach. For instance, Camagni in a seminal paper on innovative milieu (1995) writes that “external energy” for innovation processes can be captured through external networks. The RIS literature, however, has contributed to unveiling the complex and varied patterns of innovation flows. It has become apparent that the famous “local buzz and global pipelines” analogy (Bathelt, Malmberg, and Maskell 2004) is too simplistic. Tödtling et al. (2006) propose a typology, which builds on Storper’s (1995) distinction between traded and untraded interdependencies and Capello’s (1999) differentiation between static and dynamic aspects of knowledge transfer. Traded interdependencies typically have a formal or contractual basis stipulating the rights and responsibilities in the exchange process. Untraded interdependencies typically are informally and do not involve an immediate compensation. Traded linkages include both market transaction as well as formal cooperation, whereas the latter allows for a higher degree of interactive (dynamic) learning than the former. Untraded linkages encompass spillovers and informal networks. Also informal networks involve more dynamic learning than spillovers.

In empirical work, it has been shown that knowledge-based sectors and highly innovative firms use a variety of knowledge sources (Cooke et al. 2007; Grillitsch, Tödtling, and Höglinger 2013). Firms acquire knowledge from different types of sources, at different geographical scales and through different types of linkages (Grillitsch and Trippel 2014). However, the configuration and geography of knowledge networks is far from random and depends among others on the characteristics of the RIS, the dominant industries and knowledge bases, as well as the configurations of value chains (Chaminade 2011; Plum and

Hassink 2011; Tödtling, Grillitsch, and Höglinger 2012; Martin and Moodysson 2013). Extra regional knowledge sources play an important role for accessing complementary knowledge, which is not available in the region, creating momentum in innovation processes, and avoiding lock-ins (Cooke 2002; Trippl and Otto 2009; Hassink 2010; Tödtling, Grillitsch, and Höglinger 2012). Hence, regional and extra-regional networks play a fundamental role in our understanding of RIS.

4 RIS and the role of policy

The RIS approach has essentially informed policy and has been widely used as a framework for the design and implementation of regional innovation strategies in many areas of the world. Its appeal relies on the provision of a strong basis for customized, broad based innovation system policies.

The RIS approach has paved the way for what has become a conventional wisdom in contemporary debates, that is, the need for a customization of regional innovation policies that are sensitive to the specific preconditions, potentials and challenges found in a region. Such place-based innovation policies are a cornerstone of the new smart specialisation approach advocated by the European Commission.

Scholarly work on system failures of RIS (Isaksen 2001; Tödtling and Trippl 2005) has not only offered a set of convincing arguments for justifying policy interventions beyond the traditional notion of market failure. By identifying system failures or deficiencies that are typical for various RIS types, it has also uncovered the shortcomings of “one size fits all” policies. Insights into innovation problems related to ‘thinness’¹ prevailing in peripheral areas, system failures associated with ‘negative lock-in’ found in old industrial regions and innovation barriers resulting from ‘fragmentation’ (that is, lack of connectivity) in metropolitan areas have provided the foundation for formulating tailor-made innovation policy strategies.

The concept of differentiated knowledge bases (see section 3.3) has further advanced the debate on the need for and the nature of a customization of regional innovation policies. It constitutes a theoretical cornerstone of what has become known as the ‘constructing regional advantage approach’ (Asheim, Boschma, and Cooke 2011; Asheim, Moodysson, and Tödtling 2011). Its protagonists have shown both conceptually and empirically that analytical, synthetic and symbolic knowledge bases differ markedly in their policy needs and require specific support from RIS (Martin, Moodysson, and Zukauskaitė 2011; Tödtling, Asheim, and Boschma 2013; Martin and Trippl 2014). This has provided a strong basis for fine-tuning innovation strategies to the knowledge bases prevailing in the region as well as the underpinning for novel policy approaches that seek to promote new development paths by stimulating novel combinations of knowledge bases and innovation modes (Asheim, Boschma, and Cooke 2011; Isaksen and Nilsson 2013).

Recognising the multiple factors that influence innovation in different types of RIS, a common view has emerged favouring a broad mix of policy measures and platform policies over specific intervention favouring for instance a particular industry, knowledge base or mode of innovation (Cooke et al. 2007; Asheim, Boschma, and Cooke 2011). Platform policies recognise the potential for upgrading and renewing regional economies by

¹ For a further development of the notion of thinness, see Trippl, Asheim and Miörner (2015).

stimulating connections between industries and knowledge bases. The relevance of platform policies is underpinned by recent insights on combinatorial knowledge dynamics (Manniche 2012; Strambach and Klement 2012; Grillitsch and Tripl 2014; Tödting and Grillitsch 2015) as well as ideas from evolutionary economic geography, in particular the concept of branching based on related variety (Frenken, Van Oort, and Verburg 2007; Boschma and Iammarino 2009; Neffke and Henning 2013). Accordingly, innovation, and in particular more radical and path-breaking innovations, often require the combination of different knowledge bases. Analytical knowledge alone, i.e. competencies in research-, science-driven innovations, typically does not suffice. Also, empirical studies have shown that the regional endowment of related industries in regions is more conducive for growth than the presence of unrelated ones. The argumentation goes that the combination of knowledge from related industries produces novelty but is much more feasible than bringing together knowledge from unrelated industries. While this may hold in a stable macro-economic context, unrelated variety may better protect regions in times of substantial structural changes as well as promote new path creation (Boschma 2015).

Overall, the RIS approach promotes an active role of policy, which goes beyond addressing market failures and solving distributional problems. It is considered that system failures and transformative failures are legitimate reasons for policy interventions. Competitiveness of high-cost economies and the future development of transition economies cannot be grounded in comparative advantages but in turning comparative advantages into competitive advantages and in fostering Chamberlinian monopolistic competition based on product differentiation. The RIS approach demands an explicit policy push promoting such a high road, innovation-based regional development strategy (Asheim, Coenen, and Moodysson 2015).

5 Recent lines of research and key research challenges

In this section we take account of new developments within the RIS literature. We engage in particular with the latest ideas on how to forge a more dynamic perspective that can expound the nexus between regional industrial change and RIS transformation.

Recent scholarly work has begun to explore the key factors that shape the adaption and adaptability capacities of RIS, providing fresh insights into the main determinants of regional resilience. Promising lines of research are recent conceptual analyses of the ways by which RIS structures shape industrial diversification in a variety of regional settings (Isaksen and Tripl 2014; Tripl, Asheim, and Miorner 2015), thereby moving beyond overly micro-focused models of evolutionary economic geography which fail to account for the role of holistic features of RIS and urging a broader, more comprehensive view on regional industrial change. This work connects the RIS approach with evolutionary theories on path dependence to explore how RIS configurations (i.e. industrial structures, knowledge and support organisations, and institutional settings) influence the directions of regional change. A distinction between three main forms of regional industrial path development, that is, path extension, path renewal and new path creation, has been proposed (Tödting and Tripl 2013; Isaksen 2014; Isaksen and Tripl 2014).

Path extension occurs through incremental product and process innovations in existing firms and industries. Such intra-path changes may in the long run result in stagnation and decline due to a lack of renewal. Regional industries are then locked into innovation activities that take place along existing technological trajectories constraining their potentials for

experimentation and space to manoeuvre into more radical forms of innovation. This can lead to an erosion of regional competitiveness and path exhaustion. Path renewal takes place when existing firms and industries diversify into different but related activities and sectors. Such activities are facilitated by related variety (Frenken, Van Oort, and Verburg 2007; Boschma and Iammarino 2009; Neffke and Henning 2013), combinations of knowledge bases and the integration of different innovation modes (Jensen et al. 2007; Asheim, Boschma, and Cooke 2011; Manniche 2012; Strambach and Klement 2013). Path creation represents the most wide-ranging changes in a RIS. It refers to the establishment of new firms in entirely new sectors or the introduction of products new to the market (radical innovation) (Tödtling and Tripl 2013). Path creation is often research driven and requires active policy interventions and the creation of supportive organizational and institutional structures (Tripl, Asheim, and Miorner 2015).

Recent research suggests that different RIS types exhibit varying capacities to induce new path development, which primarily depends on the degree of diversity in the exploration and exploitation subsystems of a RIS (Isaksen and Tripl 2014; Tripl, Asheim, and Miorner 2015). It is argued that thick and diversified RIS provide favourable conditions for path renewal and new path creation due to the strong presence of related variety, different knowledge bases, knowledge generating organisations and academic entrepreneurship. However, they may exhibit weak structures for path extension brought about by a limited industrial production (exploitation) capacity. A too strong focus on and use of assets and resources for knowledge exploration and new path development can lead to a decrease in knowledge exploitation capacity, resulting in fragmentation problems. Organisationally thick and specialised RIS have rather weakly developed RIS structures for supporting new regional industrial path development. They mainly support path extension but face the risk of path exhaustion if positive lock-in turns into negative lock-in. Path renewal may also be triggered by the inflow of non-local knowledge and its combination with the highly specialized assets available within the region. Organisationally thin RIS have a limited capacity of promoting path extension and thus they have to deal with the danger of path exhaustion (although for different reasons than organisationally thick ones).

The weak capacity of many RIS to achieve path renewal and new path creation by means of endogenous resources has provoked an interest into the potential role of exogenous sources of new industrial growth paths not the least due to the increased pressure of globalisation. Tripl, Grillitsch and Isaksen (2015) have argued that the ways by which extra-regional knowledge (and other resources) can be exploited for and transformed into new path development is still poorly understood, calling for new foci of enquiry that establishes greater clarification of the determinants of RIS' capacities to attract, absorb and anchor non-local knowledge. Such research efforts would, however, require, a stronger integration of the RIS approach with established conceptual frameworks such as global production and innovation networks and the more recent literature on international labour mobility.

Research has so far sought to clarify how existing RIS architectures and configurations influence the likelihood that path creation and renewal take place and the ways by which policy can influence such processes. There is a growing awareness that RIS themselves have to change as an outcome of industrial change or as a precondition for facilitating industrial change. The transformation of RIS is indeed a core issue for future research, and especially to develop a better understanding about the processes and mechanisms that drive RIS transformation. Some scholars indeed argued that the RIS literature is ignorant about transformative dynamics at the system level (Tukker et al. 2007; Alkemade, Hekkert, and Negro 2011). Contributing to this debate, Weber and Rohracher (2012) introduce four

transformational system failures. First, the RIS approach is in principle indifferent as regards the content of the innovations. RIS transformation, and in particular transformation towards solving societal challenges however requires innovations towards a certain goal. Accordingly, the directionality failure relates to a lack of strategic guidance of individual behaviour towards a shared vision. Second, innovations that contribute towards a shared vision might not be taken up by the market because a number of complementary innovations are required, user behaviour needs to be adapted, or public demand is lacking. Hence, there may be demand articulation failures. Third, the policy coordination failure relates to the need of aligning policies and institutions from different sectors so that they provide coherent signals and incentives. The fourth transformative system failure refers to a lack of reflexivity. Transformation, it is argued requires monitoring, the involvement of actors in processes of self-governance, experimentation and system learning.

It will be an exciting challenge to better understand the transformation of RIS (and different types of RIS) and to analyse the implication for regional innovation policy. Key to achieve such an improved understanding will be a stronger focus on the microfoundations of behaviour within a RIS represented by actors (e.g. institutional entrepreneurs) and agencies. It will be interesting to assess, for instance, how new actor constellations are formed; how these actor constellations create new knowledge; how existing institutions, erected at multiple spatial scales, are recombined and reinterpreted, or new ones developed in order to create new paths; and how these processes link to strategic visions in the context of solving societal challenges. Given the inherent uncertainty related to transformative change and new path creation in regions, these processes are by nature experimental and how to approach such experimental processes is still an open question. Hence, moving towards a dynamic understanding of RIS, future research will be fundamental in understanding new path development in and the transformation of RIS.

References

- Agrawal, A., I. Cockburn and J. McHale (2006), 'Gone but not forgotten: knowledge flows, labor mobility, and enduring social relationships', *Journal of Economic Geography* **6**(5), 571-591.
- Alkemade, F., M.P. Hekkert and S.O. Negro (2011), 'Transition policy and innovation policy: Friends or foes?', *Environmental Innovation and Societal Transitions* **1**(1), 125-129.
- Amin, A. and P. Cohendet (2005), 'Geographies of Knowledge Formation in Firms', *Industry and Innovation* **12**(4), 465-486.
- Asheim, B. and J. Vang (2006), 'Regional innovation systems in Asian countries: A new way of exploiting the benefits of transnational corporations', *Innovation* **8**(1-2), 27-44.
- Asheim, B.T. (1995), 'Regionale innovasjonssystem - en sosialt og territorielt forankret teknologipolitikk', *Nordisk Samhällsgeografisk Tidskrift* **20**17-34.
- Asheim, B.T. (1996), 'Industrial districts as 'learning regions': A condition for prosperity', *European Planning Studies* **4**(4), 379-400.
- Asheim, B.T. (2000), 'Industrial districts: The contributions of Marshall and beyond'. in G.L. Clark, M.P. Feldman and M.S. Gertler (ed.), *The Oxford handbook of economic geography*, Oxford ; New York: Oxford University Press, 413-431.
- Asheim, B.T. (2007), 'Differentiated knowledge bases and varieties of regional innovation systems', *Innovation: The European Journal of Social Science Research* **20**(3), 223-241.

- Asheim, B.T., R. Boschma and P. Cooke (2011), 'Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases', *Regional Studies* **45**(7), 893-904.
- Asheim, B.T. and L. Coenen (2006), 'Contextualising Regional Innovation Systems in a Globalising Learning Economy: On Knowledge Bases and Institutional Frameworks', *The Journal of Technology Transfer* **31**(1), 163-173.
- Asheim, B.T., L. Coenen and J. Moodysson (2015), 'Methods and applications of regional innovation systems analysis'. in C. Karlsson, M. Andersson and T. Norman (ed.), *Handbook of Research Methods and Applications in Economic Geography*, Cheltenham: Edward Elgar, 272-290.
- Asheim, B.T. and M.S. Gertler (2005), 'The geography of innovation: regional innovation systems'. in J. Fagerberg, D.C. Mowery and R.R. Nelson (ed.), *The Oxford handbook of innovation*, Oxford: Oxford University Press, 291-317.
- Asheim, B.T. and A. Isaksen (1997), 'Location, agglomeration and innovation: Towards regional innovation systems in Norway?', *European Planning Studies* **5**(3), 299-330.
- Asheim, B.T. and A. Isaksen (2002), 'Regional Innovation Systems: The Integration of Local 'Sticky' and Global 'Ubiquitous' Knowledge', *Journal of Technology Transfer* **27**(1), 77-86.
- Asheim, B.T., J. Moodysson and F. Tödtling (2011), 'Constructing Regional Advantage: Towards State-of-the-Art Regional Innovation System Policies in Europe?', *European Planning Studies* **19**(7), 1133-1139.
- Asheim, B.T., H.L. Smith and C. Oughton (2011), 'Regional Innovation Systems: Theory, Empirics and Policy', *Regional Studies* **45**(7), 875-891.
- Aslesen, H.W. and M. Freel (2012), 'Industrial Knowledge Bases as Drivers of Open Innovation?', *Industry and Innovation* **19**(7), 563-584.
- Autio, E. (1998), 'Evaluation of RTD in regional systems of innovation', *European Planning Studies* **6**(2), 131-140.
- Baptista, R. and P. Swann (1998), 'Do firms in clusters innovate more?', *Research Policy* **27**(5), 525-540.
- Bathelt, H., A. Malmberg and P. Maskell (2004), 'Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation', *Progress in Human Geography* **28**(1), 31-56.
- Bianchi, P. and M.G. Giordani (1993), 'Innovation policy at the local and national levels: The case of Emilia-Romagna', *European Planning Studies* **1**(1), 25-41.
- Blazek, J. and P. Zizalova (2010), 'The Biotechnology Industry in the Prague Metropolitan Region: A Cluster within a Fragmented Innovation System?', *Environment and Planning C: Government and Policy* **28**(5), 887-904.
- Boschma, R. (2005), 'Proximity and Innovation: A Critical Assessment.', *Regional Studies* **39**(1), 61-75.
- Boschma, R. (2015), 'Towards an Evolutionary Perspective on Regional Resilience', *Regional Studies* **49**(5), 733-751.
- Boschma, R. and S. Iammarino (2009), 'Related Variety, Trade Linkages, and Regional Growth in Italy', *Economic Geography* **85**(3), 289-311.
- Breschi, S. and F. Lissoni (2009), 'Mobility of skilled workers and co-invention networks: an anatomy of localized knowledge flows', *Journal of Economic Geography* **9**(4), 439-468.
- Brusco, S. (1982), 'The Emilian model: productive decentralisation and social integration', *Cambridge Journal of Economics* **6**(2), 167-184.
- Burt, R.S. (2000), 'The Network Structure Of Social Capital', *Research in Organizational Behavior* **22**(0), 345-423.

- Camagni, R. (1995), 'The concept of *innovative milieu* and its relevance for public policies in european lagging regions', *Papers in Regional Science* **74**(4), 317-340.
- Capello, R. (1999), 'SME Clustering and factor productivity: A milieu production function model', *European Planning Studies* **7**(6), 719-735.
- Carlsson, B. and R. Stankiewicz (1991), 'On the nature, function and composition of technological systems', *Journal of Evolutionary Economics* **1**(2), 93-118.
- Chaminade, C. (2011), 'Are Knowledge Bases Enough? A Comparative Study of the Geography of Knowledge Sources in China (Great Beijing) and India (Pune)', *European Planning Studies* **19**(7), 1357-1373.
- Chaminade, C. and J. Vang (2008), 'Globalisation of knowledge production and regional innovation policy: Supporting specialized hubs in the Bangalore software industry', *Research Policy* **37**(10), 1684-1696.
- Cooke, P. (1992), 'Regional innovation systems: Competitive regulation in the new Europe', *Geoforum* **23**(3), 365-382.
- Cooke, P. (1998), 'Introduction. Origins of the concept'. in H.-J. Braczyk, P. Cooke and M. Heidenreich (ed.), *Regional Innovation Systems: The Role of Governances in a Globalized World*, London: UCL Press, 2-25.
- Cooke, P. (2001), 'Regional Innovation Systems, Clusters, and the Knowledge Economy', *Industrial and Corporate Change* **10**(4), 945-974.
- Cooke, P. (2002), 'Regional Innovation Systems: General Findings and Some New Evidence from Biotechnology Clusters', *The Journal of Technology Transfer* **27**(1), 133-145.
- Cooke, P. (2004), Integrating global knowledge flows for generative growth in Scotland: Life sciences as a knowledge economy exemplar. In *Global Knowledge Flows and Economic Development*, ed. J. Potter, 73-96. Paris.
- Cooke, P., C. De Laurentis, F. Tödting and M. Trippel (2007), *Regional Knowledge Economies: Markets, Clusters and Innovation*. Cheltenham: Edward Elgar Publishing.
- Cooke, P. and K. Morgan (1994), 'The regional innovation system in Baden-Wurttemberg', *International Journal of Technology Management* **9**(3-1), 394-429.
- Crevoisier, O. (2004), 'The Innovative Milieus Approach: Toward a Territorialized Understanding of the Economy?', *Economic Geography* **80**(4), 367-379.
- Doloreux, D. (2002), 'What we should know about regional systems of innovation', *Technology in Society* **24**243-263.
- Ebner, A. (2015), 'Editorial: Exploring Regional Varieties of Capitalism', *Regional Studies* 1-4.
- Edquist, C. (1997), *Systems of innovation: technologies, institutions, and organizations*. London: Printer Publishers/Castell Academic.
- Fitjar, R.D. and A. Rodríguez-Pose (2011), 'When local interaction does not suffice: sources of firm innovation in urban Norway', *Environment and planning. A* **43**1248-1267.
- Freeman, C. (1995), 'The `national system of innovation' in historical perspective.', *Cambridge Journal of Economics* **19**(1), 5-25.
- Frenken, K., F. Van Oort and T. Verburg (2007), 'Related Variety, Unrelated Variety and Regional Economic Growth', *Regional Studies* **41**(5), 685-697.
- Fritsch, M. (2003), 'Does R&D-cooperation behavior differ between regions?', *Industry and Innovation* **10**(1), 25-39.
- Gertler, M.S. (2003), 'Tacit knowledge and the economic geography of context, or The undefinable tacitness of being (there)', *Journal of Economic Geography* **3**(1), 75-99.
- Gertler, M.S. (2004), *Manufacturing culture : the institutional geography of industrial practice*. Oxford: Oxford University Press.
- Granovetter, M. (1973), 'The strength of weak ties', *The American Journal of Sociology* **78**(6), 1360-1380.

- Granovetter, M. (2005), 'The Impact of Social Structure on Economic Outcomes', *The Journal of Economic Perspectives* **19**(1), 33-50.
- Grillitsch, M. and M. Nilsson (2015), 'Innovation in peripheral regions: Do collaborations compensate for a lack of local knowledge spillovers?', *The Annals of Regional Science* **54**299-321.
- Grillitsch, M., F. Tödting and C. Höglinger (2013), 'Variety in knowledge sourcing, geography and innovation: Evidence from the ICT sector in Austria', *Papers in Regional Science*.
- Grillitsch, M. and M. Tripl (2014), 'Combining Knowledge from Different Sources, Channels and Geographical Scales', *European Planning Studies* **22**(11), 2305-2325.
- Hassink, R. (2010), 'Locked in decline? On the role of regional lock-ins in old industrial areas'. in R. Boschma and R. Martin (ed.), *The Handbook of Evolutionary Economic Geography*, Cheltenham: Edward Elgar, 450-468.
- Hassink, R. and D.H. Shin (2005), 'The restructuring of old industrial areas in Europe and Asia', *Environment and Planning A* **37**(4), 571-580.
- Herstad, S.J., H.W. Aslesen and B. Ebersberger (2014), 'On industrial knowledge bases, commercial opportunities and global innovation network linkages', *Research Policy* **43**(3), 495-504.
- Howells, J. (1999), 'Regional systems of innovation?'. in D. Archibugi, J. Howells and J. Michie (ed.), *Innovation policy in a global economy*, Cambridge: Cambridge University Press, 67-92.
- Isaksen, A. (2001), 'Building Regional Innovation Systems: Is Endogenous Industrial Development Possible in the Global Economy?', *Canadian Journal of Regional Science* **14**(1), 101-120.
- Isaksen, A. (2014), 'Industrial development in thin regions: trapped in path extension?', *Journal of Economic Geography*.
- Isaksen, A. and M. Nilsson (2013), 'Combined Innovation Policy: Linking Scientific and Practical Knowledge in Innovation Systems', *European Planning Studies* **21**(12), 1919-1936.
- Isaksen, A. and M. Tripl (2014), Regional industrial path development in different regional innovation systems: A conceptual analysis. *Papers in Innovation Studies*.
- Jensen, M.B., B. Johnson, E. Lorenz and B.-Å. Lundvall (2007), 'Forms of knowledge and modes of innovation', *Research Policy* **36**(5), 680-693.
- Knoben, J. and L.A.G. Oerlemans (2006), 'Proximity and inter-organizational collaboration: A literature review', *International Journal of Management Reviews* **8**(2), 71-89.
- Lundvall, B.-A. (1992), *National systems of innovation : towards a theory of innovation and interactive learning*. London: Pinter.
- Maillat, D. (1998), 'Interactions between urban systems and localized productive systems: an approach to endogenous regional development in terms of innovative milieu', *European Planning Studies* **6**(2), 117-130.
- Malerba, F. (2002), 'Sectoral systems of innovation and production', *Research Policy* **31**(2), 247-264.
- Malerba, F. (2005), 'Sectoral Systems: How and Why Innovation Differs Across Sectors'. in J. Fagerberg, D.C. Mowery and R.R. Nelson (ed.), *The Oxford Handbook of Innovation*, Oxford: Oxford University Press, 380-406.
- Malmberg, A. and P. Maskell (1999), 'The Competitiveness of Firms and Regions: 'Ubiquitification' and the Importance of Localized Learning', *European Urban and Regional Studies* **6**(1), 9-25.
- Manniche, J. (2012), 'Combinatorial Knowledge Dynamics: On the Usefulness of the Differentiated Knowledge Bases Model', *European Planning Studies* **20**(11), 1823-1841.

- Markard, J. and B. Truffer (2008), 'Technological innovation systems and the multi-level perspective: Towards an integrated framework', *Research Policy* **37**(4), 596-615.
- Marshall, A. (1920), *Principles of economics : an introductory volume*. London: Macmillan.
- Martin, R. (2012), 'Measuring Knowledge Bases in Swedish Regions', *European Planning Studies* **20**(9), 1569-1582.
- Martin, R. (2013), Differentiated Knowledge Bases and the Nature of Innovation Networks. *European Planning Studies*.
- Martin, R. and J. Moodysson (2013), 'Comparing knowledge bases: on the geography and organization of knowledge sourcing in the regional innovation system of Scania, Sweden', *European Urban and Regional Studies* **20**(2), 170-187.
- Martin, R., J. Moodysson and E. Zukauskaite (2011), 'Regional Innovation Policy Beyond 'Best Practice': Lessons from Sweden', *Journal of the Knowledge Economy* **2**(4), 550-568.
- Martin, R. and M. Trippel (2014), 'System Failures, Knowledge Bases and Regional Innovation Policies', *disP - The Planning Review* **50**(1), 24-32.
- Maskell, P. (2001), 'Towards a knowledge-based theory of the geographical cluster', *Industrial and Corporate Change* **10**(4), 921-943.
- Moodysson, J., L. Coenen and B.T. Asheim (2008), 'Explaining spatial patterns of innovation: analytical and synthetic modes of knowledge creation in the Medicon Valley life-science cluster ', *Environment and Planning A* **40**(5), 1040-1056.
- Moulaert, F. and F. Sekia (2003), 'Territorial innovation models: a critical survey', *Regional Studies* **37**(3), 289-302.
- Mudambi, R. and G.D. Santangelo (2015), 'From Shallow Resource Pools to Emerging Clusters: The Role of Multinational Enterprise Subsidiaries in Peripheral Areas', *Regional Studies* 1-15.
- Neffke, F. and M. Henning (2013), 'Skill relatedness and firm diversification', *Strategic Management Journal* **34**(3), 297-316.
- Nelson, R.R. (1993), *National Innovation Systems: A Comparative Analysis*. Oxford: Oxford University Press.
- Piore, M.J. and C.F. Sabel (1984), *The second industrial divide : possibilities for prosperity*. New York: Basic Books.
- Plum, O. and R. Hassink (2011), 'Comparing knowledge networking in different knowledge bases in Germany', *Papers in Regional Science* **90**(2), 355-371.
- Plum, O. and R. Hassink (2013), 'Analysing the knowledge base configuration that drives southwest Saxony's automotive firms', *European Urban and Regional Studies* **20**(2), 206-226.
- Polanyi, M. (1958), *Personal knowledge : towards a post-critical philosophy*. London: Routledge & Kegan Paul.
- Porter, M.E. (1998), 'Clusters and the new economics of competition', *Harvard business review* **76**(6), 77-90.
- Porter, M.E. (2000), 'Location, Competition, and Economic Development: Local Clusters in a Global Economy.', *Economic Development Quarterly* **14**(1), 15-35.
- Powell, W.W., K.W. Koput and L. Smith-Doerr (1996), 'Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology', *Administrative Science Quarterly* **41**(1), 116-145.
- Putnam, R.D. (1995), 'Bowling alone: America's declining social capital', *Journal of democracy* **6**(1), 65-78.
- Pyke, F., G. Becattini and W. Sengenberger (1990), *Industrial districts and inter-firm co-operation in Italy*. Geneva: International Institute for Labour Studies.

- Radosevic, S. (2002), 'Regional Innovation Systems in Central and Eastern Europe: Determinants, Organizers and Alignments', *The Journal of Technology Transfer* **27**(1), 87-96.
- Saxenian, A. (1994), *Regional advantage : culture and competition in Silicon Valley and Route 128*. Cambridge, Mass.: Harvard Univ. Press.
- Storper, M. (1995), 'The resurgence of regional economies, ten years later: the region as a nexus of untraded interdependencies', *European Urban and Regional Studies* **2**(3), 191-221.
- Strambach, S. and B. Klement (2012), 'Cumulative and Combinatorial Micro-dynamics of Knowledge: The Role of Space and Place in Knowledge Integration', *European Planning Studies* **20**(11), 1843-1866.
- Strambach, S. and B. Klement (2013), 'Exploring plasticity in the development path of the automotive industry in Baden-Wurtemberg: The role of combinatorial knowledge dynamics', *ZEITSCHRIFT FÜR WIRTSCHAFTSGEOGRAPHIE* **57**(1-2), 67-82.
- Swann, P. and M. Prevezer (1996), 'A comparison of the dynamics of industrial clustering in computing and biotechnology', *Research Policy* **25**(7), 1139-1157.
- Tödttling, F., B.T. Asheim and R. Boschma (2013), 'Knowledge sourcing, innovation and constructing advantage in regions of Europe', *European Urban and Regional Studies* **20**(2), 161-169.
- Tödttling, F. and M. Grillitsch (2015), 'Does Combinatorial Knowledge Lead to a Better Innovation Performance of Firms?', *European Planning Studies* **23**(9), 1741-1758.
- Tödttling, F., M. Grillitsch and C. Höglinger (2012), 'Knowledge Sourcing and Innovation in Austrian ICT Companies—How Does Geography Matter?', *Industry and Innovation* **19**(4), 327-348.
- Tödttling, F., P. Lehner and M. Trippel (2006), 'Innovation in knowledge intensive industries: The nature and geography of knowledge links', *European Planning Studies* **14**1035-1035.
- Tödttling, F., K. Skokan, C. Höglinger, P. Rumpel and M. Grillitsch (2013), 'Innovation and knowledge sourcing of modern sectors in old industrial regions: Comparing software firms in Moravia-Silesia and Upper Austria', *European Urban and Regional Studies* **20**(2), 188-205.
- Tödttling, F. and M. Trippel (2004), 'Like Phoenix from the Ashes? The Renewal of Clusters in Old Industrial Areas', *Urban Studies* **41**(5-6), 1175-1195.
- Tödttling, F. and M. Trippel (2005), 'One size fits all? Towards a differentiated regional innovation policy approach', *Research Policy* **34**(8), 1203-1219.
- Tödttling, F. and M. Trippel (2013), '*Transformation of regional innovation systems: from old legacies to new development paths*'. in P. Cooke (ed.), *Reframing regional development*, London: Routledge, 297-317.
- Trippel, M., B.T. Asheim and J. Miorner (2015), Identification of regions with less developed research and innovation systems. *Papers in Innovation Studies*.
- Trippel, M., M. Grillitsch and A. Isaksen (2015), External “energy” for regional industrial change? Attracting and anchoring of non-local knowledge for new path development. In *RIP Conference*. Karlsruhe.
- Trippel, M. and A. Otto (2009), 'How to turn the fate of old industrial areas: a comparison of cluster-based renewal processes in Styria and the Saarland', *Environment and planning. A* **41**(5), 1217-1233.
- Tukker, A., M. Charter, C. Vezzoli, E. Sto and M.M. Andersen (2007), *System Innovation for Sustainability 1: Perspectives on Radical Changes to Sustainable Consumption and Production*. Sheffield: Greenleaf.
- Weber, K.M. and H. Rohracher (2012), 'Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and

multi-level perspective in a comprehensive 'failures' framework', *Research Policy* **41**(6), 1037-1047.