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Regional Innovation Systems: Theory, Empirics and Policy

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ASHEIM B. T., LAWTON SMITH H. and OUGHTON C. Regional innovation systems: theory, empirics and policy, *Regional Studies*. Interest in regional innovation systems has grown significantly over the past three decades driven partly by advances in theoretical analysis, partly by the growing interest in innovation as a source of competitive advantage, and partly by the need for new policies to address regional inequalities and divergence. This article explores the elements and characteristics that exemplify the regional innovation systems approach. It provides an appraisal and synthesis of the regional innovation systems paradigm and aims to shed light on a number of areas where theoretical, empirical and policy-based questions remain unanswered. It outlines and assesses the major strands in recent theoretical and empirical debates and discusses how they might be developed to contribute to the further advancement of the regional innovation systems literature. Three interrelated questions form the key themes around which the article is structured. The first concerns the very nature of the system itself. The second concerns the boundaries of industrial districts, clusters and regional innovation systems, and the role of cognitive frontiers, knowledge transfer and learning. The third relates to the central role of knowledge and learning in clusters and regional innovation systems and in particular to the role and functioning of the labour market. These three cross-cutting themes separately and collectively provide new theoretical, empirical and policy insights; they also raise other questions which are intended to stimulate much future research.

Regional innovation systems Industrial districts Clusters Knowledge and learning Labour markets

ASHEIM B. T., LAWTON SMITH H. and OUGHTON C. 区域创新系统：理论、实践以及政策，区域研究。对区域创新系统的关注在过去的30年内得到显著提高，这部分归因于理论分析的进步，也由于创新是竞争优势的源头，同时也基于新政策强调区域不公平以及区域差异的需求。本文考察了对区域创新系统方法进行分析的要素以及特征。文章通过对区域创新系统范式的评价以及综合分析为理论、实践以及政策领域做出相应的贡献。研究概述并评价了目前理论及实践研究中主要的分支，讨论了他们在区域创新系统研究中的下一步发展方向。文章围绕三个理论核心展开。首先考虑系统本身的性质。其次考虑产业区、集群以及区域创新系统的边界，认知前沿、知识转换以及学习过程的作用。第三是知识与学习在集群及区域创新系统尤其是劳动力市场职能中的核心作用。上述三类跨界的主题各自或者整合地提供了新的理论、实践以及政策视角，同时也指出未来研究中需要注意的问题。

区域创新系统 产业区 集群 知识与学习 劳动力市场

ASHEIM B. T., LAWTON SMITH H. et OUGHTON C. Les systèmes d'innovation régionaux: la théorie, l'empirisme et la politique, *Regional Studies*. L'intérêt pour les systèmes d'innovation régionaux a augmenté sensiblement pendant les trois dernières décennies, conduit en partie par les progrès dans l'analyse théorique, en partie par l'intérêt croissant pour l'innovation comme source de l'avantage compétitif, et en partie par la nécessité des politiques nouvelles pour aborder les écarts et les divergences régionaux. Cet article examine les éléments et les caractéristiques qui illustrent les façons d'aborder les systèmes d'innovation régionaux. On évalue et synthétise le paradigme des systèmes d'innovation régionaux et éclaircit un nombre de questions théoriques, empiriques et de politiques auxquelles il faut toujours répondre. On esquisse et évalue les principaux fils des débats théoriques et empiriques récents et on discute comment on pourrait les développer afin de contribuer au progrès de la documentation sur les systèmes d'innovation régionaux. Trois questions interdépendantes constituent les thèmes clés à partir desquels on structure l'article. Le premier traite de la nature même du système. Le deuxième concerne les limites des districts industriels, des clusters et des systèmes d'innovation régionaux, et le rôle des frontières cognitives, du transfert de la connaissance et de l'apprentissage. Le troisième se rapporte au rôle primordial de la connaissance et de l'apprentissage dans les clusters et les systèmes d'innovation régionaux, et en particulier au rôle et au fonctionnement du marché du travail. Ces trois thèmes interdépendants fournissent séparément et collectivement de nouveaux aperçus théoriques, empiriques et de politique; ils posent aussi d'autres questions qui visent à encourager beaucoup de recherche future.

Systèmes d'innovation régionaux Districts industriels Clusters Connaissance et apprentissage Marchés du travail

ASHEIM B. T., LAWTON SMITH H. und OUGHTON C. Regionale Innovationssysteme: Theorie, Empirie und Politik, *Regional Studies*. In den letzten drei Jahrzehnten ist das Interesse an regionalen Innovationssystemen stark gewachsen, was teils auf die Fortschritte bei der theoretischen Analyse, teils auf das wachsende Interesse an der Innovation als Quelle von Wettbewerbsvorteilen und teils auf den Bedarf an neuen Politiken zum Ausgleich von regionalen Ungleichgewichten und Divergenzen zurückzuführen ist. In diesem Beitrag werden die Elemente und Merkmale zur Veranschaulichung des Ansatzes für regionale Innovationssysteme untersucht. Wir nehmen eine Bewertung und Synthese des Paradigmas der regionalen Innovationssysteme vor und versuchen, Aufschluss über zahlreiche Bereiche mit offenen theoretischen, empirischen und politischen Fragen zu geben. Wir beschreiben und bewerten die wichtigsten Strömungen der aktuellen theoretischen und empirischen Debatten und erörtern, wie sich diese Debatten fortführen lassen, um zur Weiterentwicklung der Literatur über regionale Innovationssysteme beizutragen. Die zentralen Themen, um die der Artikel strukturiert ist, gründen auf drei miteinander zusammenhängenden Fragen. Die erste dieser Fragen betrifft das wahre Wesen des eigentlichen Systems. Die zweite bezieht sich auf die Grenzen von Industriebezirken, Clustern und regionalen Innovationssystemen und die Rolle von kognitiven Grenzen, Wissensübertragung und Lernen. Die dritte bezieht sich auf die zentrale Rolle des Wissens und Lernens in Clustern und regionalen Innovationssystemen und insbesondere auf die Rolle und Funktion des Arbeitsmarktes. Diese drei bereichsübergreifenden Themen ermöglichen für sich getrennt und gemeinsam neue theoretische, empirische und politische Erkenntnisse; ebenso werfen sie weitere Fragen auf, die künftig zu umfangreicher weiterer Forschung Anlass geben sollten.

Regionale Innovationssysteme Industriebezirke Cluster Wissen und Lernen Arbeitsmärkte

ASHEIM B. T., LAWTON SMITH H. y OUGHTON C. Sistemas de innovación regional: teoría, empirismo y política, *Regional Studies*. El interés en los sistemas de innovación regional ha crecido de modo significativo en los últimos treinta años, impulsado en parte por los avances en los análisis teóricos, en parte por el creciente interés en la innovación como una fuente de ventaja competitiva y en parte por la necesidad de nuevas políticas que aborden las desigualdades y la divergencia regionales. En este artículo analizamos los elementos y las características que ilustran el enfoque de los sistemas de innovación regional. Ofrecemos una valoración y síntesis del paradigma de los sistemas de innovación regional con el objetivo de arrojar luz sobre toda una serie de áreas en las que las cuestiones teóricas, empíricas y políticas quedan por responder. Destacamos y evaluamos las principales tendencias de los recientes debates teóricos y empíricos y analizamos cómo podrían desarrollarse para contribuir a un mayor progreso de la bibliografía sobre los sistemas de innovación regional. Este artículo se ha estructurado básicamente en torno a tres cuestiones interrelacionadas. La primera cuestión trata sobre la propia naturaleza del mismo sistema. La segunda trata sobre los límites de las comarcas industriales, las aglomeraciones y los sistemas de innovación regional, y el papel de las fronteras cognitivas, la transferencia de conocimiento y el aprendizaje. La tercera trata sobre el papel central del conocimiento y el aprendizaje en las aglomeraciones y los sistemas de innovación regional, y especialmente sobre el papel y la función del mercado laboral. Estos tres temas transversales por separado y colectivamente ofrecen una nueva perspectiva teórica, empírica y política; también plantean otras cuestiones cuya finalidad es estimular muchas más investigaciones en el futuro.

Sistemas de innovación regional Comarcas industriales Aglomeraciones Conocimiento y aprendizaje Mercados de trabajo

JEL classifications: O, O1, O18, R, R1, R11

INTRODUCTION

Research on regional innovation has grown significantly over the past three decades driven partly by advances in theoretical analysis, partly by the growing interest in innovation as a source of competitive advantage, and partly by the need for new policies to address regional inequalities and divergence. The growth and development of the field can be traced using the Social Science Citation Index (SSCI), which shows that whereas between 1980 and 1989 only three articles in the SSCI were on the topic of 'regional innovation', some two decades later the comparable figure (2000–2009) had increased over eighty-fold to 265 articles.

The theoretical foundations of this literature are grounded in the systems of innovation approach and the older and related literature on industrial districts, as well as more recent work on clusters and innovative milieux. Since the articulation and development of the

national innovation systems (NIS) approach in the 1980s and its extension to the regional level, research on regional innovation systems (RIS) grew significantly from a baseline of zero articles in the SSCI in 1980–1989 to sixty-five articles in 2000–2009. The proportion of articles on RIS has also increased, reflecting the growing importance of this approach within social science research generally and within innovation and regional studies in particular. Fig. 1 shows the growth of the regional innovation literature in terms of the proportion of SSCI articles with the term 'regional innovation' in their title.¹

Fig. 2 traces the development of the literature on RIS, and related territorial innovation models: industrial districts, clusters and innovative milieux. The historic role of the Marshallian *industrial districts* literature and its revival in the 1990s can be clearly seen, as can the rapid growth of the clusters and RIS literature over the most recent decade for which data are available (2000–2009).

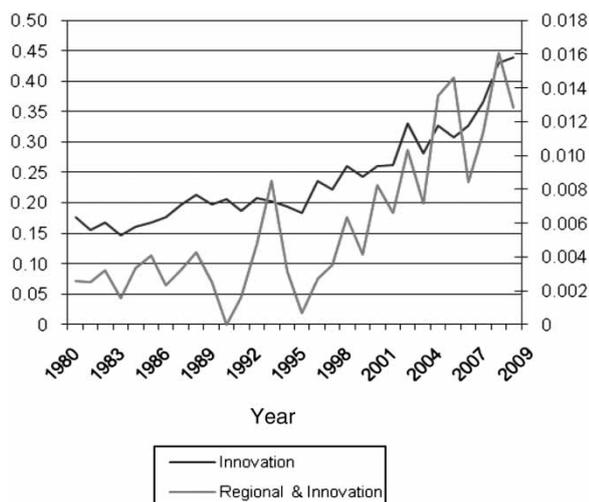


Fig. 1. Proportion of articles in the Social Science Citation Index (SSCI) with 'innovation' (left y-axis) or 'regional innovation' (right y-axis) in their title, 1980–2009
Source: SSCI and authors' own calculations

The increased availability of theoretical, empirical and policy-based publications and the articulation and development of the RIS approach have begun to enhance our understanding of the complexities of regional innovation. However, the field remains relatively new and its development has thrown up a number of unresolved research questions and posed new challenges to policy-makers.

This special issue brings together a set of articles that exemplify and develop the RIS approach. It provides an appraisal and synthesis of the RIS paradigm with the objective of shedding light on a number of areas where theoretical, empirical and policy-based questions remain unanswered. The present introductory article outlines the main contours of recent theoretical and empirical debates and discusses how the articles in this issue contribute to the further development of the

RIS literature. It starts by considering the development of the RIS approach and its theoretical antecedents identifying the different strands of the literature that have evolved following the work of Marshall, List, Freeman, Lundvall, Nelson, Brusco, Cooke, Asheim, Cooke and Morgan, and Maillat and Aydalot. Here, the relationships between these different approaches are considered and it is suggested why the RIS approach provides a unifying framework for territorial innovation models.

Three interrelated questions follow from this analysis and these form the key themes around which this issue is structured. The first concerns the very nature of the system itself. This is an area where there has been considerable intellectual endeavour that has led to fruitful demarcation of types and varieties of RIS. However, a major gap in the literature concerns the effectiveness of different varieties/types and the relationship between RIS and regional competitive advantage. The articles by Asheim, Boschma and Cooke; Fritsch and Slavtchev; Hudson, Lawton Smith and Waters; and Zhang, Xu and Liu all touch on aspects of this issue. The second key theme (which is dealt with primarily in the articles by Lawton Smith and Waters; Meyer, Libaers and Park; Ter Wal and Boschma; and Zhang, Xu and Liu) concerns the boundaries of RIS and the role of cognitive frontiers, knowledge transfer and learning. These articles consider the extent of intra- and inter-regional learning and the related question of the degree of openness of territorial innovation systems often in a dynamic setting where path dependency is an inherent characteristic. This leads to the third theme which relates to the central role of knowledge and learning in clusters and RIS and in particular to the role and functioning of the labour market. Here the findings from the articles by Hudson; Lawton Smith and Waters; and Zhang, Xu and Liu all make important contributions to our understanding of the role of the creation, attraction and utilization of human capital within RIS.

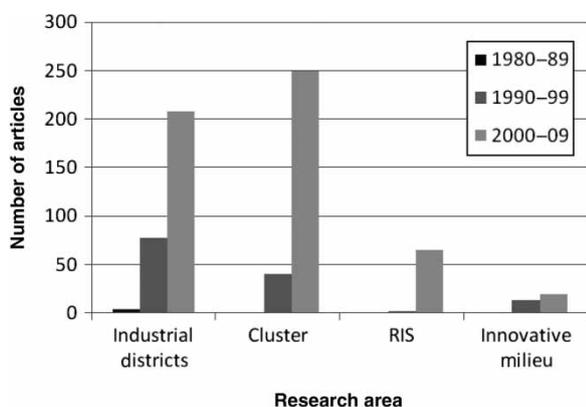


Fig. 2. Number of articles in the Social Science Citation Index (SSCI) on the following topics: industrial districts, clusters (firm-based), regional innovation systems and innovative milieu
Source: SSCI and authors' own calculations

REGIONAL INNOVATION SYSTEMS: THEORETICAL ANTECEDENTS AND DEVELOPMENT

The RIS approach has multiple theoretical antecedents drawing on the literatures on Marshallian industrial districts, economic geography, innovative milieux, clusters and national systems of innovation. Each of these is reviewed in turn, and the links between them and their influence on the development of the RIS approach are discussed.

Writing during the late nineteenth and early twentieth centuries, Marshall was one of the first economists to analyse the role of innovation in a local or regional context. For almost a century this aspect of Marshall's work was largely neglected, but during the last three

decades there has been a marked revival of interest in Marshall's work on industrial districts and innovation. A central motivation for his analysis of the localization of industry was the question of the relative efficiency of large firms compared with agglomerations of small firms and the closely related issue of the relative importance of internal economies of scale and external economies. In several of his works (for example, MARSHALL and MARSHALL, 1879; and MARSHALL, 1930)² Marshall argued that despite the growing importance of internal economies of scale and the resultant effects on the size distribution of firms (towards large firms), it was still possible for agglomerations of small firms to be efficient and to compete with larger firms on an equal footing.

The 1980s saw a revival of interest in Marshall's ideas when the concept of the industrial district was applied extensively to illuminate the economic success of post-Fordist regions based on small and medium-sized enterprises in Italy and Germany, most notably Emilia-Romagna and Baden Württemberg (for example, BRUSCO, 1982, 1990; COOKE and MORGAN, 1998). Much of this work was rooted in the wider literature on economic geography (ASHEIM, 2000; FELDMAN, 1994, 1999, 2000, 2001; GERTLER, 2003; CLARK *et al.*, 2000; HOWELLS, 1999, 2002) and territorial innovation (MOULAERT and SEKIA, 2003). With the development of the NIS literature taking hold in the late 1980s and early 1990s, the systems approach began to provide a unifying framework for a large corpus of related research on regional innovation.³ This includes the work on learning regions (ASHEIM, 1996), innovative milieux (CREVOISIER, 2004; CAMAGNI, 1995), the Triple Helix model (ETZKOWITZ and LEYDESDORFF, 1997; LEYDESDORFF, 2000), and clusters (PORTER, 1990, 1998a, 1998b; SWANN and PREVEZER, 1996; BAPTISTA and SWANN, 1998). At the core of the RIS approach is an emphasis on economic and social interactions between agents, spanning the public and private sectors to engender and diffuse innovation within regions embedded in wider national and global systems.

Given that the industrial districts literature is a common antecedent of the 'clusters', 'regional innovation systems' and 'innovative milieux' approaches,⁴ it is not surprising that there is a degree of commonality, most notably regarding the analysis of cooperation, networks, institutions, trust, inter-organizational learning and knowledge transfer. There are, however, differences in emphasis and approach. While the RIS approach draws on the industrial districts literature, it also addresses some of its limitations, in particular Markusen's critique that industrial districts focus on particular localities 'extracted from their embeddedness in a large global [or national] economy'. In her review of the industrial districts literature Markusen argues that 'a broader institutional approach' is required that encompasses 'embeddedness across district boundaries' (MARKUSEN, 1996, p. 309). A similar tendency is evident in

the innovative milieu literature which highlights the territorial nature of innovation, often at a local or sub-regional level, and the role of social capital, organization, production and innovation. It draws more heavily than the other approaches on sociological theory in combination with spatial economic analysis with an emphasis on the role of learning, apprenticeship (CREVOISIER, 2004) and skill sets. According to this approach:

it is not territory as a medium that is important but the bringing together of economic players and non-material resources [training, research] which, through their interactions, develop specific skills, know-how, rules, etc.

(MAILLAT, 1998, p. 7)

COOKE (1992) is widely attributed as coining the term 'regional innovation system' in his *Geoforum* article which provides a typology of different types of RIS further developed by COOKE (1998). The subsequent development of the RIS literature (ASHEIM and ISAKSEN, 1997; BRACZYK *et al.*, 1998; COOKE and MORGAN, 1994a, 1994b; MORGAN, 1997; HOWELLS, 1999; BAPTISTA and SWANN, 1998; OUGHTON and WHITTAM, 1997) has highlighted the role of regional learning processes and institutions in an evolutionary framework. As Fig. 2 shows, the RIS literature became established in the first decade of the twenty-first century (ASHEIM and GERTLER, 2005; ASHEIM, 2007) making significant inroads in leading social science journals.

RIS' emphasis on social capital, networking and learning within an evolutionary framework may be compared with the clusters literature. This literature is more directly concerned with competitiveness and performance and more strongly influenced by mainstream economic theory. The literature on clusters (PORTER, 1990, 1998a, 1998b; BAPTISTA and SWANN, 1998, 1999), including Porter's work on competitive advantage, developed more or less in parallel with the systems approach and related territorial models of innovation, most notably the industrial districts and innovative milieux literatures. However, whilst the ideas of clusters and RIS are clearly related, it is important to distinguish the two concepts (ASHEIM, 2007; ASHEIM *et al.*, 2006). Definitions of clusters vary, but a common element is that clusters are geographic concentrations of firms operating in the same or in related industries (ASHEIM and COENEN, 2005; ISAKSEN and HAUGE, 2002; COOKE, 2001; PORTER, 1998a, 1998b; SWANN and PREVEZER, 1996; ENRIGHT, 2003).

A number of authors build on this basic cluster definition to include interconnections between firms in a cluster; however, here it is necessary to distinguish *market* and *non-market* connections. Within a cluster there may be a high degree of trade between firms, especially if the cluster comprises firms that are vertically integrated through a supply chain. These trades are part

of normal market relationships between businesses. At the same time, there may be non-market or networking relationships between firms; firms may actively engage in cooperative ventures and joint investment within a supply chain or with competitors, for example research joint ventures. Networks may also include a variety of non-firm actors such as research organizations, universities, training bodies and so on. A cluster may consist of inter-firm market relationships alone, or alternatively the firms in the cluster may also be networked, that is, connected by both trade relationships *and* non-market, network relationships with firms and other organizations. These non-market relationships are defined here as networking relationships because they require the *active* rather than the *passive* involvement of firms in order to sustain them (OUGHTON and WHITTAM, 1997). They also depend on cooperation, trust and social capital.

The distinction between clusters and networks is important for (at least) three reasons. First, it is possible for a cluster of firms to exist in a geographic area and for there to be a high degree of trade between firms within the cluster but a lack of networking relationships, so that the only relationships between firms are market relationships. SWANN (2009, p. 149) defines this type of cluster as a *shallow* cluster. Such an emphasis on market relationships is seen by orthodox economists (perhaps mistakenly) as the general case rather than a special case.⁵ Second, as Ter Wal and Boschma (in this issue) point out, clusters are inherently geographic and spatial while the network concept is 'by definition an *a-spatial* concept' (emphasis added). Third, the distinction between clusters and networks is important because each gives rise to different types of external economies and thus each has different effects on regional competitive advantage. In the case of clusters, firms benefit from pecuniary external economies, unintended spillovers of knowledge, and the attraction of related trades, labour and consumers to the cluster through normal market processes. In the case of networks firms actively engage in cooperative activity, such as research and development (R&D), training, joint marketing, etc. via joint investment and new organizational forms. These collective external economies (OUGHTON and WHITTAM, 1997), which are realized via cooperation rather than market competition, are external to the firm but internal to the network and they require the active rather than the passive involvement of firms. Networks are therefore regionally and institutionally embedded and it is this richer set of relational linkages that is at the core of the RIS concept.

As MOULAERT and SEKIA (2003), MARTIN and SUNLEY (2003), ASHEIM (2000) and Ter Wal and Boschma (in this issue) note, there are significant differences between the cluster literature as exemplified by PORTER's (1990) work and territorial innovation models, such as industrial districts, innovative milieux and RIS. These include the latter's greater emphasis

on networking, social and institutional interactions and associated collective learning that is analysed within an evolutionary framework in contrast to PORTER's more comparative static approach. Moreover, PORTER's work is more sharply focused on the role of clusters in explaining competitive advantage at the 'regional, state and city level' (PORTER, 1998b, p. xxi).

MARTIN and SUNLEY (2003) argue that PORTER's emphasis on competitiveness is the main reason why the clusters literature took-off when much of the more complete theoretical and empirical literature on territorial innovation models has arguably had less impact, both on policy and on literature development. However, both the literature- and policy-based aspects of this claim are questionable. Fig. 2 shows not only that the volume of publications on territorial models of innovation, such as *industrial districts*, *RIS* and *innovative milieux* (MOULAERT and SEKIA, 2003) is greater than that of the clusters literature, but also that over the past decade the RIS literature has grown much faster than the clusters literature, albeit from a low base.⁶ Moreover, analysis by CRUZ and TEIXEIRA (2010) shows that it is the social capital and knowledge-based sociological literature that contributes most strongly to the growth in the clusters literature. Furthermore, the policy impact of the RIS approach has been considerable and is reflected in the shift in focus of European Union regional policy as captured by, for example, the RIS programme and the increasing proportion of structural funds assigned to regional innovation measures (LANDABASO *et al.*, 2001, 2003). Similarly, the regional policies of many countries have been heavily grounded in the RIS approach, for example, the policies of VINNOVA, Sweden's Innovation Agency, that draw on the RIS literature (for example, ERIKSSON *et al.*, 2010). The articles by Asheim, Boschma and Cooke, and by Ter Wal and Boschma in this issue show how the study of RIS can be used to inform policies designed to build innovation capacity and promote regional competitive advantage.⁷

MARTIN and SUNLEY (2003, pp. 28–31) also claim that part of the success of the clusters literature in policy circles is that it has been marketed as a 'brand' based on the positive image that clusters promote innovation and competitiveness and the use of the cluster concept as a metaphor. The authors would agree that the term 'cluster' has provided a useful label for a more complex concept. However, the RIS approach, with its more complete theoretical and policy analysis, offers a broader framework for regional innovation theory and policy. This can be seen by considering the nature of the two concepts and their relationship.

Clusters are normally included as an important component of an RIS. They may be seen as 'a concentration of "inter-dependent" firms within the same or adjacent [or integrated] industrial sectors in a small geographic area' (ASHEIM and COENEN, 2005, p. 1174) while an RIS consists of 'interacting knowledge generation and

exploitation subsystems linked to global, national and other regional systems' that may stretch across several sectors in the regional economy (p. 1174). Hence, RIS is a more generic concept than clusters and provides a more comprehensive policy framework: clusters are important, but so too are a range of other factors, agents and institutions that combine to promote and diffuse innovation within a region.

At a theoretical level, research on RIS has begun to model the innovation process in the context of a complex system, indeed the use of agent-based modelling by Zhang, Xu and Liu in this issue is an exemplar of the application of complex systems theory techniques. Knowledge is seen as central to this system and the current literature has identified the importance of the geographical dimensions of knowledge transfer as a key variable shaping regional innovation performance. However, many factors mediate this relationship. These include: the strength of the science base and knowledge transfer system, the institutional setting; the financial system; education and training; the availability and mobility of skilled labour (human capital); and public policy measures designed to promote innovation and growth. The systems approach has begun to explore the inter-linkages between these different elements and how they combine to shape innovation and regional economic performance (for a review, see ASHEIM and GERTLER, 2005).

Despite the advances that have been made in the theoretical, empirical and policy-based literatures, there are a number of areas where further research is required. The first is, as EDQUIST (2005) has suggested, that the NIS literature remains under-theorized, and it is arguable that this point also applies to RIS.⁸ Second, there is a need to understand, both theoretically and empirically, issues of system coherence, systems boundaries (including cognitive and labour market boundaries), system dysfunction and failure. In this regard, much of the empirical work on regional systems has been based on well-functioning, successful⁹ regional economies and on innovation in high-technology sectors. This needs to be supplemented with further theoretical and empirical analysis of 'less successful' systems and of innovation in more traditional industries. Third, there is a need to enhance our understanding of the dynamics of RIS and the emergence and evolution of new knowledge intensive industries, such as nanotechnology. In particular, to consider what factors shape the *evolution* and performance of knowledge-intensive industries within RIS as they go through different phases of development, growth and consolidation (PORTER *et al.*, 2005). Asheim, Boschma and Cooke (in this issue) deal with these aspects of this issue.

The present issue aims to address these three themes in detail and to provide theoretical and empirical analysis of how different parts of RIS function and interact, in particular regarding: (1) the link between regional innovation and regional competitive advantage and

effectiveness; (2) the relationship between clusters and networks, the boundaries of (regional) innovation systems, including cognitive boundaries, the degree of openness of a regional system and its ability to promote collective external economies; and (3) the development and role of labour markets. Marshall saw these as perhaps the most important elements of an industrial district, yet in the literature on RIS they have received comparatively little attention. The themes covered in this issue also have important implications for policy formulation with particular regard to the construction of regional competitive advantage and the effectiveness¹⁰ of RIS; the role of policy in promoting new high-technology sectors, labour market policies; and the interface between sectoral, regional and national policy.

REGIONAL INNOVATION SYSTEMS: VARIETIES, COMPETITIVE ADVANTAGE AND POLICY

The NIS approach was originally conceived to explain the economic performance of nations and their international competitiveness. It was initially developed by FREEMAN (1984) out of dissatisfaction with the standard theory of comparative advantage that treated technological infrastructure as exogenous and fixed. FREEMAN's (1984, 1987) analysis showed how technological capability influenced economic performance and, perhaps more significantly, how technological infrastructure was shaped by the interaction of multiple factors and agents, including government. Although the RIS approach draws on its national counterpart, the effectiveness of RIS has not always been a primary focus. A major gap in the literature concerns the relationship between innovation and regional competitive advantage at both a theoretical and an empirical level.

The article by Asheim, Boschma and Cooke uses new theoretical concepts to understand the policy process of constructing regional advantage. As discussed above, research on industrial districts (BECATTINI, 2006), clusters (PORTER, 1990), innovative milieux (CAMAGNI, 1991), RIS (COOKE, 2001), and learning regions (ASHEIM, 1996) has stressed the importance of regions as key drivers of innovation. This body of literature has claimed that knowledge externalities is geographically bounded, because geographical proximity facilitates knowledge sharing and innovation. Inspired by this literature, and forced by globalization, policy-makers in many countries have added a regional dimension to their innovation policy (FRITSCH and STEPHAN, 2005; WERKER, 2006). However, in order to be able to assess how RIS contribute to regional advantage, better measures of the effectiveness or efficiency of RIS need to be developed.

Associated with this is an empirical need to identify the balance between the effectiveness of institutions

aimed at constructing regional advantage in relation to the impact of national and international regulatory environments. This relationship requires further conceptualization. The assessment of outcomes is also underdeveloped in the literature. Hence, there is a need to develop better measures of innovation-based competitive advantage and 'systems' performance.

Much of the existing literature has focused on highly successful RIS and on regions characterized by a prevalence of medium- to high-technology industries. As a result, our understanding of dysfunctional and less successful systems is comparatively weak (however, for a recent study that attempts to redress this balance and which provides some of the initial background and stimulus to the article by Asheim, Boschma and Cooke in this issue, see EUROPEAN COMMISSION, 2006). Hence, there is a need to analyse systems failure and dysfunction, as well as 'success', in order to progress our understanding of the factors shaping regional innovation performance. Similarly, there is a need to address the bias towards research on medium- to high-technology sectors by increasing our understanding of innovation and knowledge transfer in less dynamic regions with a prevalence of more traditional industries. These issues are addressed in the articles in this issue by: Hudson, who looks at successes and failures in regional economic development in the North East of England; Zhang, Xu and Liu, who look at innovation, cognitive heterogeneity and knowledge transfer in the case of the Datang sock manufacturing cluster; and Asheim, Boschma and Cooke, who outline a strategic approach to policies for industrial renewal based on the concept of related variety, differentiated knowledge bases and platform policies.

A number of articles in this issue are grounded in a dynamic and evolutionary framework to show how systems emerge and evolve. As FELDMAN (2001) notes, a weakness of many studies of RIS is that they look at 'full-blown systems' at a point in time, without providing an analysis of how the system evolved and developed. The articles by Hudson and by Zhang, Xu and Liu address this weakness.

One of the initial puzzles that Freeman, Nelson, Lundvall and the founders of the NIS paradigm set out to solve was why R&D expenditure was such a poor predictor of innovation performance? Their answer took issue with the linear model of innovation and focused attention on systemic factors that mediate the relationship between R&D, innovation and economic performance, thus determining the effectiveness of the system. Over the past few decades a significant literature has developed on the effectiveness of national systems; however, relatively little research has been carried out on the comparative effectiveness of RIS. As Fritsch and Slavtchev (in this issue) point out,

little is still known about the conditions that are conducive or unfavourable for innovation activity and how policy could help improve the functioning of RIS.

This statement may underestimate the significant progress that has been made in recent years (for example, ASHEIM and GERTLER, 2005; BENNEWORTH *et al.*, 2009; ERIKSSON *et al.*, 2010), but it underlines the need for more research on the determinants of the performance of RIS, both theoretically and empirically.

The article by Fritsch and Slavtchev builds on some of their earlier work to explore the factors that determine system efficiency, that is, the ability of a system to maximize its innovation output given its innovation inputs. They start by constructing measures of regional R&D efficiency for German planning regions and then seek to explain the regional variation in RIS efficiency by systems factors. These include the share of private sector R&D employees in a region, the regional activities of universities and the Max-Planck and Fraunhofer Society institutes, average firm size, population density (to capture urbanization density), and sector specialization. Fritsch and Slavtchev find that population density has a positive effect on RIS efficiency, 'indicating that R&D activity is more productive in agglomerations than in rural areas'. In addition, there is evidence of spillover effects within the private sector and between public research institutes (universities, Max-Planck and Fraunhofer) and the private sector. In summary,

the results are consistent with the view that RIS performance is strongly influenced by the level and quality of interaction between its different elements.

(Fritsch and Slavtchev, in this issue)

These findings raise a number of important questions for further research, including how knowledge is transferred between actors?

This question is addressed in more detail in the articles by: Meyer, Libaers and Park; and Asheim, Boschma and Cooke. Both articles focus on the nature of knowledge with the former utilizing the concept of *cognitive distance* and the latter the concepts of *related variety* and *differentiated knowledge bases*. The article by Asheim, Boschma and Cooke takes as its starting point the original research question of the national systems of innovation paradigm (how a system of innovation shapes competitive advantage) re-focusing the question on the regional level. Their analysis combines three key concepts to provide a new policy framework for regional innovation: (1) related variety (FRENKEN *et al.*, 2007; BOSCHMA and FRENKEN, 2009); (2) differentiated knowledge bases (ASHEIM and GERTLER, 2005; ASHEIM and COENEN, 2005; ASHEIM, 2007); and (3) policy platforms (COOKE, 2007; COOKE *et al.*, 2007). Related variety uses the idea of cognitive distance to assess the extent to which knowledge can spillover or be transferred across sectors. It is argued that learning and knowledge transfer are facilitated when there is technological relatedness between sectors so cognitive distance is neither too great for learning to occur, or so close that novelty is hampered. Related variety

implies that the long term development of regions depends on their ability to diversity into new applications and new sectors while building on their current knowledge base and competences.

(Asheim, Boschma and Cooke, in this issue)

The differentiated knowledge base approach rests on the idea that R&D is too blunt an indicator to distinguish the knowledge intensity of different sectors. The article by Asheim, Boschma and Cooke distinguishes between *analytic*, *synthetic* and *symbolic* knowledge arguing that analytical knowledge is more akin to 'natural science', synthetic knowledge to 'engineering science', and symbolic knowledge to the arts. Analytic knowledge is 'universal and theoretical' (the outcome of basic research) and, thus, more easily codified via scientific process, while synthetic knowledge being 'instrumental, context specific and practice related' is more tacit in nature and dependent on the application of knowledge to specific contexts and industries. Symbolic knowledge refers to the cultural meaning of ideas, images and design; it has most resonance in cultural industries where the aesthetic/design content of goods and services is high. Symbolic knowledge may have a high degree of place specificity and its disciplinary roots are grounded in the arts rather in than the sciences. The differentiated knowledge base approach has salience within RIS because there are different rates of distance-decay across knowledge types.

Analytical knowledge tends to be less sensitive to distance-decay facilitating global knowledge networks as well as dense local collaboration. Synthetic (and symbolic) knowledge, on the other hand, has a tendency to be relatively more sensitive to proximity effects between the actors involved, thus favouring local collaboration (MOODYSSON *et al.*, 2008).

The underlying idea behind the differentiated knowledge base approach is not to explain the level of competence (for example, human capital)¹¹ or the R&D intensity (for example, high- or low-technology) of firms but to characterize the nature of the basic (or critical) knowledge input which knowledge creation and innovation processes cannot do without. Thus, knowledge bases should be understood as ontological, generic categories and, consequently, most concrete activities are in practice comprised of more than one knowledge base. The degree to which certain knowledge bases dominates, however, varies and is contingent on the characteristics of the firms and industries as well as between different type of activities (for example, research and production). According to LAESTADIUS (2007) this approach also implies that no type of knowledge should a priori be classified as more advanced, complex and sophisticated than other knowledge, or to consider science-based (analytical) knowledge as more important for innovation and competitiveness of firms, industries and regions than engineering-based (synthetic) knowledge or artistic-based (symbolic)

knowledge. Thus, it is possible to distinguish different types of RIS and this provides the basis for a level of policy detail that is missing from broad-brush measures of knowledge, such as R&D (ASHEIM and GERTLER, 2005; ASHEIM, 2007; LUNDVALL, 2004).

Asheim, Boschma and Cooke argue in this issue that understanding the related variety and differentiated knowledge bases of a region are crucial to establishing an effective regional policy model. A 'one size fits all' to regional policy is inappropriate as are naive attempts to transfer best practice without understanding the local context or to advocate cluster identification and creation. Innovation is about the creation of new products and processes, but to be effective it must draw on the capabilities of regions. The authors argue that policy platforms must be strategically based on identifying and using 'related variety' and 'differentiated knowledge bases' to construct regional advantage. The new approach to policy offers significant insight into how to overcome one of the main problems of localized production and industrial districts, namely how to renew a district facing secular decline. As the authors note,

'related variety' involves transitioning from the waning into the waxing opportunity by 'constructing advantage' through engaging 'differentiated knowledge bases' in the moulding of regional platform policies and even more localized platforms at the regional level.

(Asheim, Boschma and Cooke, in this issue)

The article by Hudson in this issue examines the role of knowledge, learning and innovation in the economic development of the North East of England regional economy from the Industrial Revolution to the present day. It is notable that the two cases of successful transformation that he discusses both depend on the development of *related varieties* of the region's knowledge base providing independent support for Asheim *et al.*'s argument.

Looking through the empirical lens of the North East of England economy, Hudson shows that popular claims of a new knowledge economy are somewhat exaggerated; knowledge has been important since the Industrial Revolution; what is distinctive across different eras, including the current era, is

the changing significance of knowledge, the varying mixes and types of knowledge and the routes through which they flow into the production of any commodity.

(Hudson, in this issue)

Hudson considers the changing character of knowledge in three phases of the North East of England economy: (1) the creation of the workshop of the world; (2) the branch plant economy; and (3) the new science-based industries and knowledge transfer from the region's universities. The economic success of the region in the nineteenth century was founded

above all on invention [and] the creation of new knowledge [deployed in the chemicals, coal mining, metals and shipbuilding industries] ... this emergent knowledge-based economy was based on a combination of endogenous capital and locally produced knowledge with imports and inflows of human labour, knowledge and raw materials. ... However – and this is the key point – all stages of the production process in these varied industries, from R&D and the production of knowledge and its translation into new processes and products ... were located in the region which became, for capital at least, the centre of a virtuous spiral of accumulation and growth.
(Hudson, in this issue)

This can be contrasted to the branch plant era where the emphasis was on productivity rather than innovation and the R&D activities of many of the major foreign-owned companies were located outside the region. Coupled with a strategy based on attracting (footloose) inward investment, regional policy also centred on entrepreneurship and the creation of small firms, but the strategy failed to ensure that the necessary skill base was created in the labour force and it failed to bring about significant regional development.

However, within this period there were rare examples of successful transitions from traditional to new sectors that fit very much with Asheim, Boschma and Cooke's analysis of related variety. These include the sub-sea technology cluster, which evolved 'from off-shore activities that in turn had developed from previous shipbuilding activity' and

a cluster of high-level globally competitive engineering service firms evolving from firms that previously had been builders of bridges, railways and related products, but that now sell their knowledge and expertise in design and project management in a global market.

(Hudson, in this issue)

The third and final period considered by Hudson emphasized the development of new science-based industries. The North East regional strategy developed by the (then) newly formed regional development agency highlighted the role of the region's universities as

the prime mechanism for rebuilding the knowledge base, identifying 'Placing universities and colleges at the heart of the region's economy' as one of six main priorities. However, there was no serious consideration of the knowledge transfer process, of the necessary relations between codified and tacit knowledge ... and of how new, codified knowledge would be used in combination with existing tacit knowledge.

(Hudson, in this issue)

The potential lessons from the cases of successful transitions of the 1990s appear not to have played a major role in the development of the strategy. The problem of transferring and translating analytic knowledge from the universities was not initially addressed; instead the strategy emphasized the promotion of Porterian clusters and only later was the approach to technology transfer

worked out. Hudson notes that it is too early to know how successful the strategy will be, not least because knowledge is only one form of capital and varieties of capital, most notably investment in fixed capital and human capital, are needed to sustain economic development and competitive advantage.

THE BOUNDARIES OF INNOVATION SYSTEMS: OPENNESS AND CONNECTIVITY

A central argument of the NIS approach is that the rate of technological change and innovation is determined by the interaction between a set of private and public sector organizations – including, firms, universities, research organizations, government, educational bodies and finance providers – that combine to create, develop and diffuse new technology and innovations (FREEMAN, 1988) with a key role played by national and regional governments. Of crucial importance is the fact that the system cannot be understood by focusing on the activities of any of its components in isolation. A corollary to this argument is that because the innovation and economic performance of countries (regions) is shaped by the systemic interaction of organizations including market (price) and other (non-price) mechanisms, differences across nations and regions are likely to persist across time and space in a path-dependent way. This is the case even in an era of increasing trade, capital mobility and globalization, because some types of knowledge and intellectual capital are less mobile than other resources and because the complexity of transferring knowledge from its basic form, into new product and process innovations, and the diffusion of innovations, is a complex, dynamic process that is difficult to replicate and transfer across borders. As a result, even in the face of globalization, localities and regions may grow in importance as the increasing role of intellectual capital leads to the creation of what MARKUSEN (1996) has termed 'sticky places in slippery space'.

The extension of the innovation systems approach to regions (COOKE, 2001; ASHEIM and GERTLER, 2005), sectors (MALERBA, 2002), and technologies (CARLSSON and STANKIEWICZ, 1991; CARLSSON, 1995; CARLSSON *et al.*, 2002) raises the question of how to define the boundaries of a system. Demarcating boundaries of what are essentially open and overlapping systems is difficult and a number of scholars have argued that boundaries often remain fuzzy (MARKUSEN, 1996; CANTWELL and NARULA, 2003; NARULA, 2003).¹² The relationship between different systems levels and their embeddedness is illustrated in Fig. 3, but questions of how to define the boundaries and their permeability remain. Of particular importance is the role of networks in defining the degree of openness of a system to different levels. In this regard, the notion of *cognitive boundaries*

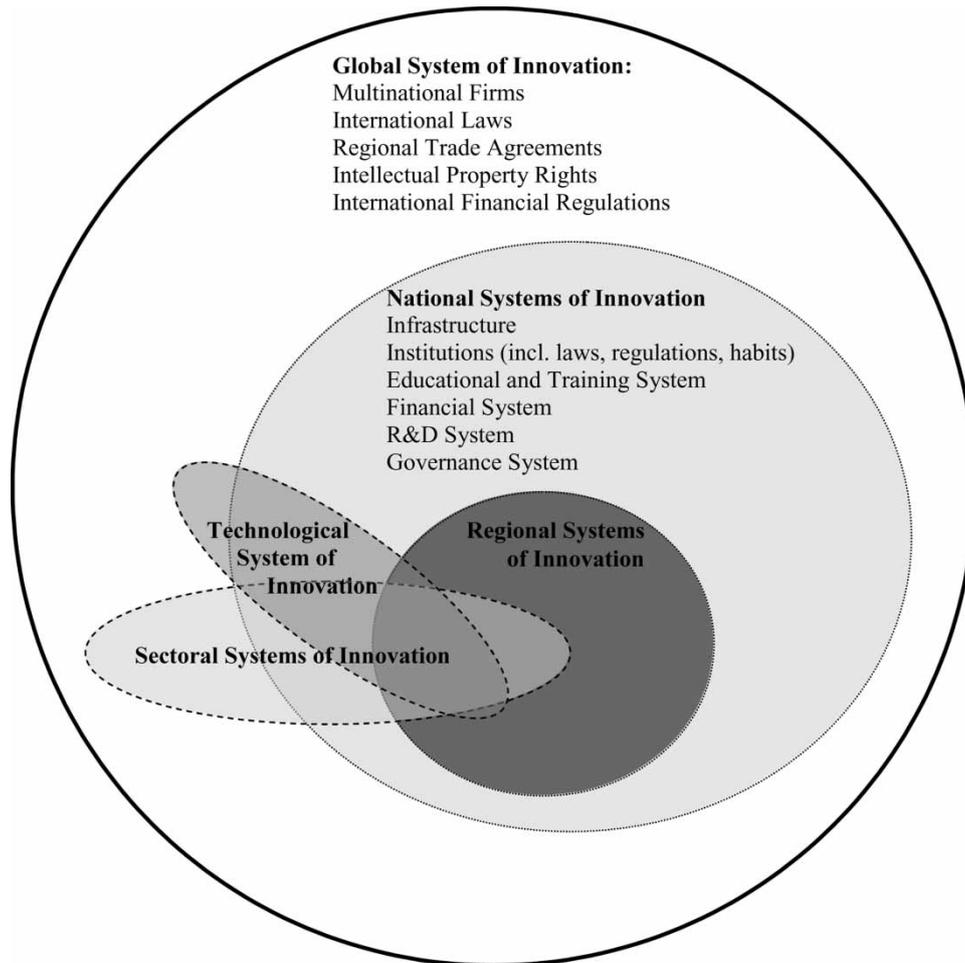


Fig. 3. Relationship between global, national, regional, sectoral and technological systems of innovation
 Source: FRENZ and OUGHTON (2005)

(see the articles by Meyer, Libaers and Park, and Zhang, Xu and Liu in this issue) that span regional and national borders, is highly relevant to the determination of innovation.

EDQUIST (2005) has argued that system boundaries may be defined in one in three ways: spatially/geographically; sectorally; and in terms of system activities or functions. Of these he argues that the first is the most straightforward, though more so for national than RIS. However, even in the case of nation-states, questions of system coherence remain. While there are strong theoretical and empirical arguments for the NIS concept and associated national policies to promote innovation (LUNDVALL, 1992a), there may also be a lack of system coherence within nation-states which implies a complementary need for finer grained analysis. At the regional level similar arguments apply; the administrative boundaries of regions often lack economic and political meaning. The same is true of sectors; the problem is less acute when these are defined at highly disaggregated levels such as the product level, but still the question of, for example, which suppliers, competitors or organizations to

include within a sectoral system may be a hard one. Edquist's third approach is to define the system in terms of activities or functions, including competence building, networking, financing of innovation, etc. While these functions are undoubtedly important at the regional, sectoral and technological levels, they are not exclusive and LUNDVALL *et al.* (2009) argue that it is unsatisfactory to define a system by its activities. Instead, they suggest that it is more fruitful to focus on innovation *processes* and that in this context national, regional and sectoral systems have meaning as a 'focusing device' for analysing innovation in much the same way as nation-states, regions and localities have provided a focus for economic analysis since SMITH (1789):

The (national/regional/sectoral) innovation system is a focusing device aiming at analysing and understanding processes of innovation (rather than allocation) where agents interact and learn (rather than engage in rational choice). The aim of using this device is to find out which alternative institutional set-ups support strong dynamic performance of a (national/regional) economy or a sector.

(LUNDVALL *et al.*, 2009, p. 7)

This is a meaningful development of Edquist's activities with the emphasis on innovation processes allowing more explicit consideration of dynamics and system evolution. In our view, territorial systems are overlapping and have *open* (OUGHTON *et al.*, 2002; LANDABASO *et al.*, 2001, 2003), often fuzzy, borders within embedded regional, national and global systems (NELSON, 2002) that may be complementary and reinforcing or contradictory and dirigiste. However, a key factor is that within a set of boundaries there is sufficient scope for interaction and coherence to enhance collective external economies.¹³

Furthermore, the typology of spatial, sectoral and technological boundaries should be extended to consider *cognitive boundaries* as discussed by a number of articles in this issue, including those by Meyer, Libaers and Park; Lui and Zhang; and Boschma and Ter Wal – these last two articles consider the role of firm and cognitive heterogeneity in relation to knowledge and skills diffusion. A further important and related concept is the degree of openness of a system, where openness captures the extent of market and non-market transactions across system boundaries. For example, firms may be networked with other firms in their sector, region or nation and/or with firms outside these systems.

The article by Ter Wal and Boschma in this issue brings together an analysis of firm heterogeneity, geographical proximity and networks and examines their co-evolution. The authors review the literature on clusters, industrial districts, innovative milieux, RIS and learning regions published in economic geography since the 1980s and note that

until recently, economic geographers did not pay too much attention to the fact that firms in a cluster differ widely in terms of size, power, and absorptive capacity. In addition, the role of geographical proximity in patterns of knowledge exchange tends to be over-emphasized, whereas the effect of networks – by definition an a-spatial concept – tends to be underestimated. Finally, most studies analyse clusters from a static perspective, while questions such as where clusters initially emerge, and why and how clusters and the advantages associated to them change over time are largely ignored.

(Ter Wal and Boschma, in this issue)

Their article makes a theoretical contribution by combining evolutionary theory and the dynamic capabilities of the firm with the literature on networks. This approach allows the authors to consider the impact of firm heterogeneity and knowledge diffusion within networks in a dynamic perspective.

In particular, it sets out a clear distinction between clusters and networks cognisant of the fact that knowledge flows are not confined to clusters but extend via networking relationships to the national and global levels. As such, the article considers the openness of RIS – a point that is also explored by Meyer, Libaers and Park. The extent of knowledge transfer is shown

not to depend exclusively on geographic proximity but also on firms' capabilities, absorptive capacity and their ability to renew capabilities over time. In addition, the article analyses the evolution of clusters and networking relationships over time distinguishing four stages of the life cycle of an industry: the introductory phase; the growth stage; the maturity phase; and the phase of industry decline or the start of a new cycle. These elements are combined to propose a theoretical framework in evolutionary economic geography for the analysis of spatial clustering in an industry based on the co-evolution of firms, industries, clusters and networks over time.

The article by Meyer, Libaers and Park marks a step in this direction with its focus on the emergence and evolution of the nanotechnology industry in the UK. Meyer, Libaers and Park draw on the innovation systems framework developed by Freeman, Lundvall, Nelson and Edquist to examine the emergence of new technologies in their geographical and cognitive context. The systems of innovation literature explores systems and their boundaries at various levels: regional, national, sectoral and technological. Drawing on this work, Meyer, Libaers and Park emphasize the distinction between spatial (regional, national) and cognitive (sectoral, technological) boundaries of innovation systems and argue that it is necessary and feasible to develop an approach that integrates both. The acceptance that different dimensions and boundaries co-exist raises the question of where new technologies emerge. Do new technologies emerge predominately within spatial boundaries or cognitive boundaries, or both? Meyer, Libaers and Park find evidence of the importance of science poles and the tendency of nanotechnology firms to cluster around established science hubs, but firms in these clusters are also networked with organizations located outside their clusters, hence the regional concentration of nanotechnology in terms of science, technology and firm location 'does not preclude strong, non-local networks from emerging along technological lines' (Meyer, Libaers and Park, in this issue).

The article by Zhang, Xu and Lui also draws on the concept of cognitive distance/proximity to explore knowledge diffusion in a traditional cluster: the Datang sock manufacturing cluster in China. More specifically, their article uses 'a cognitive community-based analytic framework' to investigate intra-cluster knowledge diffusion. Theoretical analysis on knowledge diffusion often draws on the distinction between tacit and codified knowledge; tacit knowledge is generally recognized to suffer from greater distance decay than codified knowledge. However, Zhang, Xu and Lui argue that other factors affect knowledge diffusion including the capabilities of the firm, indeed there is a large literature on absorptive capacity (COHEN and LEVINTHAL, 1990) that shows that the ability of firms to absorb knowledge from

external sources is dependent on their internal capabilities and these differ across firms. It follows that it is important to take account of firm heterogeneity within a cluster and this is the starting point for their theoretical analysis. Zhang, Xu and Lui (in this issue) develop the concept of

a cluster's cognitive community formed through the cognitive proximity between firms ... so that only those firms with similar knowledge structures would be efficient in learning and transferring knowledge.

(Zhang, Xu and Lui, in this issue)

Their article is innovative in its use of agent-based modelling and this should provide a useful basis for further research. In addition, it could be extended to consider knowledge diffusion/absorption from outside the cluster. As noted above, this possibility, which raises the question of system boundaries and openness, is considered in more detail in the articles by Meyer, Libaers and Park and by Ter Wal and Boschma in this issue.

HUMAN CAPITAL, KNOWLEDGE TRANSFER, LEARNING AND REGIONAL LABOUR MARKETS

The creation and evolution of pools of skilled labour local which is at the heart of Marshall's analysis of industrial districts and the innovative milieu approach with its emphasis on 'apprenticeship', training and collective/regional learning (CREVOISIER, 2004; MAILLAT, 1998). The creation and renewal of skilled labour and knowledge is seen as a central part of the learning process within regions (ASHEIM and GERTLER, 2005). Despite the clear recognition of the role of local and regional labour markets, there has been comparatively little research on this aspect of RIS (relevant contributions include: FLORIDA, 2002; FLORIDA *et al.*, 2008; HENRY and PINCH, 2000; LAWTON SMITH, 2009; ZUCKER *et al.*, 1997; and BOSCHMA *et al.*, 2009). The work by ZUCKER *et al.* (1997) and HENRY and PINCH (2000) provides both theoretical and empirical evidence of the role of 'people' in transferring knowledge. Zucker *et al.* track the location of what they call 'star scientists' in knowledge-intensive industries, such as biotechnology, and find that the rate of start-up firms in biotechnology is higher in the localities in which these scientists live. However, the complexity of cause and effect requires further research. Similarly, the study of the high-technology engineering cluster of Formula 1 car constructors by HENRY and PINCH (2000) shows the importance of the labour market for competitive advantage:

In the extreme case, the asset base of the firms themselves is often minimal involving, for example, some specialist machinery, a (rented?) building and a car which becomes virtually worthless in months and, critically, the knowledge of its employees. It is this knowledge base, and the

reputation that this base can command in the eyes of sponsors, which is the key element of the industry. The industry is therefore perhaps best represented as continually shifting networks of people in, and outside of, continually shifting bounded entities called firms. However, it is a knowledge base which is territorialised and this is the crucial competitive advantage of Motor Sport Valley.

(p. 206)

The findings by Henry and Pinch for this industry have resonance with the wider research conducted by Florida which shows that 'place' can be a powerful attractor (and creator) of highly skilled labour, and that critical mass is necessary to attract creative workers to a locality.

Further research is needed on the mechanisms and processes that generate innovation. These include the development of human capital and local labour markets and the mechanisms for knowledge transfer across organizations. In particular, it is necessary to enhance our understanding of the relative importance of local and non-local (national, global) sources of knowledge, how they interact, and the factors that affect the extent and speed of knowledge transfer from the science base to business. These questions require an analysis of the 'systems' factors that mediate knowledge transfer, including the role of human capital and labour markets, which have been underplayed in much of the literature, notwithstanding the fact that the regional skills base and the ability to attract qualified workers into a region are known to be highly *correlated* with regional innovation/economic performance.

The importance of education and training systems is acknowledged in the existing literature and R&D personnel and qualified staff are recognized as crucial to the innovation process. However, the question of how labour markets and human capital operate within RIS is under-theorized. In particular, there is a need to integrate analysis of the generation and employment of human capital and talent within regions (including labour migration) and the role that human capital plays in shaping absorptive capacity and innovation performance.¹⁴ Here the RIS approach could draw more extensively on the concept of learning regions and the 'apprenticeship process' identified by the innovative milieu approach, which explains how human capital and know-how are created so that knowledge does not belong to 'isolated individuals who are ready to move within space, but to collectives that are far less mobile' (CREVOISIER, 2004, p. 374).

While the RIS literature has devoted relatively little attention to the labour force and processes of labour force development, they are now emerging as being centrally important in the competitiveness of places. The possibility of talented people being attracted, trained and retained in particular locations, however, depends on the quality of the labour market as well as the characteristics of places, institutions and policy (WOLFE *et al.*, 2005). Thus, the evolution of a localized

expert labour market system involves a complex interaction of technical, economic, social and political forces, which collectively determine how economies function (WILKINSON, 1983). The article by Lawton Smith and Waters in this issue applies this notion of interdependence by focusing on the composition of networks between highly skilled people as the underlying condition for regional development. Lawton Smith and Waters position the conceptualizations of the development and function of RIS with reference to flows of labour and individuals' knowledge and competences in and through geographical spaces. In doing so they answer two questions: (1) what is the role of labour markets in the making of regions as innovative systems; and (2) what is the role of labour markets in RIS? Their empirical analysis draws on evidence from a study of scientific labour markets in Oxfordshire and Cambridgeshire and finds:

considerable mobility into each region, supporting the argument that the agglomeration of skills (BERRY and GLAESER, 2005) is the key component of the making of regional innovation systems. We show how the two counties – places which started with higher levels of human capital than most of the rest of the UK have attracted more skilled people over the last two decades, created by local entrepreneurs, thus creating RIS of particular kinds – analytic knowledge in both cases with strong accumulations of codified knowledge.

(Lawton Smith and Waters, in this issue)

The success of the Cambridgeshire and Oxfordshire regions as creators and attractors of highly skilled labour can be contrasted with Hudson's analysis of the evolution of the labour market in the North East of England. Once grounded on invention and creativity, Hudson analyses aspects of labour market failure in the second and third of the three periods studied. He identifies the sluggishness of the regional economy to modernize its skills base, weaknesses in the basic training system and an emphasis on firm-specific skills which left workers vulnerable to unemployment. As he notes, in many of its industries the region seemed unable to make a smooth transition from the old economy to the new 'branch plant economy' dominated by multinational enterprises. As the old economy declined, the new branch plant economy required different skills:

While the skill levels required of the 'new' activities were generally modest, they were nonetheless skills (technical, personal, social, and communication skills) that were not readily available in the region's labour market.

(Hudson, in this issue)

Finally, the article by Zhang *et al.* in this issue demonstrates the importance of labour in knowledge transfer and regional competitive advantage. The Datang sock cluster has been able to maintain its competitive advantage partly as a result of successful transfer of technological knowledge between firms. A crucial

factor that has facilitated knowledge transfer within the region is the formation of the cluster's cognitive community aided by the fact that a significant part of the labour force was at one time employed by town and village enterprises that shared a common technological knowledge base.

Taken together these three articles provide theoretical and empirical evidence of the functioning of high- and low-technology labour markets, their role in knowledge generation and transfer, and their contribution to regional competitiveness. However, it is evident that this is an area that is under-researched and further analysis of the role of labour processes in RIS would be beneficial. Building on LUNDVALL's (2007) distinction between narrowly and broadly defined RIS, such research would contribute to the development of the broader view of RIS by analysing innovation policy in combination with education and labour market policies.

CONCLUSION

While the regional innovation systems (RIS) literature is relatively new, it draws on well-established territorial models of innovation, as well as its older national innovation systems (NIS) counterpart. Over the past decade or so the RIS literature has made significant advances that have contributed to our understanding of innovation and policy. The articles in this issue consolidate and develop this work in three key areas: (1) the demarcation of types and varieties of RIS, their efficiency and their impact on regional competitive advantage; (2) the boundaries of RIS, clusters and networks and the role of cognitive frontiers, knowledge transfer and learning; and (3) the creation, attraction, utilization and renewal of human capital within RIS and the role of the labour market.

The articles in this issue also make a contribution to policy debates, most notably in relation to: (1) the formulation of a detailed understanding of the effectiveness of RIS and the regional knowledge base in order to construct competitive advantage using related varieties around that base; (2) understanding the role of systems boundaries, cognitive space and knowledge heterogeneity in shaping knowledge transfer which opens up the potential to integrate national and regional policy initiatives; and (3) linking and combining innovation policy with education and labour processes and policies. Overall, the articles in this issue combine to provide new theoretical, empirical and policy insights; they also reflect on and advance current debates on economic, institutional and social processes involved in regional development. A crucial aspect of the RIS debate is that of the 'system', and the interaction between the different agents involved in innovation, across the public and private sectors. This debate has to be seen in the context of the growing academic interest in the

region as a locus of innovation processes. The emphasis on how regional institutional settings influence the effectiveness of agent interaction within clusters, networks and the wider innovation systems is also an important factor in the concept's impact on policy development.

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NOTES

1. FAGERBERG (2005) carried out a similar analysis for 'innovation'.
2. These points are also discussed by ASHEIM (2000) and OUGHTON and WHITTAM (1997).
3. For two recent reviews, see MOULAERT and SEKIA (2003) and FRENZ and OUGHTON (2005); see also the journal special issues edited by MEISTER and WERKER (2004), ACS and VARGA (2002) and IAMMARINO (2005).
4. This is acknowledged in the early writings of PORTER (1998c, pp. 206–208) on clusters; CAMAGNI (1991, p. 1), which draws on Marshall's idea of industrial atmosphere and inter-firm cooperation; MAILLAT (1998) on innovative milieu; and COOKE (1992, p. 380; 2004, pp. 6–7) on RIS.
5. For two tables of cluster definitions that include shallow variants based on market relationships and proximity to richer variants that incorporate networks, non-market relationships, institutions and trust, see MARTIN and SUNLEY (2003, p. 12) and SWANN (2009, p. 149). For

a review of clusters and networking concepts, see BODE *et al.* (2010).

6. Between 1990–1999 and 2000–2009, the number of RIS publications in the SSCI increased over thirty-fold compared with a five-fold increase for the clusters literature over the same period. In part, this reflects the very low base for the RIS literature in 1990–1999, but also its rapid consolidation between 2000 and 2009.
7. This is not to say that Porter's work on clusters has not been influential in policy circles (clearly it has), but MARTIN and SUNLEY's (2003) that

Porter's notion of 'clusters' has gate-crashed the economic policy arena when the work of economic geographers on industrial localization, spatial agglomeration of economic activity, and the growing salience of regions in the global economy, has been largely ignored.

(p. 7)

is arguably an overstatement of the case.

8. Similar analysis has been made by DOLOREUX (2002) and DOLOREUX and PARTO (2005).
9. This point has been made by various authors, for example FELDMAN (2001) and DOLOREUX and PARTO (2005, p. 137), who state that studies of regional innovation 'are largely based on a few "successful" regions'.
10. Fritsch and Slavtchev discuss the related idea of the 'efficiency' of a regional innovation system which refers to the ability of a region to maximize its innovation output given the innovation resources at its disposal.
11. GUILIANI and BELL (2005) confusingly refer to 'level of competence' as 'knowledge base' instead of using the term 'competence base' to avoid misunderstandings.
12. The relationship is complicated by the activity of multinational firms (CANTWELL and IAMMARINO, 2001).
13. The authors are grateful to an anonymous referee for this point.
14. See BOSCHMA and FRITSCH (2009) and ASHEIM and HANSEN (2009), two articles in a special issue of *Economic Geography* (October 2009) on 'Technology, Talent and Tolerance in European Cities'.

REFERENCES

- ACS Z. and VARGA A. (2002) Introduction to the special issue on Regional Innovation Systems, *International Regional Science Review* **25**(1), 3–7.
- ALESINA A., SPOLAORE E. and WACZIARG R. (2000) Economic integration and political disintegration, *American Economic Review* December, 1276–1296.
- ASHEIM B. (1996) Industrial districts as 'learning regions': a condition for prosperity?, *European Planning Studies* **4**(4), 379–400.
- ASHEIM B. (2000) Industrial districts, in CLARK G., FELDMAN M. and GERTLER M. (Eds) *The Oxford Handbook of Economic Geography*, pp. 413–431. Oxford University Press, Oxford.
- ASHEIM B. (2007) Differentiated knowledge bases and varieties of regional innovation systems, *Innovation* **20**(3), 223–241.
- ASHEIM B. and COENEN L. (2005) Knowledge bases and regional innovation systems: comparing Nordic clusters, *Research Policy* **34**, 1173–1190.
- ASHEIM B., COOKE P. and MARTIN R. (Eds) (2006) *Clusters and Regional Development: Critical Reflections and Explorations*. Routledge, London.
- ASHEIM B. and GERTLER M. (2005) The geography of innovation: regional innovation systems, in FAGERBERG J., MOWERY D. C. and NELSON R. R. (Eds) *The Oxford Handbook of Innovation*, pp. 291–317. Oxford University Press, Oxford.
- ASHEIM B. T. and ISAKSEN A. (1997) Location, agglomeration and innovation: towards regional innovation systems in Norway, *European Planning Studies* **5**(3), 299–330.
- AYDALOT P. (1986) *Milieux innovateurs en Europe*. Groupe de Recherche Européen sur les Milieux Innovateurs (GREMI), Paris.
- BAPTISTA R. and SWANN P. (1998) Do firms in clusters innovate more?, *Research Policy* **27**(5), 527–540.

- BAPTISTA R. and SWANN P. (1999) A comparison of clustering dynamics in US and UK computer industries, *Journal of Evolutionary Economics* **9**, 373–399.
- BECATTINI G. (2006) The industrial district and development economics, in RAFAELLI T., BECATTINI G. and DARDI M. (Eds) *The Elgar Companion to Alfred Marshall*, pp. 664–667. Edward Elgar, Cheltenham.
- BENNEWORTH P., COENEN L., MOODYSON J. and ASHEIM B. (2009) Exploring the multiple roles of Lund University in strengthening the scania regional innovation system: towards institutional learning?, *European Planning Studies* **17(11)**, 1645–1664.
- BODE T., L'ARMEE T. and ALIG S. (2010) Research Note: Clusters vs. networks – a literature-based approach towards an integrated concept, *International Journal of Globalisation and Small Business* **4(1)**, 92–110.
- BOSCHMA R., ERIKSSON R. and LINDGREN U. (2009) How does labour mobility affect the performance of plants? The importance of relatedness and geographical proximity, *Journal of Economic Geography* **9(2)**, 169–190.
- BOSCHMA R. A. and FRENKEN K. (2009) Some notes on institutions in evolutionary economic geography, *Economic Geography* **85(2)**, 151–158.
- BOSCHMA R. A. and FRITSCH M. (2009) Creative class and regional growth: empirical evidence from seven European countries, *Economic Geography* **85(4)**, 391–423.
- BRACZYK H.-J., COOKE P. and HEIDENREICH M. (Eds) (1998) *Regional Innovation Systems; The Role of Governances in a Globalized World*. UCL Press, London.
- BRUSCO S. (1982) The Emilian model: productive decentralisation and social integration, *Cambridge Journal of Economics* **6**, 167–184.
- BRUSCO S. (1990) The idea of the industrial district: its genesis, in PYKE F., BACCATTINI G. and SENENBERGER W. (Eds) *Industrial Districts and Inter-firm Cooperation in Italy*, pp. 177–196. International Institute for Labour Studies, Geneva.
- CAMAGNI R. (1991) Technological change, uncertainty and innovation networks: towards a dynamic theory of economic space, in CAMAGNI R. (Ed.) *Innovation Networks: Spatial Perspectives*, pp. 121–144. Belhaven-Pinter, London.
- CAMAGNI R. (1995) The concept of innovative milieu and its relevance for public policies in European lagging regions, *Regional Science* **74(4)**, 317–340.
- CANTWELL J. and IAMMARINO S. (2001) EU regions and multinational corporations: change, stability and strengthening of technological comparative advantages, *Industrial and Corporate Change* **10(4)**, 1007–1037.
- CANTWELL J. and NARULA R. (2003) *International Business and the Eclectic Paradigm: Developing the OLI Framework*. Routledge, London.
- CARLSSON B. (Ed.) (1995) *Technological Systems and Economic Performance – The Case of Factory Automation*. Kluwer, Boston, MA.
- CARLSSON B., JACOBSSON S., HOLMAN M. and RICKNE A. (2002) Innovation systems: analytical and methodological issues, *Research Policy* **31**, 233–245.
- CARLSSON B. and STANKIEWICZ R. (1991) On the nature, function, and composition of technological systems, *Journal of Evolutionary Economics* **1(2)**, 93–118.
- CLARK G., FELDMAN M. and GERTLER M. (Eds) (2000) *The Handbook of Economic Geography*. Oxford University Press, Oxford.
- COHEN W. and LEVINTHAL D. A. (1990) Absorptive capacity: a new perspective on learning and innovation, *Administrative Science Quarterly* **35(1)**, 128–152.
- 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 BRACZYK H.-J., COOKE P. and HEIDENREICH M. (Eds) *Regional Innovation Systems; The Role of Governances in a Globalized World*, pp. 2–25. UCL Press, London.
- COOKE P. (2001) Regional innovation systems, clusters, and the knowledge economy, *Industrial and Corporate Change* **10(4)**, 945–974.
- COOKE P. (2007) To construct regional advantage from innovation systems first build policy platforms, *European Planning Studies* **15**, 179–194.
- COOKE P., DE LAURENTIS C., TÖDTLING F. and TRIPPL M. (2007) *Regional Knowledge Economies: Markets, Clusters & Innovation*. Edward Elgar, Cheltenham.
- COOKE P. and MORGAN K. (1994a) The regional innovation system of Baden Württemberg, *International Journal of Technology Management* **9**, 394–429.
- COOKE P. and MORGAN K. (1994b) The creative milieu: a regional perspective on innovation, in DODGSON M. and ROTHWELL R. (Eds) *The Handbook of Industrial Innovation*. Edward Elgar, Cheltenham.
- COOKE P. and MORGAN K. (1998) *The Associational Economy: Firms, Regions and Innovation*. Oxford University Press, Oxford.
- CREVOISIER O. (2004) The innovative milieus approach: toward a territorialised understanding of the economy, *Economic Geography* **80(4)**, 367–369.
- CRUZ S. and TEIXEIRA A. (2010) The evolution of the cluster literature: shedding light on the regional studies–regional science debate, *Regional Studies* **44(9)**, 1293–1288.
- DOLOREUX D. (2002) What we should know about regional systems of innovation, *Technology in Society* **24**, 243–263.
- DOLOREUX D. and PARTO S. (2005) Regional innovation systems: current discourse and unresolved issues, *Technology in Society* **27**, 133–153.
- EDQUIST C. (2005) Systems of innovation: perspectives and challenges, in FAGERBERG J., MOWERY D. and NELSON R. (Eds) *The Oxford Handbook of Innovation*, pp. 1–26. Oxford University Press, Oxford.
- ENRIGHT M. (2003) Regional clusters: what do we know and what should we know?, in BROCKER J., DOHSE D. and SOLTWEDEL R. (Eds) *Innovation Clusters and Interregional Competition*. Springer, Berlin.
- ERIKSSON A., CANIELS M., COOKE P., UYARRA E., SOTARAUTA M. and WALLIN J. (Eds) (2010) *Regional Innovation Policy in Transition*. VINNOVA Report, 2010, Number 17. Ingelore Djurheden.

- ETZKOWITZ H. and LEYDESDORFF L. (1997) *Universities in the Global Economy: A Triple Helix of Government–Industry and Government Relations*. Croom Helm, London.
- EUROPEAN COMMISSION (2006) *Constructing Regional Advantage: Principles–Perspectives–Policies*. Final report from DG Research Expert Group (Asheim B. et al.) on ‘Constructing Regional Advantage’. DG Research, European Commission, Brussels.
- FAGERBERG J. (2005) Innovation: a guide to the literature, in FAGERBERG J., MOWERY D. C. and NELSON R. R. (Eds) *The Oxford Handbook of Innovation*, pp. 1–26. Oxford University Press, Oxford.
- FELDMAN M. (1994) *The Geography of Innovation*. Kluwer, Dordrecht.
- FELDMAN M. (1999) The new economics of innovation, spillovers and agglomeration: a review of empirical studies, *Economic Innovation and New Technology* **8**, 5–25.
- FELDMAN M. (2000) Location and innovation: the New Economic Geography of innovation, spillovers, and agglomeration, in CLARK G. L., FELDMAN M. P. and GERTLER M. S. (Eds) *The Handbook of Economic Geography*, pp. 373–394. Oxford University Press, Oxford.
- FELDMAN M. (2001) The entrepreneurial event revisited: firm formation in a regional context, *Industrial and Corporate Change* **10(4)**, 861–891.
- FLORIDA R. (2002) The economic geography of talent, *Annals of the Association of American Geographers* **94(4)**, 743–755.
- FLORIDA R., GULDEN T. and MELLANDER C. (2008) The rise of the mega-region, *Cambridge Journal of Regions, Economy and Society* **1(3)**, 459–476.
- FREEMAN C. (1984) The economics of technical change, *Cambridge Journal of Economics* **18(5)**, 463–514.
- FREEMAN C. (1987) *Technology Policy and Economic Performance*. Pinter, London.
- FREEMAN C. (1988) Japan: a new national innovation system?, in DOSI G., FREEMAN C., NELSON R. R., SILVERBERG G. and SOETE L. (Eds) *Technical Change and Economy Theory*, pp. 330–348. Pinter, London.
- FREEMAN C. (1995) The ‘National System of Innovation’ in historical perspective, *Cambridge Journal of Economics* **19**, 5–24.
- FRENKEN K., VAN OORT F. G. and VERBURG T. (2007) Related variety, unrelated variety and regional economic growth, *Regional Studies* **41(5)**, 685–697.
- FRENZ M. and OUGHTON C. (2005) *Innovation in the UK Regions and Devolved Administrations: A Review of the Literature*. Report to the Department of Trade and Industry (available at: <http://www.bis.gov.uk/files/file9651.doc>).
- FRITSCH M. and STEPHAN A. (2005) Regionalization of innovation policy – introduction to the special issue, *Research Policy* **34(8)**, 1123–1127.
- GERTLER M. (2003) Tacit knowledge and the economic geography of context, of the undefinable tacitness of being (there), *Journal of Economic Geography* **3**, 75–99.
- HENRY N. and PINCH S. (2000) Spatialising knowledge: placing the knowledge community of Motor Sport Valley, *Geoforum* **31(2)**, 191–208.
- HOWELLS J. (1999) Regional systems of innovation, in ARCHIBUGI D., HOWELLS J. and MICHIE J. (Eds) *Innovation Policy in a Global Economy*, pp. 67–93. Cambridge University Press, Cambridge.
- HOWELLS J. (2002) Tacit knowledge, innovation and economic geography, *Urban Studies* **39(5–6)**, 871–884.
- IAMMARINO S. (2005) An evolutionary integrated view of regional systems, measures and historical perspectives, *European Planning Studies* **13(4)**, 497–519.
- ISAKSEN A. and HAUGE E. (2002) *Regional Clusters in Europe*. Observatory of European SMEs Report 2002 Number 3. European Community, Luxembourg.
- LAESTADIUS S. (2007) Vinnväxtprogrammets teoretiska fundament, in LAESTADIUS S. and (Eds) *Regional växtkraft i en global ekonomi. Det svenska Vinnväxtprogrammet*, pp. 27–56. Santerus Academic Press, Stockholm.
- LANDABASO M., OUGHTON C. and MORGAN K. (2001) Innovation networks and regional policy in Europe, in KOSCHATZY K., KULICKE M. and ZENKER A. (Eds) *Innovation Networks: Concepts and Challenges in the European Perspective*, pp. 243–274. Physica, Heidelberg.
- LANDABASO M., OUGHTON C. and MORGAN K. (2003) Learning regions in Europe: theory, policy and practice through the RIS experience, in GIBSON D., STOLP C., CONCEIÇÃO P. and HEITOR M. (Eds) *Systems and Policies for the Global Learning Economy*, pp. 79–110. Praeger, Westport, CT.
- LAWTON SMITH H. (2009) Skill shortages, demographic aging, and training implications for skill-based economies, *Professional Geographer* **62(1)**, 59–69.
- LEYDESDORFF L. (2000) The triple helix: an evolutionary model of innovations, *Research Policy* **29(2)**, 243–255.
- LIST F. (1841/2005) *National System of Political Economy*. [1841]; repr. (Cosimo Classics, New York, NY, 2005).
- LUNDVALL B.-Å. (1999) Technology policy in the learning economy, in ARCHIBUGI D., HOWELLS J. and MICHIE J. (Eds) *Innovation Policy in a Global Economy*, pp. 19–34. Cambridge University Press, Cambridge.
- LUNDVALL B.-Å. (2004) Introduction to ‘Technological infrastructure and international competitiveness’ by Christopher Freeman, *Industrial and Corporate Change* **13(3)**, 531–539.
- LUNDVALL B.-Å. (2007) *Innovation System Research: Where It Came From and Where It Might Go*. Working Paper Series Number 2007-01. GLOBELICS (available at: http://www.globelicsacademy.net/2011_pdf/Lundvall%20%20Innovation%20System%20Research.pdf) (accessed on 21 June 2011).
- LUNDVALL B.-Å., JOSPEH K., CHAMINADE C. and VANG J. (Eds) (2009) *Handbook of Innovation Systems and Developing Countries*. Edward Elgar, Cheltenham.
- MAILLAT D. (1998) From the industrial district to the innovative milieu: contribution to an analysis of territorialised productive organisations, *Recherches Economiques de Louvain* **64**, 111–129.
- MALERBA F. (2002) Sectoral systems of innovation and production, *Research Policy* **31**, 247–264.

- MARKUSEN A. (1996) Sticky places in slippery space: a typology of industrial districts, *Economic Geography* **72**(3), 293–313.
- MARSHALL A. (1930) *Principles of Economics*, 8th Edn. Macmillan, London.
- MARSHALL A. and MARSHALL M. (1879) *The Economics of Industry*. Macmillan, London.
- MARTIN R. and SUNLEY P. (2003) Deconstructing clusters: chaotic concept or policy panacea?, *Journal of Economic Geography* **3**, 5–35.
- MEISTER C. and WERKER C. (2004) Physical and organizational proximity in territorial innovation systems: introduction to the special issue, *Journal of Economic Geography* **4**, 1–2.
- MOODYSSON J., COENEN L. and ASHEIM B. (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**, 1040–1056.
- MORGAN K. (1997) The learning region: institutions, innovation and regional renewal, *Regional Studies* **31**, 491–504.
- MOULAERT F. and SEKIA F. (2003) Territorial innovation models: a critical survey, *Regional Studies* **37**(3), 289–302.
- NARULA R. (2003) *Globalization and Technology: Interdependence, Innovation Systems and Industrial Policy*. Polity, Cambridge.
- NELSON R. R. (1992) National innovation systems: a retrospective of a study, *Industrial and Corporate Change* **1**(2), 347–374.
- NELSON R. R. (1996) The evolution of comparative or competitive advantage: a preliminary report on a study, *Industrial and Corporate Change* **5**(2), 597–617.
- NELSON R. R. (2002) *The Sources of Economic Growth*. Harvard University Press, Cambridge, MA.
- OUGHTON C., LANDABASO M. and MORGAN K. (2002) Regional innovation systems and regional innovation strategies: catalysing innovation and growth, *Journal of Technology Transfer* **27**(1), 97–110.
- OUGHTON C. and WHITTAM G. (1997) Competition and cooperation in the small firm sector, *Scottish Journal of Political Economy* **44**(1), 1–30.
- PORTER K., BUNKER WHITTINGTON K. and POWELL W. (2005) The institutional embeddedness of high-tech regions: relational foundations of the Boston biotechnology community, in BRESCHI S. and MALERBA F. (Eds) *Clusters, Networks, and Innovation*. Oxford University Press, Oxford.
- PORTER M. (1990) *The Competitive Advantage of Nations*. Macmillan, London.
- PORTER M. (1998a) *The Competitive Advantage of Nations*, 2nd Edn. Macmillan, London.
- PORTER M. (1998b) Clusters and the new economics of competition *November–December, Harvard Business Review* 77–90.
- PORTER M. (1998c) *On Competition*. Harvard Business School Publishing, Boston, MA.
- SMITH A. (1789) *An Inquiry into the Nature and Causes of the Wealth of Nations*, 5th Edn. Methuen & Co, London.
- SWANN G. (2009) *The Economics of Innovation: An Introduction*. Edward Elgar, Cheltenham.
- SWANN G. and PREVEZER M. (1996) A comparison of the dynamics of industrial clustering in computing and biotechnology, *Research Policy* **25**, 139–157.
- WERKER C. (2006) *An Assessment of the Regional Innovation Policy by the European Union based on Bibliometrical Analysis*. Papers on Economics and Evolution Number 2006–11. Max Planck Institute of Economics, Evolutionary Economics Group, Jena.
- WILKINSON F. (1983) Productive systems, *Cambridge Journal of Economics* **7**, 413–429.
- WOLFE D. A., DAVIS C. H. and LUCAS M. (2005) Global networks and local linkages: an introduction, in WOLFE D. A. and LUCAS M. (Eds) *Global Networks and Local Linkages: The Paradox of Cluster Development in an Open Economy*. McGill-Queens' University Press, Montreal and Kingston.
- ZUCKER L., DARBY M. and BREWER M. (1997) Intellectual human capital and the birth of US biotechnology enterprises, *American Economic Review* **87**, 290–306.