Regional Development in the Knowledge Economy

EDITED BY

PHILIP COOKE &
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Regional Development in the Knowledge Economy

Regional Development in the Knowledge Economy examines the distinctive ways in which regional actors, institutions and organisations deal with the exigencies of the rise to prominence of the knowledge economy. The collection derives etymologies for many key concepts in the 'knowledge economy' and 'new regionalism' debates. The international contributions examine a range of theoretical and empirical approaches to explain contemporary regional development processes from a knowledge economy/new regionalism perspective.

The book examines the idea of value creation from the interaction of knowledge upon knowledge. This applies clearly in science-based or creative industries but also in established industries that utilise more scientific or creative knowledge as a matter of course, but with frequent barriers among technical 'communities of practice'. Otherwise comparable to professional 'epistemic communities' these are practitioner groups that must reduce cognitive dissonance to build up interactive innovation capabilities. The evidence mobilised in the book shows this is more tractable at regional level where social capital may be high and where firm inter-domain professional networks form. Policies both to build and take advantage of these capabilities are elaborated, discussed and assessed.

Philip Cooke is University Research Professor in Regional Development and founding Director (1993) of the Centre for Advanced Studies, University of Wales, Cardiff. His research interests lie in studies of Economics of Biotechnology, Regional Innovation Systems, Knowledge Economies, and Policy Actions for Business Clusters and Networks.

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Foreword

The knowledge economy is an increasingly pervasive and useful concept used to capture important aspects of contemporary economic reality. The papers in this collection explore in a variety of ways how it manifests itself in economic life. They show how special institutions like knowledge research laboratories have emerged to understand knowledge origination, management, testing, learning and exploitation. The manner in which knowledge advancement often requires the crossing of boundaries among distinctive communities of practice is explored and demonstrated. The difficulty of this on occasions is not shied away from, but the pertinence of network forms of flexible, sometimes distant, governance of knowledge interactions is repeatedly emphasised. Thus distinctive kinds of proximity, not only geographical, are shown to be of key importance to knowledge exchange, innovation and utilisation. Having said that, and at variance with the view that the Internet effaces spatial barriers, the collected papers tend to show that a variety of 'proximities' including cognitive, relational and organisational can be hypothesised, but that which common sense usually places to the forefront, geographical proximity, is generally at a premium. Hence the rise in importance for economic growth and competitiveness in the knowledge economy of accomplished regional settings that host global talent pools, including varieties of business cluster, research complex and knowledge outsourcing platform.

These observations are at the heart of the book's project, which is to explore ways in which knowledge economy effects manifest themselves in developmental asymmetries. In a sense the book investigates empirically for the first time the spatial dimension of what economists have called the 'asymmetric information' problem. Classically, this assists understanding both of how markets function but also fail – the knowledge disparity between the vendor and purchaser of a used car being the paradigm metaphor of asymmetric information. Although originating in the neoclassical economics interest in the idea of contracts between individuals and their transaction costs, the notion of such asymmetries contains many of the lines of inquiry that have stimulated evolutionary economic geographers and regional scientists to explore the roles of trust, learning, entrepreneurial risk and the uneven presence of spatially distinctive yet combined forms of knowledge among regions that either hold them back or enable them to forge ahead.

The origins of this collection lie in the Regional Studies Association (RSA) international conference on 'Reinventing Regions in the Global Economy', hosted by Scuola Superiore Sant'Anna, Pisa, Italy, 12–15 April 2003. The editors of this book were invited by the conference organisers, ably represented by Sally Hardy and colleagues of the RSA Secretariat, to manage as 'gatekeepers' the 'Knowledge Economy' track of the conference. A sign of the intense interest in the theme was the unusually large number of successful submissions of abstracts and papers to the track. A companion collection to this volume, also edited by the present 'gatekeepers', *Regional Economies as Knowledge Laboratories* (Elgar), appeared in 2004. Its focus was upon critical, theoretical, methodological and concept-measurement issues. This collection is concerned with more forensic analysis of empirical manifestations of knowledge economy impacts and effects upon regions. Among these, as countless studies now show, are the acute asymmetries in regional development opportunity and potential revealed by the locational practices of firms, economic institutions and organisations. For instance, capital cities tend to be highly privileged hosts to knowledge industries like those involved in cultural and creative, financial, professional, research, media and technological activity. Meanwhile remote, rural and older industrial regions show very little sign of being able to recruit or retain employment in such activities.

Hence, there is a policy challenge that is new and aided by relatively few signposts. Nevertheless, efforts – some of a necessarily experimental nature – are being made to identify and exploit regional assets that may assist engagement of regional actors more fully in profitable or otherwise useful knowledge economy activity. The 'house of the future' project in non-metropolitan Portugal is illustrative of network governance of innovative project work and a sign of the more 'associative' knowledge economy mode of interactive innovation. Similarly, in the same country 'distant networks' facilitate knowledge entrepreneurship through accessing global talent pools. Finland, too, has evolved numerous examples of 'distant networking' of university research to promote growth in peripheral regions lacking such knowledge-generating organisations of their own. Again, partnership-induced vision, commitment and leadership are more pronounced than either state or market initiative in getting such knowledge economy efforts off the ground. Elsewhere, notably in Italy, new models based on globally significant knowledge and entrepreneurial leadership in pursuit of clear if difficult developmental aspirations is to the fore, an Asian variant of their practice of utilising Nobel Laureate leadership of regional development strategy may also be found in Singapore. These attempts to build knowledge economies by attempting the construction of regional advantage often in unlikely places, their apparent successes and failures and lessons of potential use to policy arising from reflection upon this, form the narrative core of this collection.

The editors were helped by many friends in bringing this project to fruition through discussion of ideas represented in the book on many different occasions. We, along with present contributors Bjørn Asheim and Ron Boschma, had the experience of advising the European Commission's DG Research for over a year from 2005 on matters germane to the content of this book in their Commission on Constructing Regional Advantage (CRA). Presentations to the EU Committee of the Regions and other policy bodies ensued. We thank Dimitri Corpakis, Jean-Marie Rousseau and Lucia Gebbia for expertly facilitating these interchanges. Colleagues like China development expert Maximilian Von Zedwitz spurred us on to articulate issues connected with the rise of huge Asian economies for global competitiveness during later conversations at Pisa. Meric Gertler, David Wolfe and other colleagues in the Canadian Innovation Systems Research Network have generally been willing interlocuters, supporters and critical friends in these lines of investigation. Others in CRA, like Åsa Lindholm Dahlstrand, impressed upon us the importance of understanding 'knowledge entrepreneurship' as an underdeveloped aspect of, especially, current European economic performance in general but with acute regional asymmetries too. Finally, we wish to acknowledge the work of managing editor Jules Mohm at Routledge and particularly Gernot Grabher who read and constructively criticised the whole collection. Accordingly, we hope, the flow, clarity and connectivity of the content of the collection have improved substantially over our earlier drafts. But, we reiterate, without the initiative and stimulus provided by RSA, its conference board, and particularly the tenacity and organisational capability of its chief executive Sally Hardy, there would be no document to improve. We hope we have done justice to our many colleagues and to the book's audience.

Phil Cooke, Cardiff
Andrea Piccaluga, Pisa
December 2005

1 Introduction

Regional asymmetries, knowledge categories and innovation intermediation

Philip Cooke

Introduction

This book takes off from the position reached in earlier analyses of the ways in which regions have become key intersection points in systemic innovation by virtue of their laboratory-like institutional capabilities of policy experimentation (Osborne, 1990; Sabel, 1996; Cooke and Piccaluga, 2004). While Cooke and Piccaluga (2004) was both expository and reflective regarding key concepts, such as economy, region, knowledge laboratory, and knowledge economy (as well as critiques of aspects of these), they have now become more mainstream and settled in definitional terms.[1] Hence, by comparison, this book is probably more penetrative in respect of innovative regional development *actualité* as it co-evolves with advanced country knowledge economy imperatives, such as the rise of R&D outsourcing, the demise of routinised production, and policy demands to adjust regional knowledge imbalances and 'asymmetric information' (Akerlof, 1970).

Policy learning about 'living on thin air' creates conditions for 'light governance' of knowledge-intensive activities like software, genomics and nanotechnology, requires more roles for intermediaries and a less direct governmental hand on the microeconomic tiller (Leadbeater, 1999; Leadbeater and Miller, 2004). In the latter publication on 'the ProAm economy' Leadbeater and Miller make the following point about a transformation that is revolutionising the way new knowledge in the form of research is performed:

> In closed innovation models, consumption is the end point of a process of innovation that originates in the mind of a (special, creative) author. Consumers are passive except in exercising their right to choose among options, and to accept or reject the innovations present in those options. In open innovation, consumption and use is an essential part of the innovation process, not the end point of it. In fact, the purpose of an invention or innovation is defined not by the inventor, but by its use in networked communities.
>
> (Leadbeater, 2004, http://www.corante.com/amateur/archives/003064)

This extrapolates into community networks the dramatic organisational research innovation observed by Chesbrough (2003) regarding *where* in the knowledge economy R&D is conducted. Against the Chandlerian (1990) model of scale determining the location of such strategic activity as R&D in the laboratories of hegemonic corporations, it is now routinely done in small and medium-sized enterprises and university centres of research excellence, something we analyse in depth statistically in the section 'The emergence of a research industry', of this introductory chapter.

'Open innovation' requires study in its spatial as well as structural dimension, something authors like Caniëls and Romijn do theoretically, and Isaksen, Piccaluga *et al.*, and Asheim and Coenen do in great empirical depth in this book. It represents the rise of fidelity over secrecy as economic drivers, overturning the military 'M'-form organisation of knowledge production with the networked 'N'-form heterarchy. The latter, combining knowledge spillovers with temporary project contracts, was adumbrated in Hedlund (1994), Gibbons *et al.* (1994) and Nonaka and Takeuchi (1995). But its economic geography needed to be illuminated, as in Cooke and Morgan (1998). Once more, economic geography, defined as the microeconomic analysis of agglomerative economic activity, is revealed as the supreme disciplinary embarkation point for understanding contemporary metamorphoses in economic relations. For without any spatial vision, even Akerlof's (1970) let alone Penrose's (1959/95), Leadbeater's (1999) or Chesbrough's (2003) insights remain somewhat desiccated. But with it, as each of the contributors to this volume demonstrates, economic processes are brought to life, rooted in social interactions, embedded in institutional contexts, and irrigated by usable knowledge.

The argument of the book

So the book proceeds in the following manner. Following this introduction, the theoretical debate about the salience of 'localised knowledge spillovers' is scrutinised by Marjolein Caniëls and Henny Romijn. They show that those who argue they do not exist beyond simple pecuniary externalities found in industrial districts by Marshall (1919) are misguided. Localised knowledge spillovers, the essence of 'open innovation', thus occur, but not strictly at the level of the region or even the locality but the firm. They exist, not quite 'in the air' although that may be the medium through which some knowledge held by some knowledgeable person is communicated as useful 'know-who', or she may be a repository of 'know-that' or better, 'know-how', namely the ability to cause a desired result. 'Know-how' is a most valuable knowledge element since it embodies foresight, it is predictive and enables invocation of the capability to innovate. This, in turn, is due to its intimacy with a further key knowledge element, namely 'understanding' of cause and effect interactions that explain natural and social characteristics. By and large this is the province of individuals, here in the context of firms, rather than spatial entities like locales or regions. These may be the habitat of concentrations of specialised knowledge, or let us say 'spatial knowledge domains' but it is not the space that contains the capabilities but rather the cognitive capabilities that inhabit the space. So arguments that, for example, clusters in the spatial sense are themselves somehow analytically prior to firms and individuals are also misguided in this analysis.

Thereafter, and in distinctive ways, each chapter more or less exemplifies this perspective on the relationship between economic knowledge and regional development. Each is consistent with the following paradigm, possibly a prelude to a more full-blown theory of regional development as a process of altering 'spatial knowledge asymmetries' by generating 'spatial knowledge domains'. This proceeds from Krugman's (1995) insights into the effects of increasing returns to scale and scope whereby specialised knowledge exerts spatial monopoly effects that enable asymmetric development of competing agglomerations. This invokes also a social exclusion or 'club' effect that enables mainly those of consequence to the winning agglomeration to gain entry. It echoes Adam Smith's celebrated comment on the moral turpitude of capitalists that is especially appropriate to this analysis:

> People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices.
>
> (Smith, 1776, book 1, chapter 10, part 2)

This insight was particularly pertinent in light of the questionable balance sheet rigging practices of the likes of Enron, WorldCom and AOL during the economic boom years of the late 1990s (Fusaro and Miller, 2002; Klein, 2003).

On less shaky ground, Arne Isaksen shows how intermediation in systemic innovation in the important Scandinavian city of Oslo is performed crucially by software consultants adapting and innovating software for a multitude of commercial and public uses. This complements Aslesen's (2004) observations on the same city concerning the role of consultants more generally in enabling explicit-to-implicit knowledge transfer to occur in practice. Continuing the software theme, Anet Weterings and Ron Boschma in the following chapter take an evolutionary economic geography approach to analysing software firm clustering in the Netherlands. Rejecting a neoclassical cost and information-based explanation for this core economic geography process, they focus on knowledge spillovers, notably those that rapidly communicate tacit organisational know-how among firms. Proximity facilitates emulation from the spin-off parent firm, in the process transforming tacit labour know-how through organisational innovation, network formation and fidelity. However, their analysis also demonstrates that strong network relationships with *customers* and *competitors* have no significant effect on the innovative performance of Dutch software firms.

Next, the sectoral focus of the book turns from software to bioscience as Bjorn Asheim and Lars Coenen reveal how industries in three highly advanced northern hemisphere locales focused on the processing of natural materials like wood and food utilise extremely advanced scientific and technological know-how to construct regional advantage, even knowledge quasi-monopolies for their economic actors, supported by strong intermediation. Extending Ryan and Powell's (2004) study of functional genomics in the creation of high-yield cookery ingredient oilseed rape, otherwise the copyrighted Genetically Modified Organism *canola*, they remind us how Monsanto, Aventis, Dow AgroScience and Bayer CropScience among many others benefited financially from knowledge intermediation by Canada's National Research Council facility in Saskatoon, Saskatchewan. This place is thus a virtual monopoly knowledge domain for this specific science, exporting the ensuing and heavily patented GMO germplasm globally. Salling provides a similar category of 'monopoly with intermediation' in the production of design-intensive Danish furniture. Scania region seeks, with the support of the Swedish innovation systems agency VINNOVA, to replicate such monopoly conditions around lactobacter nutraceuticals and other functional foods. Sweden's pioneering *ProViva* was discovered in Scania's Lund University, developed by local firm Probi, and launched in Sweden in 1994, yet Danisco's *Benecol* and Danone's *Actimel* became global brand leaders.

There follow two further papers on the economic geography and policy of biotechnology by women scientists more firmly in business economics than regional science but interested in the spatial processes underlying the aspatial effects they initially noticed. Thus Maija Renko, drawing on her US research, presents an analysis of the innovation processes in biotechnology firms, studying particularly the role of market-related stakeholders (mainly customers and competitors) in this innovation process. Building on an initial interview data set from small clusters in Delaware and Florida, the current chapter includes interview data from a further 19 biotechnology firms in the San Francisco Bay Area, making it a further three-centre comparative study involving 58 US biotechnology firms altogether. Results show the inordinate importance of intermediation between entrepreneurs and scientists in communicating tacit knowledge across epistemic boundaries. Firms were asked about three key innovation stages: sourcing of knowledge; examination, development and transformation of such knowledge; and its exploitation as a commercial product or service. Each stage involves a repertory of actors representing distinctive professional fields within science, business and markets. The implicit–explicit hermeneutic or 'translational fix' requiring constant and variable iterations, makes proximity to complicit actor skills a *sine qua non* of biotechnology. This balances up the internal organisational impacts of knowledge spillovers in the preceding chapter by revealing their external organisational network characteristics. In the process both papers remind us of Galison's (1997) investigation of knowledge barriers in science, where different epistemic actors develop 'pidgin' contact or working languages, using analogies and metaphors to capture complex meanings in what Nowotny *et al.* (2002) call knowledge 'trading zones' and 'transaction spaces'.

In Margarida Fontes' following chapter on biotechnology in Portugal, an interesting comparison with the preceding chapters is set up by the fact that, like Saskatoon and Scania, agro-food biotechnology is involved. Some argue that this is not as prone to SME clustering since large multinationals like Syngenta, Avecia, Bayer, Monsanto, Avensis, Dow, Unilever, and Nestlé are comfortable with biosynthesis, biologics production, genomics and food science as historically and professionally they possessed the necessary biological talent in ways that pharmaceuticals firms continue to lack. That even such behemoths cluster is clear from the Saskatoon story, but there are also signs, most notably from Wageningen's 'Food Valley' in the Netherlands, that food genomics start-ups also co-locate in proximity to the 'mother-ship', in this case one of Europe's leading agricultural universities (Cooke, 2004). The chapter captures the global/local dyad informing biotechnology knowledge value chains by discussing the knowledge sourcing strategies devised by Portuguese firms, the motives behind their adoption, the mechanisms used for their implementation and the difficulties associated with them. The term 'distant networking' is introduced to capture this basic feature of firm behaviour, to which location is also not a matter of indifference. Their success in processing tacit knowledge is related to their devised strategies that permit them to draw creatively from a combination of local/distant relationships and to profit from functional, organisational or relational proximity, to overcome disadvantages of location. But this option has additional costs (material and immaterial) which also require particularly good relational skills. It is concluded that firms that maintain links to their local environment, while also integrating with international networks, can perform an important role as connectors between these networks, their region and its development.

As is frequently the case in conferences and books that investigate the knowledge economy the two main sectors that are most studied are biosciences and varieties of information and communication technology (ICT). The roles of cultural, financial, healthcare, creative and media sectors in this context, each of which is highly knowledge-intensive, are only beginning to be studied from that perspective. Two chapters towards the end of this collection by Irina Saur *et al.*, and Lars Qvortrup, touch upon design and culture, however, and that is to be welcomed. But first are three papers mainly examining different aspects of the contribution of knowledge institutions using, promoting or stimulating the emergence of ICT for regional development. Each is interestingly original and unlike mere accounts of specific ICT agglomerations. The first, by Kati-Jasmin Kosonen, elaborates profoundly upon Sotarauta and Kosonen (2004) in which Finland's rural Vaasa region had developed localised professorial research networks in the absence of a university, to work specifically for regional development in the knowledge economy. Now the study is extended to an analysis of six such networks promoting ICT research, *inter alia* and using ICT methodologies to enhance regional development potential. These University Filial Centres are distributed throughout Finland south of the Gulf of Bothnia in Kokkola, Kajaani, Mikkeli, Lahti and Pori regions as well as Seinajöki. The variety of institutional means, some placed in a single institution, others virtual organisations, by which *Filials* can assist knowledge economy development in less favoured regions shows how contemporary regional development policy can never again be drawn from a 'one-size-fits-all' template.

Thereafter, two Italian studies comprise the following chapters. The first, by Alberto Di Minin *et al.*, shows how the presence of intermediaries including a permanent Observatory on the high-tech cluster in Pisa, established in 2000 enabled over 200 high-technology firms to be monitored in the province of Pisa, in Tuscany. Here, a traditional manufacturing sector is slowly declining but coexists with an outstanding public research system, in which qualified human resources are attracted, educated and often retained. Start-up firms are being generated in the area and external companies are further attracted. The knowledge-based assets of the Pisa locale represent a strong potential driver for regional development. However, it is concluded that the relative weakness of networking initiatives, the lack of a clear public and private leadership in the sector, and the inadequacy of the local financial market are the main bottlenecks which might hinder further growth of an already promising cluster.

Complementing this account of regional development in modestly peripheral Tuscany is one from classically remote Sardinia. Leadership has been pronounced in the evolution of regional fortunes. Such is the untroubled embeddedness of the island's mountain population that Sardinia's gene bank is of interest to genomics firms worldwide, seeking knowledge of the secrets of the population's remarkable longevity, disease resistance but also genetic predisposition to specific pathologies. One such firm, that sells bioinformatic data of the Sardinian genome is the quixotically named SharDNA. It was founded on the Polaris Biopark near Cagliari by the key actor in Sardinia's ICT story Renato Soru, the Sardinian owner of Tiscali, Europe's largest Internet Service Provider (ISP). Passionate about regional development in Sardinia, Soru was from 2004 *Olive Tree Party* President of the Sardinian Regional Government. Distant networks include a particularly strong one between local pioneer firm Video On Line and the MIT Media Lab through the former's founder, Cagliari-based publisher Nicola Grauso. He owned newspapers and local television networks and sought to innovate in his own business. Thus in 1995 he started up Video On Line, an ISP supported by one of the ten most powerful servers in the world at the time. Strong links also exist between Video On Line and CRS4. CRS4 (Centre for Advanced Studies, Research and Development in Sardinia) was established by the Sardinian regional government, appointing the 1984 Physics Nobel Prize winner Carlo Rubbia as chairman. Grauso was fascinated by Rubbia's ideas about the feasibility of an international data transmission network; the meeting between the entrepreneur and Nobel Prize winner Rubbia took place in 1994, a short time before Video On Line started up. Thereafter, various waves of spinout and start-up business have ensued but these, while moderating Sardinia's developmental asymmetries somewhat, contribute to what remains a somewhat fragile ICT cluster in an unlikely setting.

Finally, ahead of Andrea Piccaluga's concluding chapter are two by Irina Saur and colleagues on 'The House of the Future' and Lars Qvortrup on the contribution of the University of South Denmark's 'Knowledge Laboratory' at Odense to regional development in Denmark. The 'House of the Future' is an Aveiro University initiative involving a network of design and construction firms in the surrounding Centro region of Portugal. It has facilitated the identification, creation and dissemination of mechanisms to enable firms and university research to evolve new innovation processes. These involve the creation and testing of new methodological approaches, including creativity methods and new product development techniques inspired in the multidisciplinary *milieu* of the various firm–academe working teams. The development not only of new products linked to habitat but also the opportunity to test and disseminate R&D and innovation both yielded results in a 'laboratory' entitled the House of the Future. It is open to the public who may also influence design perceptions among housing designers alert to the advantages of multi-sectoral development and cooperation in the design and construction of housing. The Qvortrup chapter also focuses on 'laboratory' interactions with regional communities and development authorities. In January 2007 Denmark will launch its new regional administrative structure. This chapter explores ideas about how knowledge centres such as universities may contribute to regional development under such altered circumstances. One is to act as a 'buffer zone' reminiscent of the 'transaction spaces' discussed earlier mediating through, in the case of Odense, the university's knowledge laboratory. This offers a buffer zone in which issues of complexity and what Qvortrup terms 'hyper-complexity' offer dynamic stabilisation of the external environment through understandings based on cognitive modelling of regional development in the internal environment of the lab. Innovative perspectives on the role of culture and media representation are expected to contribute to the achievement of this aspiration.

Regional development matters arising

It is clear from the foregoing accounts that the rise of the knowledge economy means new and various, not to say complex, ways are being found to cope with contemporary regional development imperatives. What are commonalities and key divergences in what is being perceived about the changed requirements for regional development policy? There are three of each. So, beginning with commonalities, each account demonstrates recognition of new challenges in *communication* among epistemic communities. Thus, mention is regularly made of the need for 'contact languages' or 'working languages' in knowledge 'trading zones', 'transaction spaces' or 'buffer zones'. Often, universities are seen as having potential in this regard, but they are not always available in less favoured regions. So the focus sharpens on to *research* and researchers as persons with knowledge, or even *knowledges*, that may assist those charged with responsibility for regional development who may increasingly find themselves engaging with the worlds of science and culture as well as governance.

It is also clear that the time has come to recognise that governance itself has become hypercomplex in that more stakeholders than hitherto are involved. Three elements contribute to this evolving complexity: the first is that governance professionals no longer possess the substantive knowledge of regional development good practice their predecessors had when they were responsible for discharging such responsibilities in government. So, second, the modern regional development manager mainly has process competences rather than substantive capabilities. Third, nowadays these primarily concern such responsibilities as managing knowledge outsourcing, to university or market consultants, audit compliance, again in the *external* context of regulatory due diligence, and facilitating stakeholder coalitions or networks, including scientists, entrepreneurs and other 'ProAms'. Such tasks are a product of the increased commercialisation of policy formulation, the demise of 'one-size-fits-all' regional policy, and the shift in theory from growth redistribution to growth generation.

We may conclude from this that the traditional knowledge transfer assumption that implicit knowledge is turned into explicit by binary conversations is, institutionally, wide of the mark as Galison (1997) shows even among scientists. These chapters show that there is a need, partly satisfied in some of the details of the accounts, for translators who are *complicit* with the cognitive content of both the tacit and the explicit knowledge interlocutor. An illustrative representation of such a role is presented in Table 1.1. Thus, 'knowledge domains' are spaces where distinctive kinds of knowledge prevail. Hence laboratories are domains of partly implicit 'analytical' knowledge as Asheim and Coenen refer to it in this volume. The complicit knowledge domain may be the office of a foresight consultant, adviser, or knowledge lab such as MIT's Media Lab, while the explicit knowledge domain in this context is likely to be that of the entrepreneur. Complicit knowledge is thus possessed by a third party probably with a background in the knowledge-base of the tacit knowledge holder who therefore belongs to the same 'epistemic community'. However, the complicit knowledge will also extend professionally into the explicit knowledge epistemic community, probably in business of some kind. Thus the intermediary is complicit in two epistemic communities, a scientific (or maybe a symbolic, i.e. creative arts) and a commercial one. New regional development theory thus identifies a new professional requirement, for such 'complicit brokers' as those indicated, who are globally extremely scarce in number.[2]

The two other commonalities are more straightforward, although they also have their complicit dimension. The first refers to the 'knowledge capabilities' dimension of Table 1.1. Brief mention was made of research in introducing the first commonality as a crucial variable in perceived requirements for regional development in the knowledge economy. This knowledge capability is performed by talented, exactingly trained personnel. They are talented for reasons probably neither they nor anyone else truly understands, despite the best efforts of psychologists to measure IQ. This is tacit knowledge of the deepest kind. It is from the complicit knowledge qualities of these professionals that new hybrid skills will form, not necessarily a majority, perhaps as with so-called 'disruptive researchers' in software engineering from whom innovation can be anticipated, it could be some 5–10% only of the future workforce.

Table 1.1 Knowledge: from implicit domains to regional innovation systems

	Implicit	*Complicit*	*Explicit*
Knowledge domain	Invention	Translator	Appropriation
Knowledge capability	Talent	Research	Technique
Innovation system	Institutions	Networks	Interactions

Finally, and very clearly, each narrative in the book points to the complexities of building systemic relationships that enable knowledge to flow into, within and beyond the regionally less favoured setting. Of considerable interest are the ways in which distant and proximate inter-institutional and inter-personal networking of a systemic kind are aspired to and, to varying degrees, implemented. Perhaps the Sardinian account is most memorable in this regard, with regional development being mobilised through acts of 'leadership' involving an Italian Nobel Laureate, the world-renowned MIT Media Lab, local Internet entrepreneurs, a 'Methuselah' gene bank and the Sardinian regional government. By comparison, in Finland, many regional efforts involve less celebrated but nevertheless networked research leaders combining their knowledge capabilities to foster regional growth among indigenous small firms. Elsewhere, leadership is more institutional than individual, as in Portugal, elsewhere in Italy at Pisa, in Odense, Denmark and from a state body with a regional innovation systems mission in Sweden.

But there are differences, too. The first is notably the balance of emphasis between endogenous and exogenous knowledge input to drive development. Most clearly in the US, the Netherlands and the Nordic countries, the expectation is that growth comes from endogenous entrepreneurship. The regional development problem is thus one of fine-tuning the market, evolving better social capital among businesses but not especially looking for systemic learning opportunities for innovation outside the region or state. In the southern European regions, endogeneity is seen as requiring a considerable boost from exogenous knowledge sources or their public conduits, namely universities and research laboratories. Secondly, to some degree growth is thus more 'polar' in these regions, in *Polaris* in Sardinia, for example, and urban innovation centres elsewhere, whereas a northern model of markets and networks supported but not determined by state action is more common. This may reflect a habit of seeing France and its growth poles, later transformed into technopoles, as the appropriate regional technology policy progenitor, especially in Mediterranean regions where, for example, universities are normally not significant regional economic drivers. Finally, state or market? It would be too simplistic to posit an Atlantic–Baltic market model and a Mediterranean, state-led regional innovation model. This is because the Baltic segment frequently displays innovative central state initiatives that stimulate endogeneity rather than substitute for it, something curiously true of Canada also, while it is well-known that the US federal government supports entrepreneurship indirectly through vast budget expenditures on military and medical research programmes. Denmark and the Netherlands occupy geographically and institutionally something of a middle ground in this regard.

So, briefly, which is the better model for achieving regional development in the knowledge economy, the American federally pump-primed liberal-market model, the socially more supportive, co-ordinated Canada–Baltic model, or the institutionally stimulated Mediterranean leadership model?

In respect of innovative regional growth with relatively stable social and spatial impacts, the Canada–Baltic regional innovation model is superior to the other contestants. In respect of strikingly swift innovation-led regional GDP and employment growth, followed by catastrophic decline and associated job-loss, the US research–venture capital–entrepreneurship model has been attractive to many administrations worldwide. However, as Krugman (2003) sees it, the model has, at least temporarily, unravelled with the retreat of the venture capitalists from the prospect of unsustainable risk. So much so that by 2005 many research-driven US start-up businesses were seen to be re-locating to regions like Scotland with sophisticated *public* venture funds for second-round investment (McKee, 2005). The loss of 400,000 jobs in Silicon Valley alone following the 2000 downturn also tarnished this regional development model's image considerably thereafter (Cooke, 2004). What can be said with modest confidence is that, as represented here, the 'polar' model is not as accomplished, at least in the medium-term, as its progenitors would have hoped. Some, as at Bari in Puglia, Italy's southern 'heel', are now closed down, replaced by regional experimentation along more modest, network-based lines as at Lecce, borrowed institutionally from Pisa. Along with other *research* not technology-driven, regionally interactive initiatives in Italy, Finland, Portugal and elsewhere, this probably marks a recognition that the linear, top-down polar idea has had its day and that 'one-size-fits-all' no longer works, if it ever did.

The emergence of a research industry?

The accounts in this book point unavoidably to a recognition that in the knowledge economy, the value of research capability rises dramatically. But research is expensive and what now needs attention are the contemporary dynamics of this burgeoning element of the regional development prospectus. In the past, research was mainly conducted in university departments, government research laboratories, private laboratories of large firms and in specialised smaller research firms. During the 1990s, that picture changed considerably, especially for firm-based research (in the US) as Table 1.1 shows. Of importance is the switch from large to smaller firm R&D incumbents. Remarkably, and mainly in the 1989–1999 period, the share of industrial R&D conducted by firms in the largest category, i.e. employing more than 25,000, halved from some 71% in 1981 to 36% in 2000. Simultaneously, that conducted in the smallest category, firms employing less than 1,000 grew from some 4% to 22%, and for the next category, 6% to 15%. Thus the amount of research being conducted in smaller scale enterprises (37%) was by 2000 larger than the share (36%) in firms employing 25,000 or more. Furthermore, we see in Table 1.2 a remarkable growth in the late 1990s in the share of R&D being conducted by smaller grade US businesses. Particularly striking is the manner in which the smallest category, employing less than 25 workers, rose in significance to reach comparable overall shares to firms ten times that employment size. Every category rose significantly in the 1997–1999 period excepting only the 100–249 employment group, which experienced a sharp decrease in 1999 after a major increase in 1998. It is noticeable that, in Table 1.1, the smaller category grew fast after 1989 then stabilised in 2000.

Table 1.2 Percentage of US industrial R&D by size of enterprise

Company size	*1981*	*1989*	*1999*	*2000*
<1,000 employees	4.4	9.2	22.5	22.1
1,000–4,999	6.1	7.6	13.6	15.2
5,000–9,999	5.8	5.5	9.0	8.3
10,000–24,999	13.1	10.0	13.6	14.0
25,000+	70.7	67.7	41.3	36.1

Source: National Science Foundation (2001); see also Chesbrough (2003).

Table 1.3 R&D expenditures by small US companies (millions of constant 1992 dollars)

Size of firm	*1997*	*1998*	*1999*	*change (%)*
Fewer than 25	2,536	3,804	5,579	120
25 to 49	2,455	2,525	3,824	56
50 to 99	3,415	5,155	5,779	69
100 to 249	5,907	6,622	5,707	−3
250 to 499	5,229	5,522	6,463	24
Total	19,542	23,627	27,352	40

Source: NSF (2001).

A new US phenomenon of outsourcing R&D to the smallest category of SMEs in boom times is consistent with the data in these two tables.

Regional R&D outsourcing as 'open innovation'[3]

As discussed earlier, this process is known as 'open innovation' whereby large firms outsource research to smaller firms. However, not discussed in these statistics is outsourcing of research by firms and public organisations to universities. It is clear from Figure 1.1 that other firms are the major R&D outsourcing target. However, universities are a respectable third at 22% behind commercial laboratories on 28%. Hence, under pressure for growth, industrial R&D must discover new technologies and product developments to create new opportunities. Working with tighter budgets and smaller staffs, there is little choice but to augment weakening internal resources and capabilities with external sources of research and technology as effectively and efficiently as possible.

Some countries are already positioning themselves to be growing recipients of R&D outsourcing. A study by Research and Markets of Ireland in 2004 showed the R&D outsourcing market for information technology in India growing from $1.3 billion in 2003 to over $8 billion by 2010. As many as 150 R&D centres have been established in India. Texas Instruments led the way in 1985, followed by Intel, Motorola, IBM and Cisco. In 2004, Advanced Micro Devices indicated it will design and develop a new processor from its centre there, and in 2005 Siemens announced a $500 million software R&D 'hub' raising its Indian software

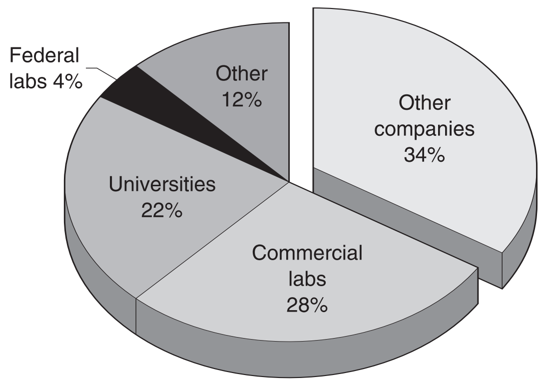

Figure 1.1 R&D outsourcing destinations.

engineering workforce by a third to 4,000 (Merchant, 2005). The success of Indian R&D centres was attributed to factors such as good management, an emphasis on quality, strong ties to universities and clear research 'roadmaps'. The growing number of R&D centres also built on the successes of pioneering companies as learning of good practice disseminated.

In the EU, figures for Sweden point to an external R&D market having expanded rapidly. The most recent available figures (1995) indicated that 33% of R&D expenditure made by manufacturing industry went to external R&D performers. Comparing annual total expenditure by manufacturing industry on external R&D since the early 1990s, there had been a fivefold increase since 1991.[4]

Total spending by German firms on R&D in the early 1990s (1991–94) was some €29 billion per year. During this same period, the number of R&D staff employed by firms fell, while the percentage of R&D expenditure purchased from third parties increased each year from 10.1% of total R&D spending in 1991 to 13.0% in 1994. The trend towards R&D outsourcing in the Netherlands in the early 1990s varied by sector. Taking as the base indicator the change in R&D expenditure as a percentage of output over the period 1990–94, growth occurred for outsourcing in the chemical industry (+24% over the four years) and especially in the food industry (+88%). Hence these trends also pointed to a growing corporate market in R&D outsourcing. As the competitive pressures on industry continued to increase, the European Association of Contract Research Organisations (EACRO) viewed this market as likely to continue to grow. It represents a significant opportunity and challenge for specialised industrial research and technology organisations, while governments, as R&D funders, review their programmes to ensure that they are in tune with the trends.

What can be said regarding the specifically regional dimension of the rise of the research industry in the knowledge economy? The ESPON (2004) report, co-financed by the European Commission allows a filtering through a number of variables of relevance to the discussion here for the European Research Area (ERA). This is summarised in Table 1.4, which constitutes a corrective to the aspatial microeconomics of the 'open innovation' analysis, and a statistical exercise involving more elaborated variables. In Table 1.4, it is possible to differentiate core macro-regions of the EU that have strong, medium and moderate combinations of variables. Some belts, like Northern Italy, far from being 'Archipelago Europe' of which it was deemed a constituent part in the early 1990s, only enter on one from four variables. However, the Nordic Countries are mostly present on all four variables, as is Southern and Eastern England, and Baden–Württemberg–Bavaria which are the only parts of ERA that appear, albeit at varying scale, in each

Table 1.4 The leading European research area regions

Regional R&D indicator	*EU macro-region/city region*
BERD	**Nordic Countries**
	Randstad and Rhine Valley
	Baden–Württemberg–Bavaria
	South and East of England
	Paris
	Southern France
R&D Intensity	**Eastern England**
	Sweden
	Helsinki
	Oulu
	Stuttgart–Munich
	Paris
	Toulouse
Tertiary education intensity	*Mid-Scotland*
	Manchester–Leeds
	Wales and Southern England
	Randstad Holland
	Baden–Württemberg–Bavaria
	Nordic/Baltic States
	Southern France
	Catalonia–Basque–Cantabria
Top publishing universities	*Mid-Scotland*
	Manchester–Leeds
	Sheffield–Nottingham
	Cardiff–Bristol
	Reading–Oxford
	London
	Cambridge
	Randstad Holland
	Nordic Countries
	Berlin
	Stuttgart–Munich–Vienna
	Northern Italy

Source: Derived from ESPON (2004).

category. Those making *three* entries are Randstad–Holland and Southern France, while those making two are Paris, Mid-Scotland, and Manchester–Leeds. This marks a significant shift northwards in the ERA research economy. Its southern border is marked by the Stuttgart–Munich and Nice–Toulouse axes. Its heartland is southern England and the Randstad while its head is in the Nordic Countries. These are the leading research zones of the European Research Area in the twenty-first century. In the USA and Canada, where this has been subject to more detailed analysis, the equivalent centres are the East and West Coasts of the USA, and smaller outliers in Austin, Texas, Minneapolis, Denver and Chicago, while in Canada it is the greater Montreal, Toronto and Vancouver regions that are prominent (Florida, 2002; 2004; Norton, 2000).

What can the regional role be as a research industry economy?

The key point regarding these trends, as shown, is that knowledgeable regions are participating in them as donors and recipients. Let us briefly examine the contraflows with regard to Sweden. In 1998 Ericsson had its largest single market (14% of sales) in China where it also placed a substantial amount of investment.[5] In 2004, Ericsson's total purchase cost in China was $10 billion, Ericsson had ten joint-ventures, and four solely funded companies in China employing more than 4,500 workers. Ericsson's investment in China reached $5.1 billion by the end of 2005 doubling its former total in one year.[6] However, it is important to note that simultaneously Ericsson also moved R&D in the opposite direction. Notably,

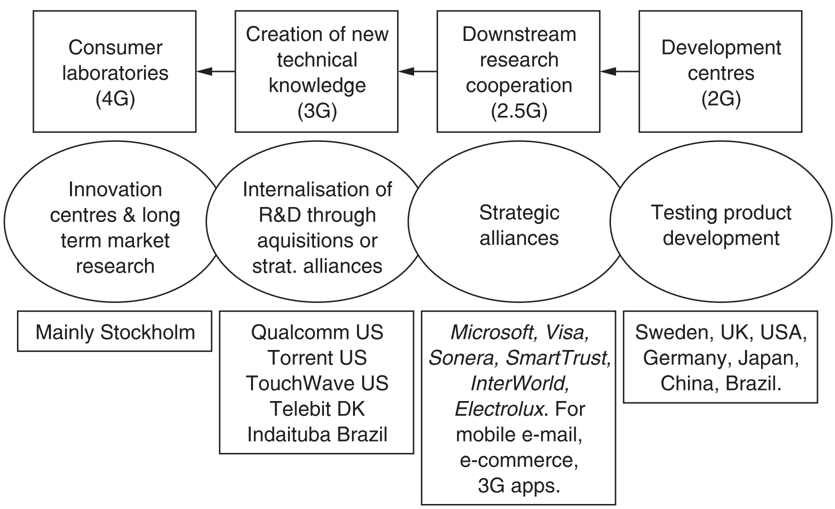

Figure 1.2 Gradual internalisation of R&D in Ericsson.
Source: Redrawn from Alvstam (2002).

interactively rather than in the linear model associated with R&D life cycle theory, the most advanced, longer-term and 'exploration' kind of knowledge creation is now being done mainly in Stockholm, while more routine, older technology 'examination' knowledge dealing with testing and product development is conducted in Sweden but also China and Brazil as well as the US and Europe. This suggests that for Ericsson at least, outsourcing of R&D (through acquisition and alliances rather than specific sub-contracts) was tactical, to fill specific knowledge gaps, and that strategic R&D can for the moment only be conducted satisfactorily in the home base. Nevertheless, before the dot.com downturn, Ericsson had 26,000 R&D personnel (25% of the total employed). This gives an indication that – as also envisaged by IBM[7] for e-services and computing – Sweden is one of the small group of northwest European countries with 'disruptive research capabilities', the others being UK, Ireland, Netherlands and the other Nordic countries. By 'disruptive research' firms mean creative, innovative, and competence-destroying capabilities on the part of, for example, software engineers.[8]

Two potentially disruptive technologies watched closely by integrators today are open-source software and nanotechnology. Each holds the promise of radically changing the landscape of information technology. The concept of open-source software, for example, challenges many notions about how software should be created and sold. Linux, developed under the open-source licence, is already provoking turmoil in the market for operating systems. The same holds true for nanotechnology. Although still a few years out, nanotechnology can greatly expand the role of integrators as small, cheap computational devices are placed in everything from medical devices to unmanned aerial vehicles.[9]

This brief analysis has shown the following. Large firms are outsourcing R&D, in some cases almost completely. Pharmaceuticals is an excellent case. But even the head of fabric and homecare products research at Procter and Gamble (not a pharmaceuticals company, rather a consumer products firm, known for toothpaste and detergents) was reported as follows:

> In 1970, only 5% of global patents were issued to small entrepreneurs. Today that figure is around one-third and rising. My biggest competitor today is a person with an idea. P&G is no longer closed to ideas from outside, as it was until about 2000 ... it is difficult for P&G to generate enough big ideas internally to fuel significant growth. The company estimates some 1.5 million scientists in academia or industry around the world have expertise relevant to P&G. So why not tap them?[10]

Hence, regional actions being taken at the initiative of national bodies with a regional remit such as VINNOVA in Sweden, or regional bodies with a 'national' remit like Scottish Enterprise[11] recognise the following. The first thing that must be done in the context of comparative national R&D ratings[12] is to identify the areas of strength in 'exploration R&D', the long-term, future market-oriented R&D by universities, firms and specialist private laboratories. Second, armed with this information, all relevant actors are called together to alert them to these development opportunities for their university Centres of Excellence, firms and laboratories to learn more, share good practice and express their requirements to regional, national and, if appropriate, supranational ministries and agencies. Third, a strategy for developing and integrating at home and abroad this newly recognised 'industry' is typically drawn up. Where there are sectoral and intersectoral networking opportunities these are identified. Similarly where any *cluster* activities and opportunities exist in the appropriate regional centres. Thus in Nordic countries such as Sweden, not only Stockholm, the capital, but Gothenburg region and Medicon region[13] are to be nurtured and promoted as key research regions. Global networking is also important and fully engaged in at all levels by universities, notably centres of global research excellence. Moreover, actors are also stimulated to engage in marketing exhibitions, trade fairs, conferences and overseas events organised to showcase the knowledge and research capabilities of the country's regional and national innovation systems.

Concluding remarks

Hence, this book holds the promise of numerous thought-provoking intellectual and policy-related lines of reasoning and action concerning regional development in the knowledge economy. Three points arise in reflecting on the implications of what follows. First, regional development policies have moved into an era where there is much greater variety on show than hitherto. As Cooke and Piccaluga (2004) demonstrated, substantial experimentation is in process, something noted also by Asheim and Coenen in this volume. From an evolutionary economic biology perspective, this is cognate to the Jurassic era, when great outbursts of variety enriched the development of species, from which were ultimately selected higher forms of intelligent life. Evolutionary economic geography is metaphorically moving through a mini-Jurassic involving successive bursts of exploration knowledge capable of enriching cultural, social and economic life. The key is to evolve capabilities to apply these such that they are examined and exploited developmentally. That is, a key aspiration is also to ensure that variety of enrichment occurs cohesively from a societal viewpoint. Regions have become key intersections of different knowledge systems with global and local reach that require superior policy guidance to that of the past for optimising both economic innovation and social integration.

Second, the book demonstrates consciousness that in a mini-Jurassic representing a movement of the forces that we call 'Globalisation', processes of open innovation mark the evolution of Globalisation 1 into Globalisation 2. Recall that early modern globalisation, as denoted by its first analysts, such as Levitt (1983) was largely understood as a globalisation of consumption, notably in apparel, fashion and other consumer goods that itself evolved into the elaboration of global production chains, networks and clusters that ensured optimal pricing for the global consumer. The orchestrators of this kind of globalisation were gross scale institutions such as multinational corporations and a globalising regulatory system vividly attacked for its overweening brand philistinism by the likes of Naomi Klein (2001).

Globalisation 2 has multinational corporations practising open innovation to an increasing degree. It was pioneered in biotechnology, where multinational corporate capabilities are at an all time low in performing elementary corporate functions. Failures include selling products with lethal effects for consumers, utilising new technologies such as combinatorial chemistry in ways that yield unmakeable compounds, and increasing incapacity to conduct, on the back of their vast, patent-protected profits, effective research into viable new products. R&D outsourcing has since spread to the automotive, ICT and consumer goods sectors (Schamp *et al.*, 2004; Chesbrough, 2003). Capturing 'constructed advantage' for open innovation is a new imperative in regional development.

Finally, as discussed, Globalisation 2 and the neo-Jurassic implications of bursts of new knowledge, globalised out-sourcing, and the need for policies to moderate social and spatial imbalances arising mean policies are now perforce 'associative' (Cooke and Morgan, 1998). But barriers among epistemic communities, let alone *within* such communities as 'science' or 'policy' where cognition in specific disciplines is reminiscent of Wittgenstein's (1958) 'language bubble', mean the need for complicit articulators with hybrid communicative skills has never been more pressing. This is in spite of injunctions to such institutions to practice direct 'Triple Helix' strategy formulation to engage fully with the knowledge economy (Etzkowitz and Leydesdorff, 1997). This is partly a knowledge management problem, one that large corporations have also signally failed to solve efficiently and effectively according to Hansen (2002). We have seen how much more difficult that is in the externalised world beyond the presumed administrative capabilities of the firm (Penrose, 1959/95). Once again, it seems that the spatial sciences may offer enabling tools to overcome both internalised and externalised complicit knowledge problems. In 2004, the aforementioned Swedish Innovation Systems Agency VINNOVA began experiments with a Geographical Knowledge System (GKS), an advance on the Canadian environmental and Indian military-inspired Geographical Information Systems approach evolving from the 1960s, as the means for systematising internal and extranet-based complicit knowledge (Johnston, 1983). By seeing the problem not as a 'train time-table' information supply issue but a cognitive or meaning formation one, as in Rashomon,[14] requiring creative dialogue among a variety of actors, regional development innovations are heralding innovative responses to knowledge economy imperatives.

Acknowledgements

First thanks in the preparation of this edited volume go to my co-editor Andrea Piccaluga, to the authors of the chapters, and to Routledge for expressing interest in the idea of the book. *Regional Development in the Knowledge Economy* had two motivating origins. First, three-quarters of the chapters took embryonic form as presentations and papers in the *Knowledge Economy* track of the Regional Studies Association conference, 'Reinventing Regions in the Global Economy' held at Pisa, 12–15 April 2003. However, with few exceptions, the present chapters display significant evolution since then. Sally Hardy and her RSA colleagues

deserve warm thanks for successfully organising the Pisa meeting. The remainder of the collection has disparate origins in two seminar workshops I attended in late 2003 and the summer of 2004. The first was in Aalborg University, at the 'Digital North Denmark Research Seminar' organised by Bent Dalum and colleagues, where Lars Qvortrup's presentation on knowledge and complexity said new and useful theoretical things about the theme of this book. The second was held by Roskilde University innovation scientists at Vedbaek, just north of Copenhagen in the research workshop on 'Management of Innovation – Are We Looking at the Right Things?' organised by Jon Sundbo and associates. The presentations of Irina Saur (and colleagues) and Maija Renko, neither from regional science nor economic geography, offered fresh perspectives relevant to the book project. This book tries to look at the right things, whether it succeeds will be judged by its readers.

Notes

1 The following usages apply. 'Region' is a governance unit between national and local levels. A 'regional economy' is '. . . the production, distribution and consumption of goods and services in a particular geographic region'. The 'knowledge economy' is measured, currently inadequately, as high-technology manufacturing added to knowledge-intensive services. Preferable, though statistically less simple, is a definition involving the occupational density of either secondary or, more acutely, tertiary-level qualified persons in the regional workforce. 'Knowledge' differs from 'information' in that it is creative and informed by meaning and understanding, whereas information is passive and, without the application of knowledge, meaningless (see Cooke and Piccaluga, 2004). To 'develop' means to evolve and augment, or enrich. Hence 'regional development' involves the cultural, economic and social enrichment of a region and its people. Here it mainly, but not exclusively, entails *economic* growth arising from increased efficiency and effectiveness in use and exchange of the productive factors of an openly trading regional economy.

2 The tasks of such brokers are variable. In a focused network like 'House of the Future' such a brokerage role by the project manager was essential in the initial phase, when there were differences in perspectives, objectives and interests among participants. However, once the 'pidgin' working language developed, presence of this function was no longer necessary on a continuous basis. Nevertheless, with greater complexity among 'big institutions' interacting on numerous changing problems and policies, it is also clear that the role would itself be more complex and on-going. This is what, in part, Lars Qvortrup's contribution regarding 'buffer zones' and training through cognitive modelling of complexity is getting at. I am grateful to Irina Saur for alerting me to this issue.

3 This is identified in Chesbrough (2003) *Open Innovation*, Boston, Harvard Business School Press.

4 These figures are found in the report by EACRO (2005) *The Changing World of Industrial R&D: The Challenges for Industrial Research and Technology Organisations and Governments*, Brussels, EACRO.

5 For example, with applied customer-related and technical adaptation R&D in co-operation with universities at Beijing and Shanghai.

6 Addressing the 'China Investment Forum', 22 January 2005, in Beijing, Ericsson China president Jan Malm said that to promote the localisation of Ericsson products in China,

the company intended to triple its annual export from China to US $4.5 billion while making efforts to invest more in R&D, developing talent and creating more jobs.

7 This analysis was provided by IBM's UK head of R&D at the Glasgow conference launching Hood *et al.* (2002) *Scotland in a Global Economy*, Basingstoke, Palgrave.

8 This concept is used in these industries as a reason for location decisions. For example Nortel located in Belfast, Northern Ireland because of the exceptional computer science talent at Queen's University (Cooke *et al.*, 2003). William Morrison, head of Nortel optical networks R&D, Belfast noted that there is a global shortage of supply of disruptive technologists, computer science labour pools typically only containing about 6% of such talent. Northern Ireland's computer scientists in optical networking software contained the anticipated 6%, which was sufficient to attract Nortel's investment in a 600 person laboratory (in 2000; numbers were reduced after the downturn).

9 A concrete example of disruptive technology occurs in the following. An Israeli medical doctor specialising in gastro-intestinal medicine was frequently told by patients that endoscopy (a camera in a tube for internal patient diagnosis) was painful to throat and oesophagus. Research on nano-cameras, for example that led by Bogdan Dragnea at Indiana University in Bloomington, USA to get an image of what goes on inside living cells and a greater understanding of how viruses work, is also occurring in Israel, some at the behest of the military. The doctor mentioned the endoscopy problem to an entrepreneur acquaintance formerly in the Israeli army rocketry service, who knew of the existence of nano-cameras for guidance purposes. The idea of a camera in a pill arose from the conversation and a commercial product *CamPill* is now in production by *GivenImage*, the entrepreneur's firm (author research interview, 6 January 2005).

10 Buckley (2005) Procter's gamble on outside ideas has paid off, *Financial Times*, 14 January, p. 11.

11 For the Scottish Enterprise 'regional development in the knowledge economy' model, see OECD (2004).

12 For example, Sweden scored 3.65 in its GERD statistic for 2001, equal first with Finland compared to the EU mean of 1.93, the US figure of 2.70 and that of Japan at 2.98: EC (2003) *Investing in Research*, Brussels, DG Research.

13 These three regions had the EU's first-placed at 59% (Stockholm), third at 54% (Gothenburg) and sixteenth at 51% (Malmö-Lund) of their workforce employed in knowledge economy jobs in 2001. They were, respectively, first, third and sixteenth in the EU's 188 NUTS2 regions. See Cooke and de Laurentis (2002) *The Index of Knowledge Economies in the EU* (RIR Report 41) Cardiff, Centre for Advanced Studies. In Norway, Bergen was sixth in Europe (52.4), Oslo seventh (52.2), and Trondheim ninth (52.1). I am grateful to Arne Isaksen for the Norwegian comparative statistics.

14 In Kurosawa's classic film, set in 11th Century Japan, a woodcutter comes across the body of a murdered man. This leads to the arrest of Tajomaru, a bandit who freely admits to murdering the man after raping his wife. However, his testimony is far different from the testimony that the raped wife gives. And neither story can match up with that of the murdered man. So who is telling the truth?

References

Akerlof, G. (1970) The market for 'lemons': qualitative uncertainty and the market mechanism, *Quarterly Journal of Economics*, 84, 488–500.

Alvstam, C. (2002) The internalisation of knowledge in manufacturing value added: the geography of Ericsson's mobile systems, and the China connection, in R. Hayter and R. Le Heron (eds.) *Knowledge, Industry and Environment*, Aldershot, Ashgate.

Aslesen, H. (2004) Knowledge intensive business services and regional development: consultancy in city regions in Norway, in P. Cooke and A. Piccaluga (eds.) *Regional Economies as Knowledge Laboratories*, Cheltenham, Edward Elgar.

Buckley, N. (2005) Procter's gamble on outside ideas has paid off, *Financial Times*, 14 January, p. 11.

Chandler, A. (1990) *Scale and Scope*, Boston, Harvard/Belknap.

Chesbrough, H. (2003) *Open Innovation*, Boston, Harvard Business School Press.

Cooke, P. (2004) The accelerating evolution of biotechnology clusters, *European Planning Studies*, 12, 915–920.

Cooke, P. and Morgan, K. (1998) *The Associational Economy*, Oxford, Oxford University Press.

Cooke, P. and de Laurentis (2002) *The Index of Knowledge Economies in the EU* (RIR Report 41), Cardiff, Centre for Advanced Studies.

Cooke, P., Roper, S. and Wylie, P. (2003) 'The golden thread of innovation' and Northern Ireland's evolving regional innovation system, *Regional Studies*, 37, 365–379.

Cooke, P. and Piccaluga, A. (eds.) (2004) *Regional Economies as Knowledge Laboratories*, Cheltenham, Edward Elgar.

Etzkowitz, H. and Leydesdorff, L. (eds.) (1997) *Universities and the Global Knowledge Economy*, London, Pinter.

European Association of Contract Research Organisations (2005) *The Changing World of Industrial R&D: The Challenges for Industrial Research and Technology Organisations and Governments*, Brussels, EACRO.

European Spatial Planning Observation Network (2004) *The Territorial Impact of EU Research and Development Policies*, Brussels, ECOTEC.

European Commission (2003) *Investing in Research*, Brussels, EC-DG Research.

Florida, R. (2002) *The Rise of the Creative Class*, New York, Basic books.

Florida, R. (2004) America's looming creativity crisis, *Harvard Business Review*, October, 122–136.

Fusaro, P. and Miller, R. (2002) *What Went Wrong at Enron*, Hoboken, John Wiley.

Galison, P. (1997) *Image and Logic: A Material Culture of Microphysics*, London, University of Chicago Press.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M. (1994) *The New Production of Knowledge*, London, Sage.

Hansen, M. (2002) Knowledge networks: explaining effective knowledge sharing in multi-unit companies, *Organisation Sciences*, 13, 232–248.

Hedlund, G. (1994) A model of knowledge management and the N-form corporation, *Strategic Management Journal*, 15, 73-90.

Hood, N., Peat, J., Peters, E. and Young, S. (2002) *Scotland in a Global Economy: the 2020 Vision*, Basingstoke, Palgrave.

Johnston, R. (1983) *Geography and Geographers*, London, Edward Arnold.

Klein, N. (2001) *No Logo*, London, Flamingo.

Klein, A. (2003) *Stealing Time*, New York, Simon & Schuster.

Krugman, P. (1995) *Development, Geography and Economic Theory*, Cambridge, MIT Press.

Krugman, P. (2003) *The Great Unravelling*, London, Penguin.

Leadbeater, C. (1999) *Living On Thin Air*, London, Viking.

Leadbeater, C. and Miller, P. (2004) *The ProAm Revolution*, London, Demos.

Levitt, T. (1983) The globalisation of markets, *Harvard Business Review*, May/June, 92–102.

Marshall, A. (1919) *Industry and Trade*, London, Macmillan.

McKee, C. (2005) Best seed fund practices in the US and EU, presentation to *Bio-Link: Linking BioTech Regions in Europe* Seminar, Genopole, Evry-Paris, 31 January–1 February.

Merchant, K. (2005) Siemens to invest $500m in Indian export hub, *Financial Times*, 10 February, 30.

National Science Foundation (2001) *Research and Development in Industry*, Washington, NSF.

Nonaka, I. and Takeuchi, H. (1995) *The Knowledge-Creating Company*, Oxford, Oxford University Press.

Norton, R. (2000) *Creating the New Economy: the Entrepreneur and the US Resurgence*, Cheltenham, Edward Elgar.

Nowotny, H., Scott, P. and Gibbons, M. (2001) *Re-thinking Science*, Cambridge, Polity.

Osborne, D. (1990) *Laboratories of Democracy*, Boston, Harvard Business School Press.

Organisation for Economic Cooperation and Development (2004) *Global Knowledge Flows and Economic Development*, Paris, OECD.

Penrose, E. (1959/1995) *The Theory of the Growth of the Firm*, Oxford, Oxford University Press.

Ryan, C. and Phillips, P. (2004) Knowledge management in advanced technology industries: an examination of international agricultural biotechnology clusters, *Environment and Planning C: Government and Policy*, 22, 217–232.

Sabel, C. (1996) Learning-by-monitoring: the dilemmas of regional economic policy in Europe, in OECD (ed.) *Networks of Enterprises and Local Development*, Paris, Organization for Economic Co-operation and Development.

Schamp, E., Rentmeister, B. and Lo, V. (2004) Dimensions of proximity in knowledge-based networks: the cases of banking and automobile design, *European Planning Studies*, 12, 607–624.

Smith, A. (1776) *Wealth of Nations*, New York, The Modern Library.

Sotarauta, M. and Kosonen, K. (2004) Strategic adaptation to the knowledge economy in less favoured regions: a South Ostrobothnian university network as a case in point, in P. Cooke and A. Piccaluga (eds.) *Regional Economies as Knowledge Laboratories*, Cheltenham, Edward Elgar.

Wittgenstein, L. (1958) *Philosophical Investigations*, London Macmillan.

2 Localised knowledge spillovers

The key to innovativeness in industrial clusters?

Marjolein C.J. Caniëls and Henny A. Romijn

Introduction

The role played by local knowledge spillovers (LKS) as drivers of innovative activity is currently hotly debated. Several competing points of view can be distinguished. Champions of LKS, of which Malmberg and Maskell (2002), Audretsch and Feldman (1996b), Jaffe *et al.* (1993) and to a lesser extent Bathelt *et al.* (2004) are notable examples, are pitted against LKS-sceptics, especially Breschi and Lissoni (2001a and 2001b). The latter argue that the importance of LKS has been highly overrated, and that the LKS-hype has come to overshadow traditional Marshallian pecuniary advantages operating in agglomerations. There are also contributions which are somewhere in between these two contrasting positions (for example, Martin and Sunley, 1996; Breschi and Malerba, 2001; Markusen, 1996).

The debate has been raging for several years, with especially the anti-LKS camp trying to elucidate and entrench its own position. However, no attempts have been made so far to resolve the controversy. The objective of this paper is to advance the debate. We argue that one important cause of the current lack of progress lies in the fact that all the main contributions to the debate, irrespective of their positions on the spectrum, have remained within the confines of the regional (i.e. meso) level of analysis. This has restricted their analytical perspective, which has led them to overlook potentially useful insights outside their own domain.

In our paper, we broaden the analytical lens beyond the regional level. We bring in the firm as an additional level of analysis, and show that this yields important new insights which make it possible to some extent to reconcile the contrasting viewpoints in the debate. More precisely, the addition of the firm-level perspective as a second level of analysis enables us to explore the interaction between the firm and the region in an integrated meso–micro fashion.

The logic of our procedure lies in the fact that regions are constituted by actors, notably firms, universities, research labs, government agencies and so on. Firms in particular are the key *loci* of decision making in processes of innovation and learning, with the other parties in the innovation system playing supporting and facilitating roles. Regional innovativeness therefore ultimately results from innovation decisions made by these actors. Insight into the behaviour of these actors, notably firms, is therefore a key towards a better understanding the innovation dynamism of regions. Evolutionary economic theory and associated resource-based views of the firm are especially suited to studying micro-level innovation and learning processes, and therefore we use insights from these literatures to build our argument.

The approach adopted in this paper differs from existing evolutionary studies that have also recognised the importance of firm-level knowledge accumulation dynamics, and that have also tried to identify mechanisms by which firm-level knowledge accumulation are enhanced within agglomerations. For example, in the Regional Innovation Systems research (Cooke, 2004 and 2001; Asheim and Isaksen, 2002; Isaksen, 2001), the innovation performance of a region '. . . depends to a large extent on *how firms utilize the experience and knowledge of other firms, research organisations, government sector agencies, etc., in innovation processes, and how they blend this with the firms' internal capabilities*' (Isaksen, 2001: 108, emphasis added). Studies employing a 'collective learning' perspective are similar in orientation (Keeble and Wilkinson, 1999; Lawson and Lorenz, 1999). In a similar fashion, Henry and Pinch (2000) have tried to operationalise Storper's 'untraded interdependencies', by tracing the mechanisms through which knowledge is circulated in a regional cluster. Some recent economic geography studies have also followed a similar line (Maskell, 2001).[1]

Yet, upon close inspection of these studies, one is still left wondering as to exactly how regional proximity is supposed to enable the speeding-up of intra-firm knowledge accumulation processes. We are left in the dark about the nature of the spatial proximity advantages that play a role here, and how these advantages impinge on firms' internal knowledge accumulation processes. The main aim in these studies has been, rather, to understand the dynamics of learning of the region as a whole, and this is explained in terms of the nature of *inter*-actor relations. The internal working of firms essentially still remain black boxes. This impedes a systematic identification of all sorts of agglomeration advantages and tracing of their impact on firm-level innovation and learning. Doing this requires that we map out the interaction between *two separate levels of analysis*, region and firm, each with their own theoretical concepts.[2] This is the approach we follow in this paper.

The plan of the paper is as follows. In the next section the main strands in the LKS debate are reviewed, and the current positions in the debate are highlighted. In order to do this effectively, we first introduce a typology of common types of market failure, of which knowledge spillovers are shown to be a sub-set. We then determine the places occupied by the different strands in the debate in terms of that typology. This exercise positions the LKS debate into the wider literature about the role of market failure in economic growth. This is the starting point for the elaboration, in the third section, of the analytical approach that we adopt in order to advance the debate. Next we revisit the most important existing contributions to the debate, commenting on these contributions from our analytical perspective. Lastly, conclusions, suggestions for further research and policy relevance are discussed.

The current state of the LKS debate

LKS are a special sub-set of a broader set of market failures that could occur in a regional setting. We construct a typology of important market failures that may occur in regional clusters, drawing on well-known writings by Scitovsky (1954), Meade (1952), Viner (1931), Bator (1979), and later contributions by Griliches (1979, 1992) and Stewart and Ghani (1991).

A first important distinction, which goes back to Viner (1931) and Meade (1952), is the one between technological externalities and pecuniary externalities. Technological (or real) externalities influence the firm's production function directly, unlike pecuniary externalities which do so indirectly through the price mechanism. The second important distinction is the one between static and dynamic externalities. Static externalities are external effects of producers' activities that can occur with constant tastes and technology (Carlaw and Lipsey, 2002). In contrast, dynamic externalities occur 'when the continuing actions of initiating agents generate technological changes that increase the value of existing technologies and/or create new opportunities for the receiving agents to make further technological changes' (Carlaw and Lipsey, 2002: 1308; Arrow 1962). Combining these two classifications results in a typology of market failures as depicted in Table 2.1. We now examine to what extent the market failures listed in each cell are likely to influence innovation and technological learning in regional clusters.

The top left cell consists of pecuniary market failures which can occur with unchanging technology, i.e. they are not a by-product of technological change. These are Marshall's (1920) external economies of scale, scope and transaction which foster industrial dynamism: regional agglomerations tend to attract specialised trade and machinery suppliers, and foster the establishment of a pool of specialised workers.

Well known examples of static real externalities in the top right cell are environmental pollution and the bees and orchards case. In this paper, however, we are not concerned with static real externalities, because they are irrelevant for

Table 2.1 Typology of important market failures in regional agglomerations

	Pecuniary	*Real*[a]
Static	External economies of scale, scope and transaction	Unpriced external effects unrelated to technological change (e.g. environmental externalities, bees and orchard)
Dynamic	Rent spillovers	Pure knowledge spillovers (intellectual gains)

Note

[a]Confusingly, early writers about externalities (Meade, 1952; Viner, 1931; Scitovsky, 1954) commonly referred to all real externalities as technological externalities. Strictly speaking, this term is correct only in respect of the sub-set of *dynamic* real externalities. Static real externalities are neither influenced by, nor give rise to, changes in technology.

the LKS debate. This is because they are neither caused by technological change, nor do they have consequences for it. In that respect they differ importantly from the static pecuniary market failures, which may indeed induce or facilitate technological change by reducing firms' innovation costs.

The bottom row of Table 2.1 contains the dynamic externalities. Unlike the static externalities in the top row, dynamic externalities are caused by the creation of new knowledge. In the bottom right cell we find real knowledge externalities, which means that these constitute direct free knowledge inputs into a firms' production function. The common name for these externalities is pure knowledge spillovers (as opposed to rent spillovers, to be discussed below). The term is equivalent to Marshall's technology spillovers, used by him to typify the ease with which ideas and skills circulate in local communities. In the modern literature about innovation in regions, this phenomenon has been commonly explained with reference to tacitness of knowledge. Geographical proximity overcomes problems with diffusion by facilitating face-to-face interaction.

In the bottom left cell, finally, we find pecuniary dynamic externalities. These are also knowledge spillovers, but their effect on firms' production function is indirect, through changes in input prices. These particular externalities are more commonly known as 'rent spillovers', following Griliches (1979, 1992). They occur when suppliers of intermediate or capital goods cannot fully appropriate the gains from technological progress embodied in their products. Users of these products thus obtain a progressively better price–quality ratio as they adopt newer vintages of intermediate and capital goods over time. The example of computers is a case in point.

At this stage in our analysis we are not able to perceive in detail how these rent externalities would operate more forcefully in clusters than elsewhere. Suffice it to say at this point that there are reasons to suppose that this is indeed the case. For example, Gertler (1993) describes several studies reporting that the effectiveness with which newly adopted machinery and equipment are utilised in firms was observed to be a function of the geographical closeness of the machinery suppliers.

We now discuss the chief contributions to the LKS debate with the help of the typology in Table 2.1. Prominent contributions to the pro-LKS camp have come from Malmberg and Maskell and writers in the so-called Economic Geography (EG) literature. In Malmberg and Maskell's (2002) paper, LKS are considered to be the true drivers of adaptation, learning and innovation, and subsequent competitiveness of clusters. While they acknowledge the existence of traditional cost-based approaches to explain the existence and development of spatial clusters, these approaches are not seen to offer relevant insights for their analysis.[3] Their view about the drivers of innovativeness in regions can thus be represented exclusively by means of the externalities listed in the bottom half of Table 2.1.

A second conclusion to be drawn from Malmberg and Maskell's work is that they view LKS predominantly as *pure* knowledge spillovers. This is evident from their emphasis on the idea that clusters facilitate transfer of tacit knowledge from one actor to another by making it convenient to meet and discuss common problems. This process is further seen to be supported by a shared local culture with specific norms, values, and institutions (Malmberg and Maskell, 2002: 433). It follows that Maskell and Malmberg can be placed in the bottom right cell of Table 2.1.

Many other pro-LKS contributions are furnished by the EG literature. Audretsch and Feldman (1996b) found empirical support for the existence of LKS. They show that the propensity of innovative activities to cluster is more pronounced than what one would expect on the basis of clustering patterns of economic activities alone. In similar vein, Jaffe *et al.* (1993) show that the geographic location of patent citations and that of the cited patents are often the same, while controlling for pre-existing concentration of research activity. Many other contributions in this line of work point towards the importance of LKS as well (see, for example, Glaeser *et al.*, 1992; Baptista and Swann, 1998; Wallsten, 2001). In Jaffe's (1996) study, knowledge spillovers are defined as intellectual gains through exchange of information for which a direct compensation for the producer of the knowledge is not given, or for which less compensation is given than the value of the knowledge (p. 5). The key in this definition is that knowledge spillovers have a local dimension, which results from tacitness of knowledge.

It follows that traditional static economies remain outside the scope of the EG research, just like in Malmberg and Maskell's work. Moreover, the emphasis on informal knowledge exchange suggests that the EG researchers have been predominantly focused on pure knowledge spillovers, again like Malmberg and Maskell. The possibility that certain knowledge spillovers may take a pecuniary rather than a real (pure) form has not been a prime concern in the EG research. Although these writers generally do show awareness of the existence of rent spillovers, these are not explicitly discussed in their empirical analysis. We conclude that the EG literature should also be positioned in the bottom right cell of Table 2.1.

The dissenting view has been most prominently voiced by Breschi and Lissoni. They criticise the pro-LKS contributions made by the EG researchers for using the LKS-buzzword '. . . as if it could encompass any kind of "localised knowledge flows", no matter whether such flows are the outcome of economic transactions, free sharing agreements or some agents' failure to appropriate the outcome of their own innovation efforts' (Breschi and Lissoni, 2001b: 976). Breschi and Lissoni thus argue that the econometric EG studies claim to find evidence of pure LKS, which, however, may partly reflect cost advantages, and that too much of cluster dynamism could thereby have been ascribed to pure LKS. Andersson and Ejermo (2002) have expounded a similar view.

However, the cost advantages that these writers refer to are not rent spillovers in the sense of Griliches, even though they themselves call them rent externalities. Rather, they are economies that allow co-located firms to access traded inputs and labour at lower cost than rivals elsewhere (2001b: 979); i.e. they pertain to Marshall's classic static economies of specialisation (specialised suppliers) and labour market economies (pool of labour with specialised skills), which are represented in the top left cell of our Table 2.1.[4] Thus, we conclude that Breschi and Lissoni feature prominently in the top left side of Table 2.1, in addition to the bottom right-hand side.

A number of writers have taken a less extreme position in the LKS debate, particularly people working within the 'New Industrial Geography' (NIG) stream of research. The term NIG has been coined by Martin and Sunley (1996) to denote a large and heterogeneous body of literature in which innovation dynamics of regional agglomerations are studied from non-mainstream economic, geographical and institutional–sociological points of view. Influential case studies focus on US high-tech clusters such as Silicon Valley and Boston's Route 128 (for example, Saxenian, 1994; Dorfman, 1983); Italian industrial districts (for example, Piore and Sabel, 1984; Best, 1990), and more generally, a number of 'innovative milieux' (Maillat, 1995), and 'regional innovation systems' (Braczyk *et al.*, 1998).

Martin and Sunley (1996) highlight the driving forces of innovation in the NIG research. LKS are listed as important. Again, these are conceptualised as pure knowledge spillovers. Rent spillovers are not considered explicitly. However, static Marshallian advantages like transaction costs, specialised suppliers and economies of scope are identified. From Breschi and Malerba's (2001) summary of the main features of NIG approaches (pp. 819–20), the importance of both pure LKS and static pecuniary advantages is also evident.

In an overview of important contributions to the industrial district literature, Keeble and Wilkinson (1999) point out that older studies in this line (for instance, Piore and Sabel) still seem to be highly inspired by Marshall's view, in which both pecuniary advantages associated with specialisation and technology spillovers (i.e. pure knowledge spillovers) play a role in explaining cluster growth. In the course of the 1990s there is more prominence of the latter. This has to do with a shift towards innovation and learning (away from economic growth in general) as a basis for cluster competitiveness, and an increasing focus on high-tech clusters. The increased emphasis on knowledge accumulation also explains increased attention for 'institutional thickness' as a precondition for competitiveness. Social institutions such as trust are seen to be highly important for the effective transfer and inter-firm flow of tacit knowledge. At the same time, static cost advantages don't entirely disappear from view (see, for example, Capello, 1999). On the whole, however, one should be careful not to infer too much about the operation of the different mechanisms from the NIG studies. There is a clear risk that one might ascribe a meaning which was not intended by the authors. At the same time it is sufficiently clear that the NIG studies as a group can be positioned in both the top left and bottom right cells of Table 2.1.

Recapitulating the discussion, our first impression gained from the debate that LKS have been commonly conceived as pure (real) knowledge spillovers. This idea that knowledge spillovers may also embody rent elements has not been explicitly considered. Secondly, LKS (interpreted in the above sense) recently appear to have gained ascendance in academic discourse *vis-à-vis* pecuniary externalities as drivers of co-location of innovative activities. Thirdly, the conception of these pecuniary externalities has been confined to static Marshallian economies.

Thus, after clearing away the terminological confusion in the debate, we are left with the conclusion that rent spillovers have not played a role of importance in the debate at all. All contributions to the debate reviewed by us can either be placed in the bottom right part of our table, and/or in the top left, while the bottom left cell is left empty (see Table 2.2 for a summary of the positions in the LKS debate). We conclude that the LKS debate has essentially revolved around the relative importance of pure LKS versus static pecuniary economies.

On the basis of our typology of externalities, we already perceived one important shortcoming in the debate so far, which relates to the obvious neglect of rent spillovers as a possibly important driver of innovativeness in industrial agglomerations. Indeed, why should it not be possible for LKS to include rent (product-embodied) elements, alongside real (people-embodied or disembodied) knowledge inputs?

However, our typology can only take us so far. In particular, it does not help us to assess how the various market failures that could conceivably enhance innovative performance of agglomerations actually affect the innovation and learning processes of the individual actors that make up these industrial clusters. This is the question which we will tackle in the remainder of this paper, through further theorising on the subject. We believe that this will yield further new insights that can advance the debate because, as argued earlier, the existing approaches in the debate have adopted a partial (regional) theoretical perspective. Even where some authors have extended into the domain of micro-economic behaviour, the knowledge accumulation processes going on within these actors remain obscure. Hence, a better grip on the micro-economic innovation and

Table 2.2 Positions of the chief contributions in the LKS debate

	Pecuniary	*Real*
Static	*External economies of scale, scope and transaction* • Breschi and Lissoni (2001a, 2001b) • New Industrial Geography studies, e.g. Markusen (1996), Keeble and Wilkinson (1999), Capello (1999)	*Unpriced external effects unrelated to technological change* • Not relevant to the LKS debate
Dynamic	*Rent spillovers* • Not explicitly considered in the LKS debate	*Pure knowledge spillovers* • Malmberg and Maskell (2002) • Economic Geography studies, e.g. Audretsch and Feldman (1996b), Jaffe *et al.* (1993), Feldman (1994) • Breschi and Lissoni (2001a, 2001b) • New Industrial Geography studies, e.g. Markusen (1996), Keeble and Wilkinson (1999), Capello (1999)

learning processes is expected to offer important new insights into the driving forces of regional dynamism. In turn, this can help to put the existing LKS debate into a broader perspective. In the next section, therefore, we proceed to elaborate a framework which puts the innovating firm centre stage.

Opening the black box: the firm-level underpinnings of innovative regions

In this section we delve into the micro-economic processes that underlie regional innovative performance. We do this by investigating the different advantages which clusters generate for innovation at the firm level. Increased innovation and learning at the firm level in turn enhances regional performance.

We use key insights from evolutionary theory to conceptualise firm behaviour.[5] The leading contributions in this literature concur that firms' economic performance is the consequence of a continuous learning process. The basis for this learning process are a firm's resources – a stock of human skills and knowledge, physical assets, and organisational routines. Routines are defined by Nelson and Winter '. . . as a set of ways of doing things and ways of determining what to do', which are built into organisations at any one time (1982: 400). Routines have the function of co-ordinating the other resources of the firm in particular ways, leading to their productive utilisation (Dosi *et al.*, 2000: 5). The economic environment generates continuous pressures on firms to subject their routines to evaluation, to ensure that the firm's competitive position is maintained.

Routines change in response to organisational search (Nelson and Winter, 1982; Radner, 1986), which involves intentional activities to improve routines for better economic performance. These activities commonly include R&D but also related activities such as training and more practical shop floor-based experimentation and improvement. Nelson and Winter use the term search '. . . to denote all those organizational activities which are associated with the evaluation of current routines and which may lead to their modification, to more drastic change, and to their replacement' (1982: 400).[6] This process of involvement in the selection of routines by firms is commonly referred to as learning. Learning is commonly a step-by-step process, involving sequential incremental de-bottlenecking interspersed with the occasional radical breakthrough. In this way, firms accumulate so-called capabilities, bundles of related routines governing the exploitation of their resources. According to Javidan (1998), the distinctive characteristic of capabilities is that they are functionally based, i.e. resident in a particular function. Examples are marketing capabilities, production capabilities, and human resource management capabilities. Capabilities that are cross-functionally integrated and co-ordinated are denoted as competencies (Ibid.).[7] Competencies express what a firm is able to do well (Prahalad and Hamel, 1990). A subset of such competencies are the basis for a firm's unique competitive advantage at a given point in time. These distinctive competencies are called *core* competencies. They encompass what the firm is able to do better than others (Lawson and Lorenz, 1999: 306). The ability to adapt core competencies quickly to changing opportunities is what ultimately drives competitiveness over time. In the words of Prahalad and Hamel, 'In the long run, competitiveness derives from an ability to build, at lower cost and more speedily than competitors, the core competencies that spawn unanticipated products' (1990: 81). Teece *et al.* (1997) refer to this ability as the *dynamic capabilities* of a firm (p. 516).

The key question is now, in which ways the acquisition of these capabilities at the level of the individual firm could be enhanced by co-location in a regional industrial agglomeration through the operation of the various externalities identified earlier. In order to address the issue, we have to examine how these externalities may impinge on the processes by which a firm modifies its organisational routines, in other words in the course of undertaking organisational search. It is at this basic point in the capability building process that external knowledge inputs play a crucial role alongside internally generated knowledge.

We discuss the linkages between agglomeration advantages and firm-level learning mechanisms with the help of Table 2.3, which has the same layout as the

Table 2.3 Effects on firm-level organisational search from externalities in regions

	Pecuniary	*Real*
Static	*External economies of scale, scope and transaction* Spontaneous effects: • Large local market gives rise to critical minimum demand for better products and processes, which induces more organisational search. • Presence of specialised suppliers and labour pool lowers transaction costs, which facilitates easy and cheap access to specialised knowledge inputs into the organisational search process. Induced effects: • Low transaction costs facilitate collaboration in innovation projects, lowering costs of organisational search. • Low transaction costs enable the collaborative realisation of lumpy innovation projects, giving rise to additional organisational search in the collaborating firms.	*Unpriced external effects unrelated to technological change* Not relevant
Dynamic	*Rent spillovers* • Presence of specialised equipment suppliers facilitates real LKS through iterative user–producer interactions. This gives rise to equipment innovations especially suited to needs of local users, resulting in a more favourable price–quality ratio for these users.	*Pure knowledge spillovers* • Higher probability that search will lead to improvement of routines, due to the ease with which information can be picked up in the local environment.

previous two tables. In each cell we list mechanism(s) through which the relevant externality is likely to influence a firm's organisational search and (consequently) its learning processes and the emergence of more advanced technological capabilities. These mechanisms have been distilled from various studies about regional development and innovation in advanced and less developed economies. The mechanisms are discussed in clockwise fashion, starting with the top left cell.

Static pecuniary externalities operating in clusters may affect firms' organisational search processes in various ways. Some of these occur entirely spontaneously in the sense that no collaborative activities are needed on the part of the actors in a cluster in order to bring them about. A first important mechanism that comes under this heading is the phenomenon that clusters can generate a critical minimum demand for new, specialised products or services that cannot be produced profitably elsewhere (Stewart and Ghani, 1991). This will stimulate organisational search within specialised supplier firms, leading to new and improved routines and capabilities needed to bring about these innovations successfully. A second important spontaneous link between static pecuniary advantages and organisational search runs through the local presence of suppliers of specialised inputs (including labour) who are attracted by large local demand. Their presence may lower transaction costs associated with procurement of specialised inputs, for example, costs associated with finding skilled workers, technical consultants, institutions providing training courses, government extension services, and suppliers of specialised machinery, materials and components. While Marshall discussed such cost-reducing effects primarily with reference to *production* activities, one may expect a similar effect on *knowledge accumulation* activities, which are the main focus of this paper. In this way, a cluster environment could be expected to reduce costs of specialised knowledge inputs in firms' organisational search for improvement.

Purposive activities by firms may lead to the capturing of additional pecuniary externalities over and above the spontaneous effects listed above, with further positive effects on firms' organisational search. In contrast to the spontaneous effects discussed above, these induced effects require inter-actor collaboration. One important mechanism is that clusters offer possibilities for firms to join networks of innovators because of low transaction costs associated with local interaction (Freeman, 1991; DeBresson and Amesse, 1991). This leads to cost advantages from sharing costs and risks associated with firms' knowledge accumulation activities, lowering the costs of their organisational search. A second mechanism involves inducement of *more* organisational search as a result of pooling resources. This happens because clusters make it feasible for firms to embark on large, costly innovation projects that are beyond the capacity of individual investors (Baptista, 1998).

The content of the lower right cell in Table 2.3 indicates how a firm's own learning process may be complemented by pure knowledge spillovers from other local parties, thereby increasing the efficiency of its search process. It has been widely noted that the implementation of knowledge from outside the firm increases the chances of that firm's success (Nelson, 1993; Feldman, 1994; Von Hippel, 1988; Baptista, 1998). Firms might benefit from complementarity and synergy effects that arise from the knowledge accumulation processes of other firms in the cluster. Investments in innovation and learning, therefore, can be expected to yield a higher pay-off in clustered firms than in firms located elsewhere. Free knowledge inputs are more easily observed and absorbed from the local environment than from afar.

Underlying the idea behind this mechanism are essential features of evolutionary theory, namely bounded rationality and heterogeneity (Simon, 1986). Economic agents have imperfect knowledge and have a selective perception of their environment. Moreover, each actor is different from others in its behavioural routines and knowledge base. This provides the basis for knowledge spillovers across firms.

Feldman (1994) has provided the theoretical arguments why knowledge spillovers could be expected to be facilitated by short geographical distances across the actors, using Dosi's five stylised facts of the innovative process.[8] Complexity and uncertainty associated with innovation can be expected to be more easily dealt with due to ease of personal communication. Reliance on basic research could be facilitated through face-to-face interaction with university scientists, so that basic scientific research is translated more easily into practical applied knowledge. Possibilities for learning-by-doing are expected to be greater because of direct contact with customers and suppliers, which makes it easier to share new knowledge which is still highly tacit. Finally, clusters are seen to function as a storehouse of accumulated capabilities in particular innovation areas, which promotes the generation of new innovations.

Finally, with the benefit of insights into firm-level search and learning processes, we can now construct a plausible argument why rent spillovers could also be expected to contribute to economic dynamism of agglomerations (bottom left cell). Most likely, rent spillovers constitute indirect agglomeration effects, which require other types of externalities in order to come about. First, agglomeration induces local establishment of specialised technology suppliers (a static pecuniary effect), which in turn facilitates iterative user–producer interactions frequently needed to clear bottlenecks and address specific user requirements that crop up in the course of innovation processes (resulting in pure knowledge spillovers). These processes will subsequently lead to rent spillovers when the results of local ongoing interaction ultimately become embodied in more appropriate and better-quality machinery and equipment for user firms. Indeed, it is common for some of the economic surplus resulting from such improvements to spill over to technology users (Geroski, 1995).[9] This process underlies the earlier-quoted phenomenon observed in the studies mentioned by Gertler (1993), that companies located close to their machinery suppliers register higher machine productivity than companies whose suppliers are located far away.

In conclusion, by joining up key theoretical insights from regional innovation literature with core principles from the evolutionary theory of the firm, it is possible to distil a comprehensive framework which maps out a range of mechanisms through which externalities occurring in regional agglomerations could enhance economic growth. Some of these mechanisms operate by furnishing cost advantages to firm-level knowledge accumulation. Others run through pure knowledge spillovers that enhance the effectiveness of firms' knowledge accumulation processes; while a third mechanism (which rides piggy-back on the other two) involves rent spillovers. Our integrated micro–meso framework thus provides a broader perspective than the frameworks based on the regional ('meso') level of analysis alone. The framework suggests that there is indeed considerable scope for confusion concerning the sources of regional growth differentials shown by empirical data. Not only is it possible that some of the patterns observed in EG studies may have been wrongly ascribed to pure knowledge spillovers while they might actually constitute static pecuniary externalities (i.e. Breschi and Lissoni's argument); but one should also be aware of possible misinterpretation of empirical patterns on account of dynamic pecuniary externalities that might occur alongside pure (real) knowledge externalities.

We will now revisit the most important individual contributions to the LKS debate, re-examining the validity of their arguments and conclusions in the light of our framework.

Revisiting the debate with our framework

Using the broader analytical lens which our framework affords, we discuss key contributions to the debate anew. We start with the pro-LKS contributions. It was already noted above that Malmberg and Maskell's 'knowledge-based theory of clustering' is based solely on the pure LKS mechanism, which primarily affects knowledge creation through facilitation of the learning process. These authors do not explicitly consider the additional possibility of any pecuniary externalities affecting learning and innovation in clusters, either of the static or the dynamic variety.

From the perspective of our framework presented above ('Opening the black box'), Malmberg and Maskell's position can be traced to a failure to fully conceptualise intra-firm learning. Although they recognise the importance of firm-level processes in their paper, they do not actually probe the nature and operation of these processes. Thereby they miss out on an important insight, namely that intra-firm creation of new knowledge is driven substantially by organisational search, which is set in motion through purposive investments. Therefore they fail to see that clustering of firms may reduce the costs and risks of such investment (as shown in the top left cell of Table 2.3), which could increase the attractiveness of undertaking these investments. These static economies, then, are another important factor through which technological learning can be speeded up, and innovation can be increased, in addition to the learning-facilitating effects induced by real LKS. Moreover, by not using firm-level theoretical insights that learning processes can be stimulated by external interaction, they also miss out on possible additional rent benefits accruing from these exchanges, in the form of better price–quality ratios of capital goods used in production. Thus, with the benefit of our framework, Malmberg and Maskell's position in the debate seems untenable. Their discussion about the role of LKS is pertinent, but their contribution falls short of developing a comprehensive knowledge-based theory of spatial clustering.

The EG contributions suffer from a similar kind of problem, which was already signalled by Breschi and Lissoni (2001a). Their aim was to find support for the existence of pure LKS as a driving force of agglomeration in innovative activity (although not explicitly denying the existence of pecuniary elements in these spillovers). From this analytical point of departure they set out to develop ways to measure LKS, and collect empirical support for the existence of LKS. It now becomes clear that this analytical lens could have led them to ascribe too much of their empirical findings to pure LKS, overlooking additional innovation-enhancing effects arising from various pecuniary externalities, both static and dynamic. The advantage of our micro–meso framework is that it highlights a comprehensive range of innovation-enhancing mechanisms that could operate in regional clusters, and thereby raises awareness of the possibility that there may be mechanisms other than pure LKS at play. It thus contributes to maintain a balanced assessment of regional innovation patterns observed in empirical research.

Moving to the anti-LKS contributions, our framework leads us to concur with Breschi and Lissoni's contention that pecuniary advantages could be important drivers of innovation in clusters along with pure knowledge spillovers. However, we do not see any reason to limit the conceptualisation of LKS to pure public goods, the way Breschi and Lissoni have done. Their argument that scholars may have ascribed localisation effects from Marshallian economies of scale, scope and transaction erroneously to LKS remains valid even when adopting a broader concept of dynamic externalities which allows for rent spillovers along with pure real knowledge flows.

However, our framework also allows an alternative way of looking at Breschi and Lissoni's work, one which is compatible with their strict public goods definition of knowledge spillovers. In this alternative interpretation, on the other hand, Breschi and Lissoni's static conception of *pecuniary* externalities is unduly narrow. There is no reason why dynamic pecuniary externalities (rent spillovers) could not play a role as well. In sum, irrespective of which of the two interpretations one prefers to follow, the conclusion is the same, namely that Breschi and Lissoni have missed out on the possible impact of dynamic pecuniary externalities (rent spillovers) on learning and innovation in regions.

The range of intermediate positions taken up by NIG researchers in the debate seem to be broadly compatible with the results of our framework, except that rent spillovers are again missing. Moreover, contributions in this field tend to highlight just one or two mechanisms, while our Table 2.3 lists a whole range of them. Individual NIG researchers also differ on what those precise mechanisms should be. Thus, NIG contributors tend to adopt a partial view of the ways by which agglomerations could conceivably give an impetus for learning. Again, this can be traced to the absence of an analytical perspective, in the NIG research, on how firms actually accumulate new knowledge. This prevents them from systematically analysing the different forces in operation.

It now also becomes apparent that our assessment of the NIG position in the debate differs markedly from that of Breschi and Lissoni. The latter have suggested that the NIG body of research essentially supports the pro-LKS view. In their words, '. . . NIGs accept, and often openly propose LKS as a very important agglomeration force. Indeed, many research efforts within NIG are placed upon explaining how and why knowledge spillovers are extremely likely to be highly localised' (Breschi and Lissoni, 2001a: 264). They motivate this observation with reference to the fact that NIG studies give great importance to tacit knowledge, trust, social networks, etc., which are believed to be important in agglomerations. According to Breschi and Lissoni, this would implicitly indicate that local knowledge diffusion (i.e. pure LKS) is considered important in the NIG literature about clusters. In particular, they argue that this is indirectly evident in the insistence, by the NIG researchers, on a number of preconditions necessary for knowledge to diffuse effectively in a local environment – for example, the existence of local institutions and culture-promoting mutual trust, entrepreneurship, and possibly a sense of belonging to the local community of people and firms.

A rather different interpretation of the NIG position emerges when we bring our Table 2.3 to bear on the NIG literature. The NIG researchers emphasise that a local milieu is a good basis for *co-operation* (e.g. Storper, 1992; Braczyk *et al.* 1998; Maillat, 1995; Schmitz and Nadvi, 1999). Such co-operation may indeed facilitate pure knowledge spillovers. However, it may also provide possibilities for sharing costs and risks of R&D and overcoming 'lumpiness' problems in large R&D investment projects, all of which may promote investments in R&D and (hence) firm-level search and learning. It may also promote ongoing user–producer exchanges leading to innovation rents for technology users. Since all these mechanisms are associated with pecuniary externalities, Breschi and Lissoni's attempts to rope NIG squarely into the pro-LKS camp appear to be a bit rash.

We conclude that all contributions to the debate so far appear to have missed out on something or other. When we supplement regional innovation theory with a micro-economic theoretical underpinning, these conceptual problems and measurement issues come to the surface. After analysing them in the light of our framework, it appears that there remains little theoretical ground for the LKS debate. There is no *a priori* theoretical reason to exclude either pecuniary advantages or pure (real) knowledge spillovers as drivers of innovation in regional clusters. (Nor, if we want to take an alternative perspective, would there be any reason to exclude either static externalities or dynamic spillovers.) Thus, the opposing views can be reconciled on the theoretical level. Now, empirical research is needed to shed light on the relative importance of the various mechanisms in different settings. Some preliminary suggestions in this direction are given in the next section.

Conclusions and implications for further research

After reviewing the discussion about LKS in the literature so far, one cannot escape the impression that stepping outside the confines of regional-level analysis is a fruitful way of taking the debate forward. In this paper, this has been achieved by inserting new insights from the evolutionary theory of the firm. In this fashion it became possible to systematically derive a typology of different mechanisms through which regional agglomeration may stimulate learning and innovation. When this typology was brought to bear on the extant approaches in the debate, the limitations of the arguments advanced by both sides came clearly into view, and it became evident that little theoretical ground for the LKS debate remains.

More generally, the exercise conducted in the paper illustrates how the adoption of a particular theoretical perspective may influence one's focus of analysis, definition of concepts and approaches, and one's interpretation of empirical findings. By broadening the analytical lens, we obtain a more complete view of regional learning and innovation dynamics which makes us aware of factors that were overlooked in earlier research, which could in turn give a new impetus for empirical work. As Myrdal argued, theoretical analysis can never be value-free, but the point is that we have to strive to be conscious of this fact, so that possible biases arising from the choice of a particular perspective are brought out into the open. 'The only way in which we can strive for objectivity in theoretical analysis is to lift up the valuations into full light, making them conscious and explicit, and permit them to determine the viewpoints, the approaches, and the concepts used' (Myrdal, 1968: 33). Deliberately shifting one's analytical point of view is a good way of achieving this. Applying this general principle to the subject matter at hand, we are led to received theory which provides valid arguments leading to the conclusion that all kinds of externalities may be important for innovation in clusters in principle. Needless to say, our own exercise is also still a limited one, and extensions in other directions may show yet new insights. Still, we believe that we have taken a step towards a comprehensive knowledge-based theory of innovation in regions.

On the basis of the theories explored in our paper, we concur with Breschi and Lissoni's observation that extant LKS research appears to have accepted (pure) knowledge spillovers too readily as the universal driving force of regional innovativeness and growth. The significance of this conclusion lies in the risk of unduly narrowing the scope of research about the role of geographical proximity in the generation and diffusion of new knowledge, which may give rise to naïve policy suggestions (Breschi and Lissoni, 2001b: 976–77).

Different types of market failures call for different types of policies. In this connection it is especially important to distinguish between (pure and rent) spillovers on the one hand, and static pecuniary economies on the other hand. If spillovers would be the chief mechanism operating in clusters, we are facing a situation in which market forces lead to sub-optimal social outcomes due to private under-investment in innovation and learning. Common public interventions to counteract such undesirable effects from these externalities would need to include public subsidies for R&D, education and training; and public investments in R&D to complement private-sector innovation efforts. Such policies are not called for in situations where static pecuniary economies are the dominant form of market failure. In this case, divergence between private and public interests is not the issue (Scitovsky, 1954), since static pecuniary economies work through the market mechanism. In this situation, it would make more sense for public policy to aim primarily at facilitating and inducing research networking and collaboration, as indicated in our Table 2.3.

A vivid example of (pure) LKS taken too far is given in Audretsch and Feldman's (1996a) discussion about the expected relationship between the industry life cycle and the tendency of innovative activities to agglomerate. The essence of their argument is that agglomeration tendencies will tend to be relatively stronger in early stages of the industry life cycle than in more mature stages, because tacit knowledge plays a more important role in the early phases of the innovation process when a dominant product standard has not yet emerged and user needs are poorly articulated. The essential agglomeration force in their analysis lies in the ease with which tacit knowledge can be transmitted locally. Thus they conclude that '. . . the propensity for innovative activity to geographically cluster would be expected to . . . decline as the industry evolves over the life cycle towards maturity' (1996a: 259). Bearing in mind our framework, this conclusion disregards the possibility that other types of agglomeration advantages could become more prominent in later stages of the industry life cycle. Insights pointing towards the likely occurrence of this pattern can be inferred from Abernathy's work. Exploring how the sources of competitive advantage evolve as industries mature, he pointed out that over time industries tend to evolve away from radical product innovation characterised by high uncertainty and high tacit knowledge, towards incremental cost-reducing innovation centred around a dominant product design (Abernathy, 1978). In other words, agglomeration tendencies may not necessarily decrease as an industry matures, but rather the specific nature of innovation-inducing mechanisms may change in favour of mechanisms instrumental in reducing costs. In particular, economies of scale, scope and transaction are likely to deepen at this stage, when the industry's market is well developed and a wide range of specialised suppliers has become established. Possibly, incremental user–producer interactions aimed at cost-reduction in production (associated with rent spillovers rather than pure knowledge spillovers) is also likely to become more important at this stage.

Another reason to doubt the universality of (pure) LKS as the innovation and learning-enhancing force lies in the inherent variations in the sectoral patterns of technological change exhibited by different types of industries (Pavitt, 1984). For example, pure knowledge (but also rent) spillovers could be expected to assume special importance in specialised supplier-industries (such as machinery and instruments) because of the importance of product design and product development. Innovations tend to be developed in interaction with users where face-to-face exchange facilitates tacit knowledge transmission. On the other hand, static pecuniary economies could be expected to play a particularly significant role in supplier-dominated industries (such as traditional manufacturing sectors), since their product users are price sensitive and cost cutting is important.

Our concluding observations are still tentative, but they suggest considerable need for further research to disentangle the drivers of innovation and learning in agglomerations in practice. Unless we get a better grip on the specific agglomeration mechanisms inducing innovation and learning in specific situations, it will be hard to come up with credible and detailed guidelines for regional innovation policy.

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Notes

1 A useful review of these and similar approaches is contained in MacKinnon *et al.* (2002). A comprehensive overview of studies that have addressed the relationship between regional clusters and knowledge in various ways can be found in Morosini (2004).

2 A first attempt in our direction has been made by Bathelt *et al.* (2004). After a brief excursion into intra-firm learning processes, they distinguish two different mechanisms through which these processes can be influenced by co-location. One mechanism relies on the working of economies of scale and scope and other kinds of traded interdependencies, and the other on untraded interdependencies (knowledge spillovers). The classification developed in our paper is more detailed and more systematic.

3 According to Malmberg and Maskell (2002), the agglomeration advantages which have been traditionally distinguished are all of the static pecuniary type. They include: (1) reduced costs for producing and maintaining a dedicated infrastructure and other collective resources; (2) well-functioning markets for specialised skills; (3) reduced interaction costs for co-located trading partners.

4 At first sight it would appear as if the *New* Economic Geography (NEG) approach (not to be confused with the EG approach discussed above) also belongs in the anti-LKS camp. Krugman, the most prominent exponent of this approach, has repeatedly voiced his scepticism of the localness of knowledge spillovers. In Krugman (1991), he argues that cluster dynamism is chiefly driven by traditional Marshallian cost advantages such as a large labour pool and specialised suppliers. Similarly, Ottaviano and Puga's (1998) survey of NEG literature features a number of models in which regional dynamism is explained solely in terms of cumulative causation and forward and backward linkages, combined with increasing returns (i.e. various pecuniary advantages), while LKS do not feature at all. On closer inspection, however, these NEG writers fall outside the debate, as they are not concerned with explaining regional agglomeration of *innovation*, but with regional agglomeration of *economic activity* in general. Naturally, the role of LKS would feature comparatively less prominently in their work than in that of the EG writers for that reason alone.

5 The interpretation of the essential features of evolutionary theory offered here is based on insights from a number of leading contributions in the field. However, it should be noted that individual writers in this line of research differ considerably in the terminology they use. This has given rise to much confusion and internal inconsistencies. In addition, relationships between concepts are often left imprecise and implicit (for a discussion of some of these problems, see the introductory chapter in Dosi *et al.* (2000)). The purpose of this paper is merely to develop a workable framework in which the essential features of evolutionary thinking are reflected

adequately, without going into the ins and outs of these conceptual and terminological problems.

6 In addition to organisational search, serendipity is sometimes mentioned as a mechanism of organisational learning (e.g. Cohendet *et al.* (1998)). Cyert and March typify this trial and error mechanism as follows: 'Any decision rule that leads to a preferred state at one point is more likely to be used in the future than it was in the past; any decision rule that leads to a non-preferred state at one point is less likely to be used in the future than it was in the past' (1963: 99). However, we do not consider serendipity in this paper, since its contribution to learning is limited in comparison with organisational search. As Bell (1984) observed, effortless learning-by-doing by itself will soon exhaust a firm's learning possibilities. In order to progress significantly, purposive investments in organisational search are required.

7 Although there are other authors who use the concepts of capability and competency interchangeably (e.g. Lawson and Lorenz, 1999).

8 We use Feldman's contribution merely to make it clear that the occurrence of LKS is theoretically plausible. However, one should not conclude from this that we follow the EG point of view in the LKS debate. The five stylised facts do not imply anything about the relative importance of LKS versus pecuniary advantages in agglomerations.

9 However, Geroski (1995) argues that at least part of this surplus is likely to be a reward for efforts made by the users in the course of the iterative innovation development process. To the extent that this is the case, these effects do not constitute externalities.

References

Abernathy, W.J. (1978) 'A general model: Innovation and process change in a productive unit', in: W.J. Abernathy, *The Productivity Dilemma. The Roadblock to Innovation in the Automobile Industry*. Baltimore, Johns Hopkins University Press, 68–85.

Andersson, M. and O. Ejermo (2002) 'Knowledge production in Swedish functional regions 1993–1999', paper presented at the Ljungby workshop on Knowledge Spillovers and Knowledge Management in Industrial Clusters and Industrial Networks, 19–21 September.

Arrow, K.J. (1962) 'Economic welfare and the allocation of resources for invention', in: *The Rate and Direction of Inventive Activity: Economic and Social Factors*, NBER Special Conference Series vol. 13. Princeton, NJ, Princeton University, 609–25.

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.

Audretsch, D.B. and M.P. Feldman (1996a) 'Innovative clusters and the industry life cycle', *Review of Industrial Organization*, 11 (2), 253–73.

Audretsch, D.B. and M.P. Feldman (1996b) 'R&D spillovers and the geography of innovation and production', *American Economic Review*, 86 (3), 630–52.

Baptista, R. (1998) 'Clusters, innovation and growth: A survey of the literature', in: G.M.P. Swann, M. Prevenzer and D. Stout (Eds) *The Dynamics of Industrial Clusters: International Comparisons in Computing and Biotechnology*. Oxford, Oxford University Press, 13–51.

Baptista, R. and P. Swann (1998) 'Do firms in clusters innovate more?', *Research Policy*, 27 (5), 525–40.

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.

Bator, F.M. (1979) 'The anatomy of market failure', in: E. Mansfield (Ed.) *Microeconomics. Selected Readings* (3rd Edition). London, W.W. Norton and Co., 425–50.

Bell, R.M (1984) ' "Learning" and the accumulation of industrial technological capability in developing countries', in: M. Fransman and K. King (Eds) *Technological Capability in the Third World*. London, Macmillan, 187–209.

Best, M.H. (1990) *The New Competition. Institutions of Industrial Restructuring*. Cambridge, Polity Press.

Braczyk, H., P. Cooke and M. Heidenreich (Eds) (1998) *Regional Innovation Systems*. London, UCL Press.

Breschi, S. and F. Lissoni (2001a) 'Localised knowledge spillovers versus innovative milieux: Knowledge "tacitness" reconsidered', *Papers in Regional Science*, 80, 255–73.

Breschi, S. and F. Lissoni (2001b) 'Knowledge spillovers and local innovation systems: a critical survey', *Industrial and Corporate Change*, 10 (4), 975–1005.

Breschi, S. and F. Malerba (2001) 'The geography of innovation and economic clustering: some introductory notes', *Industrial and Corporate Change*, 10 (4), 817–33.

Caniëls, M.C.J. and H.A. Romijn (2005) 'What drives innovativeness in industrial clusters? Transcending the debate', *Cambridge Journal of Economics*, 29 (4), 497–515.

Carlaw, K.I. and R.G. Lipsey (2002) 'Externalities, technological complementarities and sustained economic growth', *Research Policy*, 31 (8–9), 1305–15.

Capello, R. (1999) 'Spatial transfer of knowledge in high technology milieux: Learning versus collective learning processes', *Regional Studies*, 33 (4), 353–65.

Cohendet, P., P. Llerena and L. Marengo (1998) 'Theory of the firm in an evolutionary perspective: A critical assessment', paper presented at the 2nd Annual Conference of the International Society for New Institutional Economics, Paris, 18–19 September.

Cooke, P. (2004) 'The role of research in regional innovation systems: New models meeting knowledge economy demands', *International Journal of Technology Management*, 8 (3/4/5/6), 507–33.

Cooke, P. (2001), 'Regional innovation systems, clusters, and the knowledge economy', *Industrial and Corporate Change*, 10 (4), 945–73.

Cyert, R.M. and J.G. March (1963) *A Behavioural Theory of the Firm*. Englewood Cliffs, NJ, Prentice-Hall.

DeBresson, C. and F. Amesse (1991) 'Networks of innovators: A review and introduction to the issue', *Research Policy*, 20, 363–79.

Dorfman, N. (1983) 'Route 128: The development of a regional high-technology economy', *Research Policy*, 12, 299–316.

Dosi, G., R.R. Nelson and S.G. Winter (Eds) (2000) *The Nature and Dynamics of Organizational Capabilities*. Oxford, Oxford University Press.

Isaksen, A. (2001) 'Building regional innovation systems: Is endogenous industrial development possible in the global economy?', *Canadian Journal of Regional Science*, 24 (1), 101–20.

Jaffe, A.B. (1996) *Economic Analysis of Research Spillovers. Implications for the Advanced Technology Program*. Gaithersburg, MD, National Institute of Standards and Technology.

Jaffe, A., M. Trajtenberg and R. Henderson (1993) 'Geographic localization of knowledge spillovers as evidenced by patent citations', *The Quarterly Journal of Economics*, 108 (3), 577–98.

Javidan, M. (1998) 'Core competence: What does it mean in practice?', *Long Range Planning*, 31 (1), 60–71.

Feldman, M.P. (1994) *The Geography of Innovation*. Boston, Kluwer.

Freeman, C. (1991) 'Networks of innovators: A synthesis of research issues', *Research Policy*, 20 (5), 499–514.

Geroski, P.A. (1995) 'Do spillovers undermine the incentive to innovate?', in: S. Dowrick (Ed.) *Economic Approaches to Innovation*. Aldershot, Edward Elgar, 76–97.

Gertler, M.S. (1993) 'Implementing advanced manufacturing technologies in mature industrial regions: Towards a social model of technology production', *Regional Studies*, 27 (7), 665–80.

Glaeser, E., H. Kallal, J. Scheinkman and A. Shleifer (1992) 'Growth in cities', *Journal of Political Economy*, 100 (4), 1126–52.

Griliches, Z. (1992) 'The search for R&D spillovers', *Scandinavian Journal of Economics*, 94, Supplement, S29–S47.

Griliches, Z. (1979) 'Issues in assessing the contribution of research and development to productivity growth', *The Bell Journal of Economics*, 10 (1), 92–116.

Henry, N. and S. Pinch (2000) 'Spatialising knowledge: placing the knowledge community of Motor Sport Valley', *Geoforum*, 31 (2), 191–208.

Keeble, D. and F. Wilkinson (1999) 'Collective learning and knowledge development in the evolution of regional clusters of high technology SMEs in Europe', *Regional Studies*, 33 (4), 295–303.

Krugman, P. (1991) *Geography and Trade*. Cambridge, MA, MIT Press.

Lawson, C. and E. Lorenz (1999) 'Collective learning, tacit knowledge and regional innovative capacity', *Regional Studies*, 33 (4), 305–17.

MacKinnon, D., A. Cumbers and K. Chapman (2002) 'Learning, innovation and regional development: A critical appraisal of recent debates', *Progress in Human Geography*, 26 (3), 293–311.

Maillat, D. (1995) 'Territorial dynamic, innovative milieus and regional policy', *Entrepreneurship and Regional Development*, 7 (2), 157–65.

Malmberg, A. and P. Maskell (2002) 'The elusive concept of localization economies: Towards a knowledge-based theory of spatial clustering', *Environment and Planning A*, 34, 429–49.

Markusen, A. (1996) 'Sticky places in slippery space: A typology of industrial districts', *Economic Geography*, 72 (3), 293–313.

Marshal, A. (1920) *Principles of Economics*. London, Macmillan.

Martin, R. and P. Sunley (1996) 'Paul Krugman's geographical economics and its implications for regional development theory: A critical assessment', *Economic Geography*, 72 (3), 259–92.

Maskell, P. (2001) 'The firm in economic geography', *Economic Geography*, 77 (4), 329–44.

Meade, J.E. (1952) 'External economies and diseconomies in a competitive situation', *Economic Journal*, 62, 54–67.

Morosini, P. (2004) 'Industrial clusters, knowledge integration and performance', *World Development*, 32 (2), 305–26.

Myrdal, G. (1968) 'The beam in our eyes', in: G. Myrdal, *Asian Drama – An Inquiry into the Poverty of Nations. Volume I*. New York, Pantheon, 5–35.

Nelson, R.R. (Ed.) (1993) *National Innovation Systems. A Comparative Analysis*. Oxford, Oxford University Press.

Nelson, R.R. and S.G. Winter (1982) *An Evolutionary Theory of Economic Change*. Cambridge, MA, The Belknap Press of Harvard University Press.

Ottaviano, G.I.P. and D. Puga (1998) 'Agglomeration in the global economy: A survey of the "New Economic Geography" ', *World Economy*, 21, 707–31.

Pavitt, K. (1984) 'Sectoral patterns of technical change: Towards a taxonomy and a theory', *Research Policy*, 13, 343–73.

Piore, M. and C. Sabel (1984) *The Second Industrial Divide: Possibilities for Prosperity*. New York, Macmillan.

Prahalad, C.K. and G. Hamel (1990) 'The core competence of the corporation', *Harvard Business Review*, May–June, 79–91.

Radner, R. (1986) 'The internal economy of large firms', *Economic Journal*, 96, Supplement, 1–22.

Saxenian, A. (1994) *Regional Advantage. Culture and Competition in Silicon Valley and Route 128*. Harvard, Harvard University Press.

Schmitz, H. and K. Nadvi (1999) 'Clustering and industrialization: Introduction', *World Development*, 27 (9), 1503–14.

Scitovsky, T. (1954) 'Two concepts of external economies', in: *Journal of Political Economy*, April, as reprinted in: A.N. Agarwala and S.P. Singh (Eds) (1963) *The Economics of Underdevelopment*. New York, Oxford University Press, 295–308.

Simon, H.A. (1986) 'On the behavioural and rational foundations of economic dynamics', in: R.M. Day and G. Eliasson (Eds) *The Dynamics of Market Economics*. Amsterdam, North Holland, 21–44.

Stewart, F. and E. Ghani (1991) 'How significant are externalities for development?', *World Development*, 19 (6), 569–94.

Storper, M. (1992) 'The limits to globalization: Technology districts and international trade', *Economic Geography*, 68 (1), 60–93.

Teece, D.J., G. Pisano and A. Shuen (1997) 'Dynamic capabilities and strategic management', *Strategic Management Journal*, 18 (7), 509–33.

Viner, J. (1931) 'Cost curves and supply curves', *Zeitschrift für Nationalökonomie*, 3, 23–46. (Reprinted in: American Economic Association (1953), *Readings in Price Theory*. London, Allen and Unwin.)

Von Hippel, E. (1988) *The Sources of Innovation*. New York, Oxford University Press.

Wallsten, S.J. (2001) 'An empirical test of geographic knowledge spillovers using geographic information systems and firm-level data', *Regional Science and Urban Economics*, 31 (3), 571–99.

3 Knowledge-intensive industries and regional development

The case of the software industry in Norway

Arne Isaksen

Introduction

The last few years have seen a growing interest in the spatial impact of the knowledge economy, and in particular on the location pattern of the so-called knowledge-intensive industries (Eurostat, 2002). These are seen as industries with comparatively high R&D intensity, and services that are large users of embodied technology and have comparatively many workers with higher education (OECD, 2001a) – in short, high-tech manufacturing and knowledge-intensive services. These industries seem to be much more uneven in spatial terms than the industries they are beginning to supersede (Cooke, 2002: 18), as the new industries are biased towards large cities and university towns. The skewed location pattern is explained by the fact that cluster formations have become more prominent. As scientific knowledge has become an important input factor, it is argued that clusters mostly grow up near universities and research institutions where new, scarce and often uncodified knowledge is created (pp. 130–31).

There is, however, debate about the meaning of concepts like knowledge-intensive industries. Smith (2000), for example, warns against a 'high-tech trap' in discussions of the knowledge economy, in which some industrial sectors are selected as *the* knowledge-intensive ones. Smith introduces the concept of 'a distributed knowledge base' for industries, pointing to the fact that scientific knowledge flows into firms from many sources along their value chain. Industries have significant indirect knowledge flows, and many so-called low-tech sectors are seen as important users of scientific knowledge generated elsewhere. This means that the sectors may be large users of knowledge even if the sectors have low internal R&D intensities.

This chapter deals with one of the emblematic industries of the knowledge economy, i.e. the software industry. The chapter analyses more precisely some effects of the skewed location pattern of the software industry in Norway. In addition to being a knowledge-intensive service industry as defined by OECD (2001a), the software industry is an important knowledge base for other industries. As a knowledge-intensive business service (KIBS) sector the software industry is seen to trigger innovation processes, particularly in client firms (Hertog, 2002). Software firms can be facilitators of innovations in supporting client firms in their innovation processes as specialist consultants, they can be carriers of innovation if they transfer existing innovations (like specific software solutions) from one firm or industry to another, and they can be sources of innovation if they play major roles in initiating and developing innovations in client firms.

The alleged role of software firms as facilitators of innovation means that a centralised location pattern of the software industry may have important implications for regional industrial development. A centralised location pattern means that a range of professional expertise is concentrated in some key urban centres. In a nutshell, the argument is that professional services such as R&D, design, brand creation, advertising, and upgrade packages are gaining a more pivotal role in the production process in a more complex and competitive industry (Daniels and Bryson, 2002). Firms in large cities usually have better access to nearby expertise and external advice than firms in more peripheral locations. Specialised service providers may play an important role in stimulating innovations and growth among client companies, and firms benefit in some cases from geographical proximity to professional service providers. The concentration of the software sector (and the KIBS sector in general) in large cities may then trigger innovation and growth in other industries in these cities in particular, which may lead to more uneven regional development.

The software industry is heavily biased towards the Oslo region in Norway. This chapter examines to what extent the concentration in Oslo influences the performance of software firms in Oslo *vis-à-vis* similar firms in other parts of Norway, i.e. whether traceable cluster mechanisms and cluster effects are found in Oslo. The chapter also examines to what extent the many software firms in Oslo have any effect upon the use of software consultants and software solutions by Oslo firms, and in that respect may stimulate the competitiveness of Oslo firms. The chapter shows that the software industry in Oslo constitutes a regional cluster according to some common indicators, while other parts of Norway hardly contain any software clusters. The chapter compares behaviour and performance in software firms in Oslo with similar firms in other parts of the country. Some differences exist, but they are not as pronounced as one should expect from reading the literature. The chapter also traces some triggering effects of the geographical concentration of software firms in Oslo as Oslo firms in general are adopting new ICT solutions to a larger extent than firms in other parts of the country.

The rest of the chapter comprises three main parts. The next section reviews important aspects of cluster theories and theories about KIBS that can guide us in how to analyse possible consequences of the clustering of software firms in Oslo. The third and fourth sections utilise different empirical surveys to assess whether cluster mechanisms are found to a larger extent in software firms in Oslo than in corresponding firms in other parts of Norway, and whether wider consequences are to be traced in Oslo businesses. Finally, the last section draws some broader conclusions from the study of the Oslo software industry.

Clustering of KIBS and urban industrial development

The current knowledge-based economy is, as said, seen to be highly skewed in geographical terms (Cooke, 2002: 130–131). Clusters of firms in high-tech and knowledge-intensive industries grow up in large cities, in particular. Clustering is seen to enhance further growth in knowledge-intensive industries in large cities through the stimulating business environment (Porter, 2000) created by the clustering occurring in these places. Knowledge-intensive industries are further seen to be of strategic importance in stimulating the innovativeness and competitiveness of other firms. Knowledge-intensive business services (KIBS) are in particular seen as 'innovation agents' through the sector's knowledge transfer capability and ability to co-produce innovation with clients (Hertog, 2002). The argument is further that some kinds of knowledge transfer suppose face-to-face interaction between sender and receiver (Leamer and Storper, 2001), which means that the KIBS sector may above all promote the innovativeness of other firms in large cities. This section discusses in more detail what kinds of effects a regional cluster of KIBS firms are supposed to have on the cluster firms themselves (i.e. the KIBS firms belonging to the cluster) as well as on other nearby firms. In the two following sections I then discuss to what extent the assumed effects are to be found in the Oslo software cluster.

Upgrading mechanisms in regional clusters

The crux of the cluster theory is that clusters are environments able to stimulate the productivity and innovativeness of cluster firms and the formation of new businesses (e.g. Porter, 2000; Scott and Storper, 2003). Firms belonging to working regional clusters are seen to achieve competitive strength not available for comparable firms outside clusters (Bathelt *et al.*, 2004). This kind of understanding leads, for example, for the OECD (2001b: 1) to claim that 'clusters enhance the economic performance of the enterprises within them'.

The assertion that cluster firms achieve some competitive advantages is, however, mainly based on theoretical considerations and analyses of fairly few, successful and well-known clusters. Few quantitative studies that, for example, systematically compare the development of cluster firms and equivalent firms outside clusters exist (Markusen, 1999). A European Commission report (EC, 2002) refers to studies from several European countries indicating that cluster firms on average demonstrate somewhat larger job growth, profits and productivity than firms in corresponding industrial sectors outside clusters. Further, Porter (2003) claims that the US regional industrial development is strongly influenced by the existence of clusters in export or traded industries. Traded clusters contribute to a relatively high average wage level and patenting in a region. Thus, some hints of particular cluster effects exist, but few studies seem to empirically demonstrate the alleged advantages of clusters.

What kinds of mechanisms are then seen to stimulate the innovation capability and upgrading of cluster firms? And what are the specific advantages that cluster firms may experience? The discussion of upgrading mechanisms in clusters has traditionally revolved around two main themes. The first theme involves the question whether cluster firms are mainly upgraded by means of regional or extra-regional resources (i.e. resources found outside of the geographical boundary of clusters). One viewpoint underlines that upgrading mainly takes place by way of local collaboration between firms (such as producers, component suppliers and machine builders) and with local supporting organisations. The argument is that co-located and similar firms may develop joint resources and knowledge that may promote the upgrading of several local companies. Others maintain that upgrading mainly comes about when local firms are linked to players outside of the cluster, in particular demanding clients and large corporations (Schmitz, 2004). Cluster firms are in different ways linked to global value chains often governed by multinational corporations and powerful customers. The rules of the game and possibilities of upgrading are then set by dominant global players and international quality and labour standards.

The other main subject in discussions of the upgrading of cluster firms includes whether cluster firms gain competitive strength from 'hard', economic and market related conditions or from 'soft', socio-cultural and institutional ones. The first approach underlines the importance of local rivalry (Porter, 1998), knowledge spillovers and external economies. Co-location is seen to speed up competition between firms in the same area, and the firms can easily observe and monitor each other as well as copy each other's successful solutions, which stimulate innovation activity (Malmberg and Maskell, 2002). External economies point to the fact that firms gain access to 'shared inputs' such as specialised suppliers, trained labour, etc., in a regional cluster. The cost of shared inputs is lowered as savings in production costs are passed from specialised suppliers (serving numerous local firms) to client firms. The client firms will then derive a benefit not available to similar firms in less highly localised settings (Harrison *et al.*, 1996). It is also part of the argument that cluster firms may carry out innovation processes fairly fast through their knowledge of and proximity to specialised input factors from suppliers, consultants and diverse specialists.

The other approach emphasizes the importance of socio-cultural and institutional factors for the innovation capability of cluster firms. The approach stresses firm collaboration beyond market transaction, based on factors like trust, social consensus and shared aims among local players (Amin and Thrift, 1994). Trustful collaboration is said to develop in particular when players interact repeatedly over time, which is more likely to occur when players are located in the same region and share a common history and culture (Gertler, 2004: 75–76). A closely related argument is that innovation activities stimulate regional clustering in particular if the information input includes complex uncodifiable messages, 'which require understanding and trust that historically have come from face-to-face contact' (Leamer and Storper, 2001: 641). Thus, clustering is regarded as most significant in sectors that are crucially dependent on tacit or informal knowledge, often in pre-commercialisation stages (Martin and Sunley, 2003), and clustering is of 'real importance for business competitiveness by enabling acquisition of vital new knowledge through local informal networks' (Keeble and Nachum, 2002: 79).

The two themes discussed above (i.e. regional versus extra-regional resources, and economic versus socio-cultural factors) more or less merge in the more recent focus on learning capabilities in cluster theories (e.g. Asheim, 2000; Best, 2001). This approach stresses the importance of creation and diffusion of unique knowledge in order for cluster firms to upgrade their activity. Of particular importance is the linking of cluster firms to universities, research institutes or entrepreneurial firms having considerable innovation activity. Companies can be tied to knowledge organisations all over the world, and advanced firms often try to find the best and most relevant knowledge irrespective of location, as Bathelt *et al.* (2004) maintain when underlining the importance of global pipelines for the upgrading of clusters.

This argument is contested by Cooke (2006) who maintains that the demand of (some type of) firms for proximity to sources of economically valuable knowledge has never been greater. The argument here is that much of the information needed to innovate in the new, knowledge-based sectors is seen to have important elements of tacitness and firm specificity (Acs *et al.*, 2002: 4), and is thus 'available only through access to the right persons, often few in numbers, who are working in a given problem area' (Leamer and Storper, 2001: 655). It may be particularly advantageous to locate in an innovative, regional cluster when the rate of innovation is high, as is the case in new industries according to the product life cycle theory (Lundquist, 1996). Young clusters usually include numerous firms experimenting with new products and processes, and firms can then more easily capture and adapt new ideas if located in a cluster.

KIBS and industrial development

One has to add one more element to the argument of cluster effects when studying clusters of knowledge intensive business services (KIBS) firms. The additional element relates to the assumed effect of KIBS firms on other nearby companies. KIBS firms deliver expert knowledge to be used by other companies. These expert services are seen as crucial in making industries more efficient and competitive. The sector is hence regarded as a significant source of information, consultancy services and specialised knowledge for other industries and public services. KIBS are designated as 'innovation agents' (Metcalfe and Miles, 2000) on account of their ability to stimulate innovation and transfer knowledge to clients.

The alleged increasing importance of the KIBS sector in industrial development resembles the idea of Thrift (2005) of a more knowledgeable or soft capitalism in which firms increasingly reflect on their own business. Soft capitalism is seen to be characterised by increasing production and distribution of managerial knowledge to business leaders, and to leaders in multinational firms in particular. Chief amongst the producers of 'packaged' management knowledge are business schools, management consultants (which are KIBS firms), and management gurus.

The argument goes further by maintaining that the increasing need for managerial and other knowledge-intensive services reflects specific current development trends (Roberts *et al.*, 2000). Industry is seen to be becoming more complex and more exposed to competition. To be competitive firms have to launch new products early, maintain a high quality, be able to tailor products for particular groups of customers and have an efficient organisation. With a growing demand for quick adjustments firms need access to relevant knowledge and firms' learning ability is becoming important (Lundvall and Johnson, 1994). The result is seen to be an increased need for knowledge-intensive services (Daniels and Bryson, 2002); for research and product development, organisational changes, introduction of new technology, marketing, etc. KIBS are seen to be developing increasingly into an informal 'knowledge transfer structure' (Strambach, 2001: 66) that supply clients with vital information and knowledge in their innovation process.

There are several possible geographical outcomes related to the increased use of knowledge-intensive services in innovation activity. One argument maintains that the knowledge transfer from KIBS firms is often non-routine flows with ambiguous information content that is notably adverse to extension over long distances (Scott and Storper, 2003: 582). On the other hand, KIBS firms may stimulate innovation also in companies other than their clients. New knowledge developed by KIBS firms, for example novel principles for the management of value chains or client relations, may be implemented by a number of companies. Knowledge may be manifest as information in manuals, course books and computer programs that are widely distributed. Knowledge (or what Thrift (2005) calls the new managerialist discourse) also circulates to business by the activity of business schools professors, management gurus and management consultancy.

Even if there exist much packaged management prescriptions, the view of innovation as basically interactive learning means that KIBS firms first of all can influence innovative processes at their clients. The argument here is that KIBS firms often develop services and gain new knowledge in collaboration with clients, frequently when trying to solve the clients' specific problems and challenges (Hertog, 2002). Consultancy services are thus often developed in collaboration between KIBS firms and clients, in which the provision of advanced services requires close, long-term cooperation between the participants. Software firms, for example, rely on pilot clients to inspire and provide feedback on new solutions. The quality of new software then depends on the quality of the collaborative process between the clients and the software firm. Such cooperation may initiate a two-way learning process (Wood, 2002: 5). Feedback from clients provides information leading to changes in existing, and to the development of new, services in the KIBS firms, that later on may be turned into packaged services to a broader range of clients. At the same time KIBS firms, through their provision of services, contribute to innovations in client firms.

The literature often maintains that the KIBS sector is largely concentrated in urban areas, and the sector is regarded as an essential component of the innovation system of large cities (Fischer *et al.*, 2001). The argument is then that urban businesses have better access to the expert services delivered by KIBS firms than do firms in other regions, in particular compared to those in peripheral areas. Thus, urban businesses can be more frequent users of the types of knowledge services that are most efficiently offered by close proximity than firms located in other areas. A related argument is that firms that benefit from geographical proximity to knowledge-intensive services may choose to locate in urban areas.

Based on the above considerations, an alleged increased need for non-routine knowledge intensive services in firms' innovation activity should benefit, in particular, firms in regions with a high range, availability and quality of KIBS suppliers. A high supply of KIBS in some regions could then lead to demand for even more professional services in the initially advantaged regions. The outcome is supposed to be a self-reinforcing concentration of KIBS suppliers and firms demanding good access to external advice and services in these regions (up to some point of disadvantages of concentration, at least).

The above theoretical contributions lead to some propositions as regards possible effects of clusters of KIBS firms on regional industrial development. Cluster firms should generally have some benefits compared to corresponding firms outside of clusters. This is in particular the case in knowledge-intensive clusters in fairly new industrial sectors in which access to scarce and 'sticky' knowledge is seen to be important. Cluster firms should usually have more local, formal and informal cooperation, find more relevant knowledge locally, face more local rivalry and find more demanding customers locally. Cluster firms should also reveal better competitive performance in terms of higher export rates and innovation activity (cf. Simmie, 2002: 206; Malmberg, 2004). Additionally, the view of KIBS as innovation agents points to the fact that companies located near concentrations of KIBS firms should in general use more knowledge-intensive services and to a larger extent implement innovative solutions from these specialised firms than more 'isolated' companies.

The claims that clusters trigger innovation activity in cluster firms, and that knowledge-intensive services are crucial to innovation and growth in other industries seem, however, poorly substantiated by empirical studies. The two next sections 'test' these theoretical propositions using empirical data from a specific KIBS sector, i.e. the software industry in Norway.

Clustering of software firms in Oslo

The Norwegian software industry (defined as NACE 72) contained about 36,000 employees in 2001 (Table 3.1). It is one of the most innovative service industries in Norway, and certainly the service sector with the highest R&D cost per employee (Norges forskningsråd, 2001). The number of employees more than tripled from 1991 to 2001. Nearly 60% of all employees have higher education, which means that data freaks and young school-leavers do not dominate the sector.

The software industry is, like most knowledge-intensive sectors, heavily concentrated in Oslo.[1] The Oslo region has as much as eight times as many employees as the second largest region (Bergen with 2,400 jobs in the software industry). The Oslo region had a somewhat slower growth than the other Norwegian regions,

Table 3.1 Key figures for the software industry in Norway in 2001

Regional types	*Number of employees*	*Location quotient*[2]	*Share of employees in Norway*	*Average number of employees per region*	*Percentage of higher educated employees*	*Percentage growth 1991–2001*
The Oslo region	19,346	2.5	53.4	19,346	60.5	200
Three large city regions	6,574	1.1	18.1	2,191	60.1	211
Medium-sized cities	8,828	0.6	24.4	167	51.9	230
Small towns	1,083	0.2	3.0	14	48.8	266
Peripheral areas	402	0.3	1.1	3	45.9	363
Norway	36,234	1.0	100	Not relevant	57.8	212

Source: Norwegian register data, matched employer–employee files.

indicating a general shift towards a more decentralised location in the software industry also in Norway, as stated by Howells (2000). Decentralisation is made possible by the growth in packaged software and reduced maintenance activity that needs close ongoing contact with clients. However, particularly the two most peripheral regional types in Table 3.1 started from very small initial bases.

A vital point for the subsequent analyses is the fact that Oslo constitutes a regional cluster in the software industry due to its high concentration of jobs in the industry, and due to linkages between firms in the industry and between software firms and local clients (Isaksen, 2004). Other regions may also have smaller agglomerations of collaborating firms, or firms taking advantages of a common labour market, or other shared inputs. However, according to Table 3.1 agglomerations of software firms are very seldom outside Oslo and the three next largest cities. According to several studies the mere location quotient also prevents most other regions from meeting the criteria of being a regional cluster. It is common to claim that a regional cluster should have significantly more jobs than the national average in the region's dominating industry or industries. Thus, a total of 154 clusters are identified in the UK meeting the criterion of being 'regional highs'. These are groups of five digit SIC sectors that have a location quotient over 1.25 and/or over 0.2% of the regional workforce (DTI, 2001). The identification, however, is seen to represent a first assessment only as many of the identified clusters, on closer examination, may be concentrations of industries rather than clusters, as clusters should have inter-related firms.

The central problem in identifying regional clusters by using secondary sources is that such sources cannot tell whether or not any significant networks or linkages exist between firms in the identified industries in a region (cf. Simmie, 2002: 203). In the case of the software industry in Oslo personal interviews with firm managers demonstrate much collaboration between local players, and particularly close ties between software firms and some large, local clients (Isaksen, 2004). The region with the next highest location quotient in the software industry is Trondheim, having a quotient of 1.3[3] and nearly 1,900 software jobs in 2001. Trondheim has traditionally been recognised as the 'capital of technology' in Norway housing the University of Science and Technology and the largest technical research institution in Norway. Trondheim thus has a strong university and R&D sector, but is seen to have a fairly weak position concerning knowledge-intensive industries (Spilling and Steinsli, 2003). Thus, considering location quotients, Trondheim may be seen as a regional cluster (following the criteria in DTI, 2001), but it is questionable whether the region has the number of firms and significant networks and linkages necessary to constitute a functioning software cluster. No other Norwegian region seems to meet the criteria for being regional clusters by their low location quotients, which demonstrates that they do not form 'regional highs'. At least, other regions are definitely much smaller software agglomerations than Oslo.

The bias towards Oslo may reflect a 'capital region' and a 'transport node' effect due to the fact that Oslo has the best national and international transport infrastructure to serve wider markets, and is the main site for the location of headquarters in public organisations and private companies (Jakobsen and Onsager, 2005). Nevertheless, following the above theoretical review the software industry in Oslo is expected to have some characteristics compared to this industry in the rest of the country. Software firms in Oslo should have more local collaboration and demonstrate overall better competitive performance than their counterparts in the rest of Norway.

The analysis of such differences is mainly based on the results of a telephone survey. The survey concentrated on software firms with five employees or more in the three most central regional types, as these areas contain the bulk of employees (and firms) in the Norwegian software industry (cf. Table 3.1). The firms surveyed employ about 20% of the number of employees in the total population of firms in the software industry in Norway. The 269 software firms surveyed are part of a larger sample of 800 knowledge-based firms. The firms were randomly sampled. More than 2,300 firms were contacted to obtain 800 answers, i.e. the response rate was 34. We do not know the characteristics of firms that did not want or did not have the time to answer the survey. The survey obtained answers from mainly smaller firms, as the average number of employee is 27. The sample is slightly biased towards firms in the regional type 'large city regions' when compared with the distribution of employees in the software industry as a whole.

Software firms in Oslo reveal some 'cluster mechanisms'

The first task is to analyse differences between software firms in Oslo and the two other regional types. The results revealed in Table 3.2 are not clear-cut, and in some cases the differences between the regional types are not statistically significant. However, Table 3.2 indicates that software firms in Oslo are somewhat more involved in local collaboration and experience more innovation pressure from local rivals than similar firms in the two other regional types.

The first four indicators in Table 3.2 consider different aspects of local collaboration and networking. Firms were asked whether important collaborators are mainly found locally, nationally or abroad. Half of the firms in the two most

Table 3.2 Indicators of cluster mechanisms in the software industry in three regional types

Indicator	*The Oslo region*	*Three large city regions*	*Medium-sized cities*
1. Percentage of firms having important co-operators locally	51	50	25*
2. Percentage of firms co-operating with other companies on competence building	59	36*	58
3. Firms' assessment of the importance of informal networks in their innovation activity. Level where 1 means no importance and 6 very important	3.8*	3.2*	3.3*
4. Percentage of firms obtaining important knowledge to be used in innovation activity in the local area	56	71	51
5. Percentage of firms in which venture organisations, seed bed funds, or business angles have been the most important source of finance	18	6	14
6. Percentage of firms experiencing strong competition in local markets	53	46	36
7. Average percentage of the firm's turnover coming from local markets	33	38	28

Source: Telephone survey June 2002.

Note
*Statistically significant at 5% level according to the chi-square test (indicator 1 and 2) or t-test (indicator 3: large cities and medium-sized cities significantly different from Oslo).

central regional types find important collaborators locally, while only one quarter of the firms in the medium-sized cities have important local collaborators. An examination of small firms (with 5–19 employees) only reveals that 59% of the firms in Oslo, 53% of the firms in the large cities, and 29% of the firms in the medium-sized cities report having important local collaborators. About 20% of the firms in all the regions find their important collaborators abroad.

The next indicator shows that more firms in the Oslo region and in the medium-sized cities co-operate with other companies in competence building compared to firms in the large city regions.[4] This second indicator alludes to a more general picture as regards co-operation. Firms were asked about their co-operation with other companies regarding eight subjects. Firms in large cities co-operate considerably less with other companies on all these subjects.

Considering the two first indicators in common, software firms in Oslo co-operate quite considerably with other local companies on most subjects (Figure 3.1).[5] Oslo firms co-operate as much as firms in medium-sized cities, but co-operate much more with local companies. Firms in large cities co-operate clearly less than firms in the two other regional types, but the large city firms that do so co-operate with local companies just as much as Oslo firms. The overall picture shows that firms in the medium-sized cities collaborate least locally, while firms in the large cities are in a middle position. Thus, a clear centre–periphery pattern occurs as regards the amount of local collaboration.

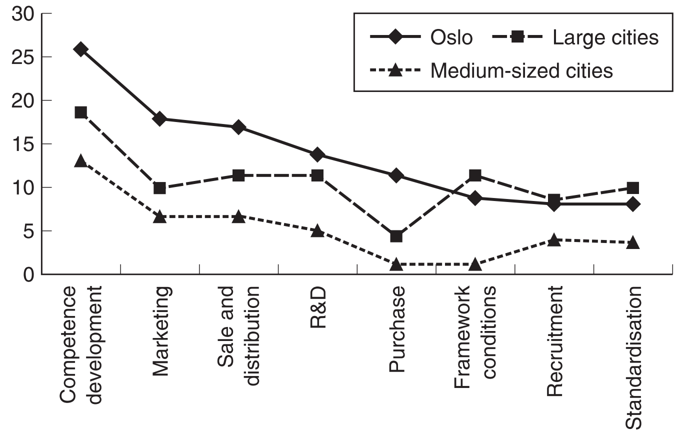

Figure 3.1 Share of firms having important local collaborators on different subjects. Source: Telephone survey June 2002.

The third indicator in Table 3.2 seems to confirm the result in Figure 3.1. Software firms were asked to assess the importance of informal networks on, among other things, their innovation activity. Firms assessed informal networks to be of about medium importance in their innovation activity. However, informal networks are seen to be somewhat more important in the Oslo region than in the two other regional types. The same picture applies when the firms assess the importance of informal networks in gaining information about technological trends and market trends. In both cases firms in the Oslo region on average assess informal networks as somewhat more important than firms in the two other regional types. These results *may* point to the fact that firm managers in Oslo can gain more information from their informal networks than firms in the other areas. By being located in a larger agglomeration, Oslo firms have access to a larger number of colleagues in other firms, and to persons working in client companies, R&D institutes, specialist firms, etc.

Indicator 4 in Table 3.2 may at first glance contradict the conclusions regarding the importance of informal networks. Software firms in the three large city regions, in particular, obtain important knowledge for innovation activity locally. That may reflect the importance of the University of Science and Technology as a knowledge base in Trondheim and the importance of oil companies in Stavanger and Bergen. However, Table 3.3 indicates that the high degree of local knowledge used may be a weakness rather than a strength of the software industries in the large city regions as a group. On average, firms in the three large cities innovate markedly less than firms in the other regional types. One possible interpretation of such a result is that firms in the large cities are hampered by their use of mainly local knowledge in innovation activity. At least firms in Oslo and the medium-sized cities more often find knowledge internationally or in other parts of Norway. In general small firms more often than larger firms find their important knowledge for innovation activity locally, but the difference between the regional types relates to all size classes.

The comparatively high reliance on local sources of knowledge *and* simultaneously relatively low innovation activity in software firms in the large cities may illustrate an important point in the discussion on regional clusters. While face-to-face business contact is necessary in tacit knowledge exchange (Cooke, 2006), wider, extra-local connections are also of importance (Amin and Thrift, 2002; MacKinnon *et al.*, 2002). External connections to the global economy are seen to play an important role in bringing in ideas and knowledge in sustaining competitive advantage. The mainly small software firms in the telephone survey definitely seem to rely quite a lot on local contacts, but the results also indicate that too large a reliance on local knowledge sources may hamper firms' innovation activity.

Venture capital is seen to play an important role in financing innovation and knowledge-intensive firms in their early stages (Cooke, 2002: 154). Table 3.2 (indicator 5) shows that firms in Oslo are more often financed by venture organisations, seed bed funds, or business angles than, in particular, firms in the large city regions. This result probably reflects the fact that the greater part of venture capital companies in Norway is located in the Oslo region (Langeland, 2005). Venture capitalists often rely on uncodified information submitted through social and professional relations when evaluating projects. Being located in an area where such capital is most available in Norway, Oslo firms seem to have better prospects of having their investments funded by venture capital.

The sixth indicator in Table 3.2 to assess 'cluster mechanism' is firms' judgement of competition on the local market. A strongly competitive environment is seen as a main stimulus for innovation in companies, and particularly local competition is seen to stimulate innovation activity (Porter, 1998). Relatively more firms in the Oslo region (irrespective of size classes) experience strong competition in the local market. This is as expected given that Oslo has by far the largest concentration of software firms.

Oslo firms are more involved in innovation activity

The cluster theories maintain that firms benefit from being part of a cluster, and thus cluster firms should on principle perform better than equivalent firms outside of clusters. Table 3.3 demonstrates that the Oslo software firms have the highest scores on performance indicators like export rate and involvement in innovation and R&D, followed by firms in medium-sized cities and firms in the large city regions.

Firms' export rate is often seen to illustrate their competitiveness. Software firms in Oslo sell on average most on international markets, but the differences in average export rate between software firms in the three regional types are small. Large firms (with 100 employees and more) are most export-oriented,[6] but even small software firms have some export activity. The next three indicators

Table 3.3 Indicators on the performance of software firms in three regional types

Indicator	*The Oslo region*	*Three large city regions*	*Medium-sized cities*
1. Average percentage of firm's turnover on international markets	18*	10*	16
2. Percentage of firms that invested in R&D 1999–2001	50	20*	39
3. Percentage of firms that invested in any innovation activity 1999–2001	69	47*	58
4. Average percentage of the company's turnover used for innovation activities in 2001	22	16	20

Source: Telephone survey June 2002 ($n = 269$).

Note

*Statistically significant at 5% level according to the chi-square test (indicator 2 and 3) and or t-test (indicator 1: large cities significantly different from Oslo).

in Table 3.3 concern firms' innovation and R&D activity. Clusters are seen to stimulate the pace of innovation, which underpins future productivity growth and competitiveness (Porter, 1998: 80). Indicator numbers two and three in Table 3.3 show the same result: comparatively more software firms in Oslo than in the other two regional types invest in R&D and other innovation activity.[7] Oslo firms also use slightly more of their turnover on innovation activity than firms in the medium-sized cities, and particularly more than firms in the large cities (indicator 4).

These findings from the telephone survey to software firms are supported by results from the Community Innovation Survey (CIS) in Norway. By use of the CIS, Aslesen *et al.* (1999) demonstrate that the industrial sector 'Computer and related activities' is significantly more innovative in terms of output in Oslo than in the rest of Norway. Oslo has thus relatively more innovative firms in this sector than other parts of Norway. Similarly, firms in this sector in Oslo have a much larger share of new and improved services as part of their turnover than the national average. The results indicate that the wider industrial and knowledge milieu in the Oslo region stimulates innovation activity in the software firms to a larger extent than the corresponding milieus in the other regions. However, the medium-sized cities score nearly as high as Oslo on indicators 1 and 4.

The empirical analysis supports to some extent the assertion that cluster firms are more involved in local collaboration and experience more severe competition from local rivals than similar firms outside clusters, and also the assertion that clustering stimulates firms' innovation activity. The next question is how the Oslo software cluster may affect the competitiveness of other industries in Oslo, and particularly the use of new software solutions by these industries. Does the software cluster in Oslo trigger use of more innovative software solutions by Oslo firms compared with firms in other parts of Norway?

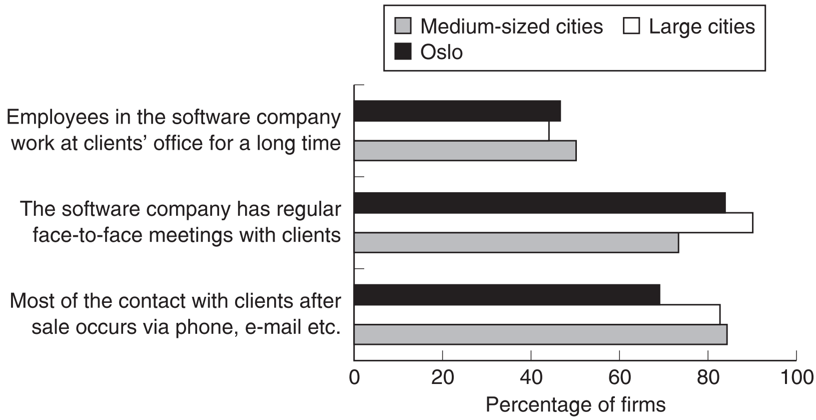

Figure 3.2 The contact with clients during a project by software firms in different regional types.
Source: Telephone survey June 2002 ($n = 269$).

Clustering of software firms and effects on the rest of industry

As revealed in the theoretical part of this chapter, KIBS firms (such as software companies) are often seen as an important part of the knowledge base of innovating companies (Daniels and Bryson, 2002; Hertog, 2002). The interactive innovation model conceptualises innovation activity as a complex learning process in which firms build up competence in-house step by step, but also often need to acquire technical and market-relevant expert knowledge from external players (e.g. Asheim and Isaksen, 1997). The argument is further that firms located close to a whole series of professional services may benefit compared to firms with less access to such services, as much collaboration between KIBS suppliers and clients includes knowledge that is difficult to codify.

As regards the software industry, software firms and clients have close contact according to Figure 3.2. Half of the software firms work extensively at clients' offices, and most software firms have regular face-to-face meetings with clients. Figure 3.2 also indicates that face-to-face meetings with clients are particularly important in the tender, sale and contract phase. After a sale most firms, particularly firms outside Oslo, collaborate with clients via phone, e-mail, etc. However, software firms very often negotiate new contracts or develop new solutions based on signals from clients (Isaksen, 2004). Thus, much activity takes place before contracts are signed.

Figure 3.2 indicates that software firms often cooperate closely with clients in projects. Table 3.4 shows that potential clients may also benefit from proximity to a number of specialised KIBS firms. Easy access to a cluster of KIBS firms at least seems to stimulate increased use of services from these firms. According to several

Table 3.4 Share of firms maintaining that consultants are of medium or great importance as a source of information in innovation

	The Oslo region	*Three large city regions*	*Medium-sized cities*	*Remaining regions*
Percentage of firms	29	19	20	23

Source: CIS 2001 ($N = 1687$).

large-scale, quantitative innovation studies innovative firms generally regard KIBS (or consultancy firms) as less important information sources and innovation partners, far less important than players along the value chain and fairs and exhibitions (e.g. Cooke *et al.*, 2000: 75–76). The same results emerge in the Community Innovation Survey (CIS) in Norway. However, as demonstrated in Table 3.4 the CIS also reveals that a much larger share of firms in Oslo than in other parts of Norway view consultants as an important source of information for innovation purposes.[8] Moreover, two-thirds of consultant users in the telephone survey maintain that geographical proximity to consultants stimulates increased use. Companies demand knowledge and expertise from the KIBS sector of a national and international standard, but they also seem to demand local attendance in order to be able to cooperate closely with some consultancy firms.

A 'distance effect' in the use of software consultants is also indicated in a survey by Statistics Norway about the use of ICT in Norwegian industry (Pilskog *et al.*, 2001).[9] Table 3.5 shows that relatively more firms in Oslo and Akershus county (which together approximately match the Oslo labour market region) use different ICT solutions than the norm in Norway. Software firms can assist clients in installing and using these ICT solutions all over Norway, but the 'rub-off effect' may be largest in areas where a lot of firms make their money by selling such solutions. Thus, the greater use of ICT solutions by Oslo firms *may* be a result of the activity in the Oslo software cluster.

Table 3.5 Different indicators to measure the use of ICT solutions in the private sector in Norway in 2000

Indicators	*Oslo*	*Akershus*	*Average for Norway*
Share of firms with internet access	81	76	74
Share of firms with home page	59	53	48
Share of firms with intranet[a]	31	27	23
Share of firms with extranet[b]	14	12	5
Share of firms with EDI[c]	22	21	19

Source: Statistics Norway.

Notes

a Intranet is internet used internally in a firm.

b Extranet is a firm's home pages made available for particular external players, such as clients and suppliers.

c EDI (Electronic Data Interchange) is transmission of data electronically between two data systems, for example relating to orders and invoicing.

Conclusion

This chapter employs novel empirical material to analyse important propositions drawn from cluster theory and theories about the role of KIBS in industrial development. The theories maintain that cluster firms on average should perform better than more 'isolated' firms. Furthermore, clusters of KIBS firms should affect the innovation activity and competitiveness of nearby companies as KIBS firms possess expert knowledge that in some cases is delivered most efficiently by face-to-face contact.

The chapter contrasts aspects of the behaviour and performance of software firms in Oslo with those of similar firms in other parts of Norway, i.e. firms that are *not* located in regional clusters, or firms that are at least part of much smaller agglomerations of software firms than the one found in Oslo. It must be underlined that functioning regional clusters are often characterised by 'soft' factors that are difficult to quantify, such as industrial atmosphere (Marshall, 1890), institutional thickness (Amin and Thrift, 1994), collective learning (Keeble and Wilkinsson, 1999), and untraded interdependencies (Storper, 1997). It may then be difficult, if we only use quantitative indicators, to really grasp what distinguishes the firms in the Oslo software cluster from similar firms in other parts of Norway. Nevertheless, the telephone survey identifies some 'cluster effect' in the software industry in Oslo. Software firms in Oslo are somewhat more involved in local collaboration and experience more severe competition from local rivals than corresponding firms in other parts of Norway. The clustering in Oslo also seems to stimulate innovation activity in software firms and the use of consultants and of ICT solutions by local firms in general. Thus, the initial propositions based on theory are to some extent supported by the analysis of the Norwegian software industry.

However, the differences in behaviour and performance between software firms in Oslo and those outside of this region are not always clear-cut and are not as pronounced as one should expect from reading much of the cluster literature. At least two factors may contribute to reducing the differences between the clustered and the non-clustered software firms. These are factors that may also be of more general relevance and which one should take into consideration when examining the alleged advantages for firms of being located in a regional cluster.

The first factor relates to the fact that the software industry has grown very fast during the last decade and contains many young firms. The development of external economies and local collaboration that often characterises a regional cluster will take some time. Extensive local collaboration beyond market transactions requires in particular time to develop as such collaboration is based on informal rules and conventions shared by local players (Storper, 1997). 'Light' institutions such as meeting places, common services, associations and informal contact network (Amin and Thrift, 2002) also develop over time. Thus, being a young industry and agglomeration, typical cluster features and effects may not be fully developed in the Oslo software industry.

Secondly, the empirical data also point to the significance of wider extra-local connections, not least for the software firms in the smallest regions. Many software firms outside Oslo may be seen as 'dispersed clustered' (Keeble and Nachum, 2002), i.e. they may be functionally integrated into a nation-wide production and innovation system as they serve important clients in Oslo, take part in larger projects organised by Oslo software firms, cooperate with mainly foreign platform suppliers located in Oslo, and participate in branch meetings and seminars that are mainly arranged in this area.[10] This second factor illustrates a general difficulty in comparing the competitiveness of companies in and outside of regional clusters, not least because it is not evident what is meant by a 'cluster firm'. A company may be located in a cluster (i.e. be a member of an industry and region comprising a regional cluster) without functionally belonging to the cluster, and thus not benefiting much from its location (beyond the local buzz argument put forward by Bathelt *et al.*, 2004). On the other hand, a company may be located outside the geographical boundary of a cluster, but be part of the cluster in a functional sense, for example by finding central suppliers or customers in the cluster. This may be the case in Norway as software firms outside Oslo may utilise 'the Oslo milieu' in their activity.

Notes

1 All types of regions in Table 3.1, except peripheral areas, are constructed so as to contain labour market areas around centres (cities, towns) of different size classes (Foss and Selstad, 1997). The most central region consists of 20 municipalities at the core of the Oslo region. The next region includes the three largest city regions in Norway following Oslo (Bergen, Stavanger, and Trondheim). Medium-sized cities include a large number of city regions having between 20,000 and 200,000 inhabitants. Small towns consist of small centres and their commuting hinterland with less than 20,000 inhabitants. The peripheral areas are a 'rest category' containing the remaining municipalities when towns and cities have been defined.

2 The location quotient is the share of employees that one industrial sector has in a region in proportion to the sector's share of all employees in Norway. The ICT industry comprises 5.7% of all employees in the Oslo regions as compared to 2.6% in Norway. The location quotient is then 5.7 divided by 2.6.

3 The two other regions constituting 'the large city regions', Bergen and Stavanger, both have a location quotient of 1.0.

4 The telephone interviews offered standardised answering categories. The interviewees were, for example, asked if the firm co-operates (formally or informally) with other firms in competence building. In this case the interviewees themselves had to interpret the meaning of 'competence building', and such interpretations may vary between interviewees. However, the self-categorisation by interviewees is not expected to vary systematically between persons in different regional types, i.e. there is no reason why persons in Oslo in general should define 'competence building' in other ways than persons in other parts of Norway. Results also demonstrate that the difference between regions as concerns co-operation in competence building points to a more general picture valid for other types of co-operation.

5 Figure 3.1 shows firms that collaborate with other companies on a specific subject *and* mainly have important collaborators locally. For example, 26% of the software firms in Oslo both collaborate with other companies on competence development and mostly find important collaborators locally.

6 Large firms have 49% of their turnover on international markets, while the figure is 23% for medium-sized firms (20–99 employees) and 11% for small firms.

7 Investment in innovation includes, in addition to investment in R&D, investment in product development, marketing and launching of new products.
8 Heidi Wiig Aslesen had the idea of using the CIS to examine different views of consultants among firms in different regions, and she also provided the data in Table 3.4.
9 The survey is compiled from a representative sample of 4,800 firms with more than 10 employees in the private sector in Norway.
10 Based on information from interviews with firm managers (Isaksen, 2004).

References

Acs, Z. J., H. L. F. de Groot and P. Nijkamp (2002), Knowledge, Innovation and Regional Development, in Acs, Z. J., H. L. F. de Groot and P. Nijkamp (Eds.), *The Emergence of the Knowledge Economy*. Springer, Berlin, Heidelberg, New York (1–14).

Amin, A. and N. Thrift (1994), Living in the Global, in Amin, A. and N. Thrift (Eds.), *Globalization, Institutions, and Regional Development in Europe*. Oxford University Press, Oxford (1–22).

Amin, A and N. Thrift (2002), *Cities. Reimagining the Urban*. Polity, Cambridge, UK.

Asheim, B. T. (2000), Industrial Districts: The Contribution of Marshall and Beyond, in Clark, G. L., M. P. Feldman and M. S. Gertler (Eds.), *The Oxford Handbook of Economic Geography*. Oxford University Press, Oxford (413–31).

Asheim, B. T. and A. Isaksen (1997), Location, agglomeration and innovation: Towards regional innovation systems in Norway? *European Planning Studies* 5, 3: 299–330.

Aslesen, H. W., T. B. Braadland, A. Ekeland and F. Ørstavik (1999), Performance and co-operation in the Oslo region business sector. *Step-report* 05/99, STEP-group, Oslo.

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.

Best, M. H. (2001), *The New Competitive Advantage. The Renewal of American Industry*. Oxford University Press, Oxford.

Cooke, P. (2002), *Knowledge Economies. Clusters, Learning and Cooperative Advantage*. Routledge, London and New York.

Cooke, P. (2006), Asymmetric Knowledge, Digital Knowledge Flow Platforms and Regional Innovation Systems, in Assimakopoulos, D. and E. Carayannis (Eds.), *Knowledge Creation, Diffusion and Use in Innovation Networks and Clusters*. Macmillan, London.

Cooke, P., P. Boekholt and F. Tödtling (2000) (Eds.), *The Governance of Innovation in Europe. Regional Perspectives on Global Competitiveness*. Pinter, London and New York.

Daniels, P. W. and J. R. Bryson (2002), Manufacturing Services and Servicing Manufacturing: Knowledge-based Cities and Changing Forms of Production. *Urban Studies*, 39, 5–6: 977–91.

DTI (2001), *Business Clusters in the UK – A First Assessment*. Department of Trade & Industry, London.

EC (European Commission) (2002), *Regional Clusters in Europe*. Report in the framework of the Seventh Observatory of European SMEs, submitted to the Enterprise Directorate General by KPMG Special Services, EIM Business & Policy Research, and ENSR. Brussels.

Eurostat (2002), Employment in high tech and knowledge intensive sectors in the EU continued to grow in 2001. Statistics in focus, Science and Technology, 04/2002.

Fischer, M. M., J. Revilla Diez and F. Snickars (2001), *Metropolitan Innovation Systems.* Springer, Heidelberg.

Foss, O. and T. Selstad (1997), Bosettinger og næringer, in Foss, O. and T. Selstad (Eds.), *Regional arbeidsdeling*. Tano Aschehoug, Oslo (11–36).

Gertler, M. S. (2004), *Manufacturing Culture. The Institutional Geography of Industrial Practice.* Oxford University Press, Oxford.

Harrisson, B., M. R. Kelley and J. Gant (1996), Innovative Firm Behaviour and Local Milieu: Exploring the Intersection of Agglomeration, Firm Effects, and Technological Change. *Economic Geography*, 72, 3: 233–58.

Hertog, P. den (2002), Co-producers of innovation: on the role of knowledge-intensive business services in innovation, in Gadrey, J. and F. Gallouj (Eds.), *Productivity, Innovation and Knowledge in Services*. Edward Elgar, Cheltenham, UK and Northampton, MA, USA (223–55).

Howells, J. (2000), Computer Services: The Dynamics of a Knowledge-Intensive Sector, in Andersen, B. *et al.* (Eds.), *Knowledge and Innovation in the New Service Economy*. Edward Elgar, Cheltenham, UK and Northampton, MA, USA (121–41).

Isaksen, A. (2004), Knowledge-based Clusters and Urban Location: the Clustering of Software Consultancy in Oslo. *Urban Studies*, 41, 5/6: 1157–74.

Jakobsen, S-E. and K. Onsager (2005), Hovedkontor i storbyene – funksjoner, lokaliserigsbetingelser og regionale effekter. I Vatne, E. (Ed.), *Norske storbyers funksjon i norsk økonomi*. Spartacus, Oslo.

Keeble, D. and L. Nachum (2002), Why do business service firms cluster? Small consultancies, clustering and decentralisation in London and southern England. *Transactions of the Institute of British Geographers*, 27 (1): 67–90.

Keeble, D. and F. Wilkinson (1999), Collective Learning and Knowledge Development in the Evolution of Regional Clusters of High Technology SMEs in Europe. *Regional Studies*, 33 (4): 295–303.

Langeland, O. (2005), Kunnskapsrik kapital – finansiering av innovasjon og entreprenørskap. I Vatne, E. (Ed.), *Norske storbyers funksjon i norsk økonomi*. Spartacus, Oslo.

Leamer, E. E. and M. Storper (2001), The Economic Geography of the Internet Age. *Journal of International Business Studies*, 32, 4: 641–665.

Lundquist, K.-J. (1996), Företag, regioner och internationell konkurrens. Om regionala resursers betydelse. *Meddelanden från Lunds universitets Geografiska Institutioner* avhandlinger nr. 129. Lund University Press, Lund.

Lundvall, B.-Å. and B. Johnson (1994), The Learning Economy. *Journal of Industry Studies*, 1: 23–42.

MacKinnon, D., A. Cumbers and K. Chapman (2002), Learning, innovation and regional development: a critical appraisal of recent debates. *Progress in Human Geography* 26, 3: 293–311.

Malmberg, A. (2004), Teorier om klustre – var står vi, in Arbo, P. and H. Gammelsæter (Eds.), *Innovasjonspolitikkens scenografi*. Tapir Akademiske Forlag, Trondheim.

Malmberg, A. and P. Maskell (2002), The elusive concept of localization economies: towards a knowledge-based theory of spatial clustering. *Environment and Planning A*, 34 (3): 429–449.

Markusen, A. (1999), Fuzzy Concepts, Scanty Evidence, Policy Distance: The Case for Rigour and Policy Relevance in Critical Regional Studies. *Regional Studies*, 33, 9: 869–884.

Marshall, A. (1890), *Principles of Economics*. Macmillan, London.

Martin, R. and P. Sunley (2003), Deconstructing Clusters: Chaotic Concept or Policy Panacea? *Journal of Economic Geography*, 3, 1: 5–35.

Metcalfe, J. S. and I. Miles (2000) (Eds.), *Innovation Systems in the Service Economy: Measurement and Case Study Analysis*. Kluwer, Dordrecht.

Norges forskningsråd (2001), *Det norske forsknings- og innovasjonssystemet – statistikk og indikatorer*. 2001, Oslo.

OECD (2001a), OECD Science, Technology and Industry Scoreboard 2001 – Towards a knowledge based economy. OECD, Paris.

OECD (2001b), *OECD-DATAR World Congress on Local Clusters*, OECD, Paris. http://www.oecd.org/document/22/0,2340,en_2649_34173_2022166_1_1_1_1,00.html.

Pilskog, G. M., L. Solheim og K. Ødegård (2001), Bruk av informasjons- og kommunikasjonsteknologi i næringslivet i 2000. *Rapporter* 2001/42. Statistics Norway, Oslo/Kongsvinger.

Porter, M. (1998), Clusters and the new economics of competition. *Harvard Business Review*, November–December, pp. 77–90.

Porter, M. (2000), Locations, clusters and company strategy, in Clark, G. L., M. P. Feldman and M. S. Gertler (Eds.), *The Oxford Handbook in Economic Geography*. Oxford University Press, Oxford (253 – 74).

Porter, M. E. (2003), The Economic Performance of Regions. *Regional Studies*, 37, 6&7: 549–578.

Roberts, J., I. Miles, R. Hull, J. Howells and B. Andersen (2000), Introducing the New Service Economy, in Andersen, B., J. Howells, R. Hull, I. Miles and J. Roberts (Eds.), *Knowledge and Innovation in the New Service Economy*. Edward Elgar, Cheltenham UK, Northampton, MA, USA (1–9).

Schmitz, H. (2004) (Ed.), *Local Enterprises in the Global Economy. Issues of Governance and Upgrading*. Edward Elgar, Cheltenham (UK) and Massachusetts (USA).

Scott, A. J. and M. Storper (2003), Regions, Globalization, Development. *Regional Studies*, 37, 6&7: 579–93.

Simmie, J. (2002), Trading Places: Competitive Cities in the Global Economy. *European Planning Studies*, 10, 2: 201–14.

Smith, K. (2000), What is the 'knowledge economy'? Knowledge-intensive industries and distributed knowledge bases. Paper presented to the DRUID Summer Conference on the The Learning Economy – Firms, Regions and Nation Specific Institutions, 15–17 June 2000.

Spilling, O. R. and J. Steinsli (2003), Evolution of high-technology clusters: Oslo and Trondheim in international comparison. *Forskningsrapport* 1/2003, Norwegian School of Management, BI, Oslo.

Storper, M. (1997), *The Regional World: Territorial Development in a Global Economy*. Guilford Press, New York.

Strambach, S. (2001), Innovation Processes and the Role of Knowledge-Intensive Business Services (KIBS), in Koschatzky, K., M. Kulicke and A. Zenker (Eds.), *Innovation Networks – Concepts and Challenges in the European Perspective*. Springer Physica, Heidelberg (53–68).

Thrift; N. (2005), *Knowing Capitalism*. Sage Publications, London.

Wood, P. (2002) (Ed.), *Consultancy and Innovation. The Business Service Revolution in Europe*. Routledge, London and New York.

4 The impact of geography on the innovative productivity of software firms in the Netherlands

Anet Weterings and Ron Boschma

Introduction

There is an expanding literature on the application of evolutionary economics in the field of economic geography (e.g. Storper, 1997; Cooke and Morgan, 1998; Boschma and Lambooy, 1999). One application has drawn recent attention from scholars, that is, the spatial evolution of newly emerging industries (e.g. Storper and Walker, 1989; Arthur, 1994; Klepper, 2002; Boschma and Wenting, 2004; Buenstorf and Klepper, 2004; Cantner *et al.*, 2004). In this literature, attention is paid to the mechanisms through which an industry evolves, by linking industry location to the process of firm entry and firm exit, and to processes of knowledge creation and diffusion (Boschma and Frenken, 2003).

In this paper, we provide the example of the Dutch software sector to demonstrate how evolutionary economics may contribute to a better understanding of the spatial pattern of a newly emerging industry. We present different evolutionary mechanisms, which may, alone or in combination, decide where new industries will emerge in space. First of all, we relate the notion of agglomeration economies to the importance of knowledge spillovers. In doing so, we claim it is essential to distinguish between four types of spatial externalities, that is, urbanisation economies (irrespective of sectoral composition), Jacobs' externalities (based on a large variety of sectors), localisation economies based on related variety (due to co-location of complementary sectors), and localisation economies based on specialisation (in one and the same industry). We expect these types of spatial externality to have different effects on the growth of a new sector, and in different phases of an industry's life cycle (Boschma and Wenting, 2004). Second, studies have pointed out that spin-off dynamics may have a large impact on the growth and spatial evolution of many industries, because they provide mechanisms through which knowledge spills from one organisation (the parent firm) to the other (the spin-off company) (see e.g. Klepper, 2002; Agarwal *et al.*, 2004). Third, network relationships may be an alternative or additional mechanism through which tacit knowledge is effectively transferred, and interactive learning takes place between organisations (Breschi and Lissoni, 2002; Gertler, 2003).

Since these mechanisms may, in combination or alone, determine the spatial evolution of new industries, empirical studies need to isolate the impact of each of them. Using cross-sectional data of 265 software firms in the Netherlands, the main objective of this chapter is to examine the impact of these mechanisms on their innovative performance. The software sector is an interesting case. It is a relatively young sector that is still characterised by relatively low entry barriers and some degree of technological turmoil. An empirical analysis of the current geography of the software sector provides us with a snapshot of the spatial features of a sector that is in the midst of its expansion phase, but has not yet been confronted with standardisation and market concentration. Another issue raised in this chapter is how to measure innovative performance in general, and in service sectors in particular. In our study, we measure the innovative productivity of software firms. The advantage of this indicator is that it accounts for both input and output dimensions of innovation. In other words, when measuring the innovative output of a firm (in terms of new products), this indicator controls for the amount of resources the firm devotes to research with the purpose of developing new products.

The paper is organised as follows. The next section gives a brief overview of the literature that deals with the spatial evolution of industries from an exclusively evolutionary angle. The spatial evolution of the Dutch computing services and software industry in the last decades is then briefly outlined. The following section introduces the empirical case, providing information on the data sources, the main variables used in the estimation models, and the research design. The last section presents the empirical results of the regression analyses. Finally, some short conclusions are given.

The spatial evolution of an industry from an evolutionary perspective

We provide three explanations for the spatial formation of new industries, that is, agglomeration economies, spin-offs and networks, that will be tested in the empirical part. In the concluding part of this section, we adopt an industry life cycle approach, which assumes these mechanisms to play a different role in different phases.

Agglomeration economies

In regional economics, agglomeration economies provide a key explanation for the spatial concentration of an industry. Spatial externalities may arise because of the presence of a well-developed infrastructure, a thick and diversified labour market, local access to specialised suppliers, market vicinity, and the presence of local knowledge spillovers. This last factor is especially interesting from an evolutionary point of view, because it points out that the creation and diffusion of knowledge and competences is affected by geographical proximity. Whatever the reasons, agglomerations not only enable incumbent firms to perform better, as compared to non-local firms (resulting in less exits), they will also attract firms from other regions and stimulate the creation of new firms with new ideas (leading to more entries).

Since the 1990s, the literature on agglomeration economies has put emphasis on the benefits of geographically localised knowledge spillovers (see Feldman and Audretsch, 1999). While the more traditional agglomeration economies are called *static* externalities, *dynamic* externalities are associated with local knowledge spillovers, learning dynamics, innovation and regional development. Firms in large agglomerations are assumed to be more innovative, because they obtain more external knowledge, while geographical proximity facilitates the effective transfer of knowledge between organisations (for a detailed elaboration on the relationship between innovation and proximity, see Boschma, 2005). In the literature, it is common to distinguish between three types of spatial externality, that is, urbanisation economies, Jacobs' externalities, and localisation economies (based on specialisation), each of which may have a particular impact on the growth of a new sector. In this chapter, we add a fourth type, that is, localisation economies based on related variety. From an evolutionary point of view, we expect this type of spatial externality to play a quite prominent role in the first phase of the industry's life cycle (Boschma and Wenting, 2004).

Urbanisation economies can be associated with a local abundance of knowledge spillovers. Consequently, the larger the agglomeration, and the more connected it is with the outside world, the more local firms have access to external knowledge. Vernon (1966) pointed out that new and young firms have to deal with many changes in the technology and products and, therefore, require information and know-how from external agents, which can be found more easily in large concentrations of firms and people. By contrast, firms located outside such areas have to rely on either internal efforts, or face higher opportunity costs when acquiring external knowledge (Feldman, 1994). More recently, the (regional) innovation system literature (e.g. Cooke *et al.*, 1998) points out that the innovative performance of firms may improve considerably from a local supply of a range of other organisations, such as universities, risk capital suppliers and educational facilities, that is more available in large agglomerations. In doing so, it is acknowledged that local access to knowledge is not sufficient for innovation, but also requires local access to other resources (e.g. capital, skilled labour and specialised inputs). In addition, large agglomerations are well endowed with a large amount of potential and critical customers, enhancing innovative behaviour of firms (Porter, 1990). This may be especially relevant for knowledge-intensive services. Because innovations in knowledge-intensive services often follow from new or changing demands of customers, it might be essential to be located in the vicinity of many potential (and demanding) customers.

Urbanisation economies are externalities available to local firms in which the impact of a particular local mix of industries is not accounted for. By contrast, two other types of spatial externality focus explicit attention on the fact that inter-organisational learning may be enhanced by the sectoral composition in agglomerations, but in different ways. That is, firms can learn from other local firms in different industries (Jacobs' externalities), or from local firms in the same industry (localisation economies based on specialisation). In the former case, agglomerations characterised by a broad range of sectors do not only provide many incentives for new ideas, they also provide valuable resources (such as complementary capabilities) required for interactive learning (Boschma, 2005). In the literature, it is often stressed that Jacobs' externalities are more likely to spur radical innovations, because pieces of knowledge taken from different sectors are combined. In the latter case, firms can learn effectively, because their search behaviour is more likely to be successful when they can draw on their existing knowledge base, and they can better absorb external knowledge that comes close to their own competences (Nelson and Winter, 1982). As a result, geographical proximity may stimulate the build-up of similar competences: local firms sharing and accumulating similar (tacit) knowledge will have a better absorptive capacity and learning ability than non-local actors. In this respect, localisation economies are expected to enhance more incremental innovations, because knowledge spills over between similar firms, leading to gradual (instead of radical) improvements of existing products and processes.

In the recent literature, one argues that the positive externalities in specialised agglomerations only occur when combined with a certain type of market structure (in terms of degree of local competition). However, the literature is rather ambiguous as far as the potential effects of local competition on innovation and economic growth in specialised agglomerations are concerned (Glaeser *et al.*, 1992; Henderson *et al.*, 1995). It comes down to the question of what type of market structure is believed to enhance innovation. Proponents of new growth theory point out that knowledge spillovers are more important when there is little local competition, because rents of knowledge can be better internalised by firms. By contrast, Porter (1990) has stressed the importance of local competition as an incentive for innovation, which makes firms in clusters invest more in R&D, leading to knowledge spillovers between local firms.

As noted earlier, the notion of Jacobs' externalities accounts for heterogeneity (or diversity) in economies as one of the driving forces of long-term urban development (Jacobs, 1969, 1985). Jacobs' ideas have been embraced by evolutionary thinkers (Lambooy, 2002). There is increasing awareness, however, that a diversity of sectors as such (as covered by Jacobs' externalities) is not sufficient. In fact, the process of inter-firm learning remains a black box. Basically, it overlooks the fact that inter-organisational learning requires absorptive capacity, that is, a not too great cognitive distance, to enable communication and interpretation of new knowledge (Nooteboom, 2000). Some degree of related variety may avoid problems of miscommunication, meaning a diversity of sectors that complement each other in terms of knowledge. Consequently, agglomerations may provide localisation externalities based on related variety, enabling local firms in complementary sectors to learn effectively from each other (Frenken *et al.*, 2004). As a result, localisation economies based on related variety provide access to diverse but complementary knowledge resources, stimulating knowledge spillovers between local firms in complementary sectors, and enhancing their innovative performance (Boschma, 2005). Recent empirical studies tend to confirm this: a number of new industries emerged in regions specialised in industries that were technologically related. Examples are the television industry in the US, which developed on the local foundations of the radio sector (Klepper and Simons, 2000), and the US automobile sector, which took benefit from local resources in related industries, such as bicycle making and coach building (Klepper, 2002).

In the empirical part, we assess the impact of the four types of agglomeration economies on the innovative performance of software firms. There are, however, other mechanisms through which knowledge spillovers may occur between firms, and should therefore be isolated analytically in empirical research. Below, we deal with two such mechanisms, that is, spin-offs and network relationships.

Spin-offs

Spin-offs are firms that were founded by a former employee of an incumbent firm in the same industry. An expanding literature gives evidence of the important role spin-offs have played in the rise and development of new industries. Adopting an evolutionary perspective, the spin-off process is viewed as a mechanism in which knowledge is transferred from one firm to the other (Helfat and Lieberman, 2002). As a result, spin-off firms are believed to perform better than other types of entrants, because they can draw on pre-entry working experience in the same industry, which other start-ups lack. This experience may concern acquired knowledge with respect to business opportunities, technologies and customer demand. Klepper (2002) even went a step further, suggesting a positive relationship between the performance of the parent organisation and the survival probability of the spin-off firm.

There are also other reasons mentioned in the literature that may explain the economic performance of spin-off firms. Spin-offs may benefit from technical and organisational support from the parent itself. However, it is important to acknowledge that over-embedded relationships may also have an opposite, negative effect on the performance of spin-offs. In other words, spin-offs that have retained a firm relationship with its parent may suffer from what has been called by Granovetter (1985) as 'weakness of strong ties'. In addition, spin-offs may build on relationships and contacts (with customers, employees, investors) that the founder had established during his stay at the parent organisation (Brüderl and Preistendörfer, 1998). Moreover, prior working experience in a successful incumbent firm may also increase the reputation of the spin-off firm, providing, for instance, better access to start-up capital, employees and customers (Stuart and Sorenson, 2003).

Thus, spin-off firms are expected to be more innovative as compared to other entrants, because founders can build on pre-entry experience and relationships established during their previous jobs at parent firms. With respect to geography, empirical studies tend to demonstrate that spin-offs locate where their parents are based. We have, however, little understanding of why this might be the case. A plausible explanation is that spin-offs, like any other start-up, start their business in the region where the founder lives, which most probably means, in the case of spin-offs, near the parent organisation. Another explanation might be that spin-offs maintain pre-established relationships, either with the parent organisation, or with other (local) agents, which may keep the founders in their home region (Sorenson, 2003). In other words, the spin-off process may be regarded as a powerful mechanism through which knowledge diffusion takes place in a rather limited geographical area.

Network relationships

In the foregoing, we mentioned that the economic success of spin-off firms may be attributed to pre-established relationships with the parent organisation, or with other agents. The same applies to firms in general. Lundvall (1988) was one of the first to recognise the importance of trust-based relationships between suppliers and users for interactive learning processes to take place.

It is commonly stressed in the literature that network relations facilitate the transfer of tacit knowledge (Gertler 2003). It requires that exchanging partners share some basic similarities such as a language, common 'codes' of communication, shared conventions and norms, and personal knowledge of each other based on a past history of successful collaboration or informal interaction. Firms involved in strong network relations with other firms are often assumed to be more capable to adapt their product. To get an insight into the needs of the customers, firms regularly meet with customers to test their product and adapt it to the specific needs of their customers. To obtain the necessary inputs, firms have to interact with suppliers to clarify their specific demands. However, as mentioned before, it should not be overlooked that network relationships may also turn into over-embedded relationships, leading to situations of negative lock-in (Uzzi, 1997).

What is important to note is that network relationships are not necessarily local. As mentioned before, firms may benefit from agglomerations because they provide access to a great number of potential suppliers, customers and other organisations. However, non-local relationships may be as important as local ones, providing an additional mechanism for interactive learning and knowledge creation. The essence is that effective knowledge transfer requires mutual understanding between agents, which are accomplished in social networks, or communities of practice (Breschi and Lissoni, 2002). Such network constellations do not necessarily require permanent co-location. Most recently, the literature stresses that network relationships organised at the local level run the risk of over-embeddedness. In that respect, establishing non-local relationships is central, because they may bring new variety into the organisation.

Dynamic perspective on the spatial evolution of industries

In the foregoing, we presented in a rather static way three mechanisms (agglomeration economies, spin-offs and networks) that may explain the spatial formation of new industries. We now add a dynamic perspective, presenting an industry's life cycle approach, which assumes these mechanisms to play a different role in different phases. For the sake of simplicity, we distinguish between two stages of development of a new industry, that is, a first phase (rise and early expansion) and a second phase (late expansion and maturing phase).

Since Vernon (1966), it is common to believe that the positive effects of urbanisation economies at the first stage of development will be overtaken by localisation economies based on specialisation as an industry develops. In the first phase of the life cycle, access to external information and know-how is essential, because the technologies the new firms use, and the products they develop and merchandise, are not (yet) standardised. Big agglomerations are likely to offer such attractive settings, because they provide access to generic resources like labour, capital and other inputs. However, at this stage, localisation economies based on related variety may also play a role, because they offer a stock of potential entrepreneurs and skilled labour that can be readily exploited by entrants in the new industry.

By contrast, localisation economies based on specialisation do not play a role at this stage, because the new industry requires new types of knowledge, skills and inputs which existing individuals and organisations (with old habits and routines) cannot provide (Boschma and Lambooy, 1999). However, when the industry grows and concentrates in space, localisation economies based on specialisation play a more pronounced role, because a specialised labour force, specialised suppliers and specific knowledge become increasingly available, stimulating the further spatial concentration of the industry.[1] The same applies to the potential effects of local competition that are expected to become stronger in later stages of development (Klepper, 1996).

Similarly, spin-off dynamics will hardly matter in the first stage, because there are simply few firms with a great deal of experience in the new field of economic activity. The exception will be those entrants that are founded by employees of pre-existing firms in related industries (Boschma and Wenting, 2004). At later stages, spin-offs (especially the ones having experience in successful parents) will be of increasing importance, despite the fact that competition pressures increase and entry barriers rise. The same line of reasoning applies to network relationships with suppliers. For instance, the new industry will benefit from network relationships only when its demand for specialised inputs has reached such levels that specialised suppliers can survive and prosper. This is confirmed by low levels of vertical disintegration at the start of a new industry (Klepper, 1996), which makes it unlikely that firms profit from specialised suppliers.

Summary

The foregoing leads us to the following interim conclusions. We expect that urbanisation economies, but especially localisation economies based on related variety, matter in the early phase of development of a sector. By contrast, localisation economies based on specialisation, local competition, spin-off dynamics and network relationships will matter more in the second phase of the life cycle of an industry.

When applying and testing these ideas to the case of the software industry, we have to account for some peculiar features of this industry. First, since we do not conduct a long-term analysis of the software sector, it is important to determine which phase of its life cycle the sector is in now. In the next section, we will clarify that the software sector is currently in the expansion phase, meaning we expect urbanisation economies and localisation economies by related variety to affect positively the performance of software firms. In addition, we have to reformulate and specify in more detail the above-mentioned hypothesis concerning network relationships. First, network relationships with suppliers are expected to be of minor importance in the software industry, because these are often rather standardised (Casper and Whitley, 2004). Second, network relationships (in terms of regular interactions) with customers are, on the other hand, considered essential, due to the specific nature of services, being in general less standardised than manufacturing products. As far as the software sector is concerned, this is even more true, because it concerns customised production almost as a rule. Third, network relationships with competitors are also expected to be of importance, because it is quite common in the software sector to work and produce together in projects (Grabher, 2002).

Spatial evolution of the Dutch computing services and software industry

As in other western countries, the computing services and software industry grew swiftly in the Netherlands during the second half of the 1990s. Figure 4.1 shows that the industry demonstrated a rather steady growth during the 1980s and the beginning of the 1990s, followed by an accelerating growth in later years due to the widespread adoption of the personal computer and the rise of the Internet. From 2001 onwards, the growth of the number of computing services and software firms has somewhat flattened out, due to the end of the Internet boom. Nevertheless, the number of firms active in this sector still continues to rise, although at a much lower pace.

In Figure 4.2, we get a more detailed picture concerning the evolution of the Dutch computing services and software sector (NACE 72)[2] in terms of the number of entrants, bankruptcies and the total number of firms. The year 1995 is used as an index to show the relative growth of the industry since that time. Clearly, the number of bankruptcies increased dramatically. However, this should be put in perspective. In absolute numbers, only 311 software firms went bankrupt in 2002, out of a total number of 17,991 software firms (Statistics Netherlands, 2003). Moreover, in 2001, the number of entrants still exceeded by far the number of bankruptcies, resulting in a growth of the total number of firms. But one should remember that bankruptcies form only a small part of all firms that exit an industry. For instance, in 1999, Statistics Netherlands reported 13,000 closures, but only 3,000 actual bankruptcies. Therefore, the number of exits in the computing

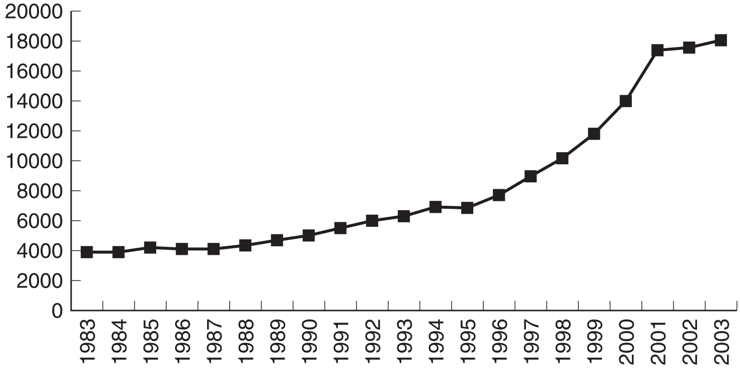

Figure 4.1 Number of computing services and software firms in the Netherlands 1983–2003 (NACE 72).
Source: Weterings (2005).

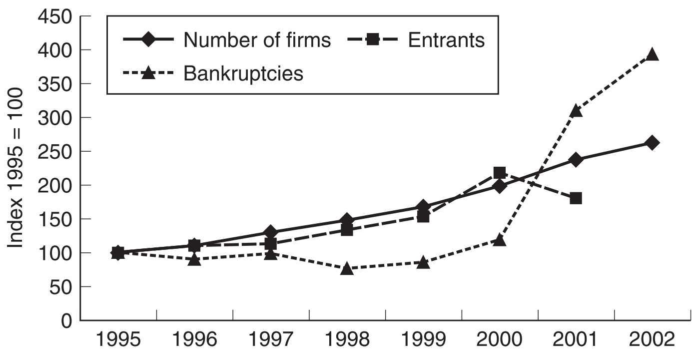

Figure 4.2 Index of number of firms, entrants and bankruptcies in the Dutch computing services and software sector 1995–2002 (NACE 72).
Source: Statistics Netherlands (2003).

services and software sector is probably much higher than the number of bankruptcies presented in Figure 4.2. This is even more true when one notes that the percentage of bankruptcies in the software sector is almost twice that percentage for all Dutch industries. Whatever the exact figures, it is still too early to say if the rise in bankruptcies indicates the start of a shakeout in the software sector, which is commonly observed at some stage of development of an industry (Klepper, 1996). The rise of the number of exits might be temporary because the drop in firm growth might be caused by short-term business cycles. In addition, the growing importance of the Internet still offers many new market opportunities, while there is no sign of market dominance by a few players. On the contrary, the Dutch software sector consists of many small firms specialised in niches of the business-to-business market. Although tendencies towards standardisation exist, many different standards still co-exist in software (Grimaldi and Torrisi, 2001). In sum, there is ample reason to believe that the Dutch computing service and software sector is currently in its expansion phase, which corresponds more or less with the end of the first phase or the start of the second phase of the industry's life cycle outlined in the previous section.

In Figure 4.3, we have depicted the spatial evolution of the Dutch computing services industry for the period 1981–2001, measured as location quotients in the 40 so-called COROP regions of the Netherlands. A location quotient of more

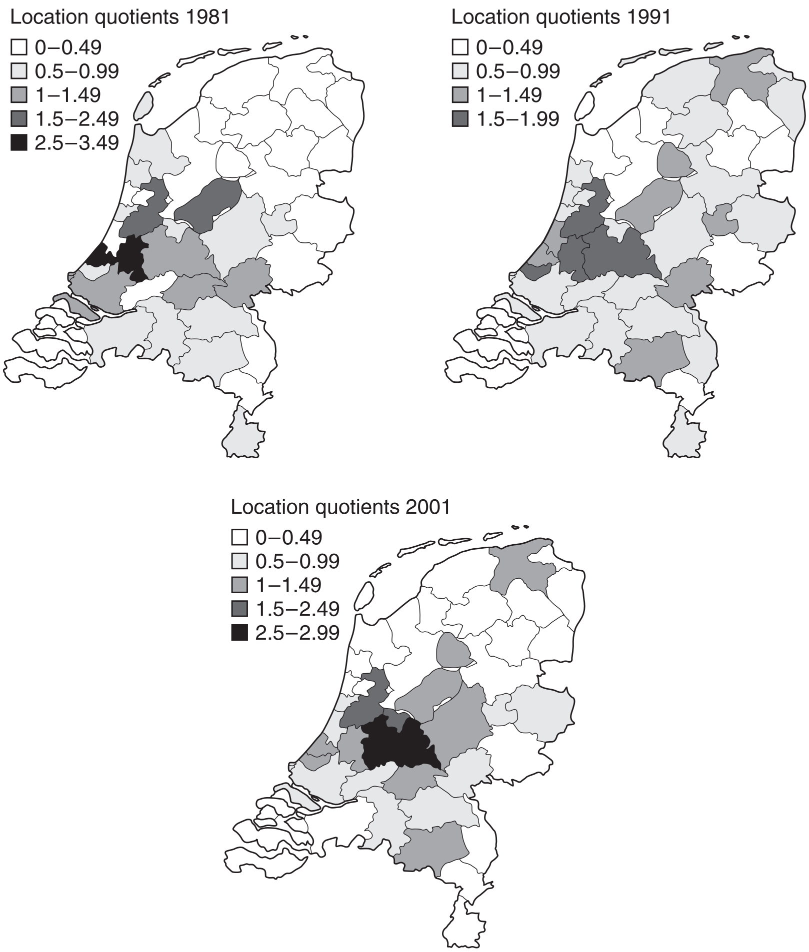

Figure 4.3 Location quotients of the employment in the computing services industry in 40 COROP regions in 1981, 1991 and 2001.
Source: Koerhuis and Cnossen (1982); Netherlands Institute for Spatial Research (2003).

than 1 means that the share of employment in this sector in a region is higher than its regional share of employment in all industries in the Netherlands. By and large, one can observe that, until the 1980s, the computing services industry mainly developed in the economic core areas of the Netherlands, that is, the Randstad in the west. In the 1980s, a typical process of spatial diffusion to more peripheral areas took place, while, at the same period, the industry became more and more concentrated in the Amsterdam and the Utrecht regions. In the 1990s, a reverse process of spatial concentration occurred, reinforcing the leading position of the Utrecht region. This latter outcome of further spatial concentration of the Dutch computing services sector is confirmed by an increase of the Gini coefficient from 20 in 1991 to 27 in 2001.

Figure 4.4 allows us to take a more detailed look at the latest period, describing the spatial evolution of the software services sector (NACE 72101, 72102 and 7220) in terms of number of firms, rather than in terms of employment. Once again, the location quotients of the 40 COROP regions are presented. Not surprisingly, the Utrecht region, followed by the Amsterdam region, shows the highest scores. However, what is also noticeable is an emerging corridor of software companies along the A2 highway in the central part of the Netherlands, stretching from north to south.

Operationalisation

A sound analysis of the spatial evolution of an industry requires at least data on the location of all entrants and exits, their pre-entry techno-economic background, data on the growth and decline of incumbent firms, data on (different types of) linkages between firms, etc. However, as is the case for other industries, such data are not available for the computing services industry in the Netherlands. We have gathered cross-sectional data by two telephone surveys among 265 software firms located in the Netherlands (see for details, Boschma and Weterings, 2005). As a result, we have not conducted a duration analysis of the software sector. Instead, we have taken a snapshot of an industry that is still in the midst of its expansion phase, in order to assess the current impact of geography on the innovative performance of Dutch software firms.

This section provides information on the data we used and the indicators we measured, in order to assess the effects of (different) types of agglomeration economies, spin-offs and network relationships. First, we explain the use of innovative productivity as the dependent variable in our model. Then, we set out which independent variables have been included in the estimation model. Finally, we present some descriptive statistics concerning the main variables.

Innovative productivity

We have used three dependent variables to measure the innovative performance of software firms. In our survey, firms were considered innovative when they had launched a new product or service on the market since 2000. These firms were

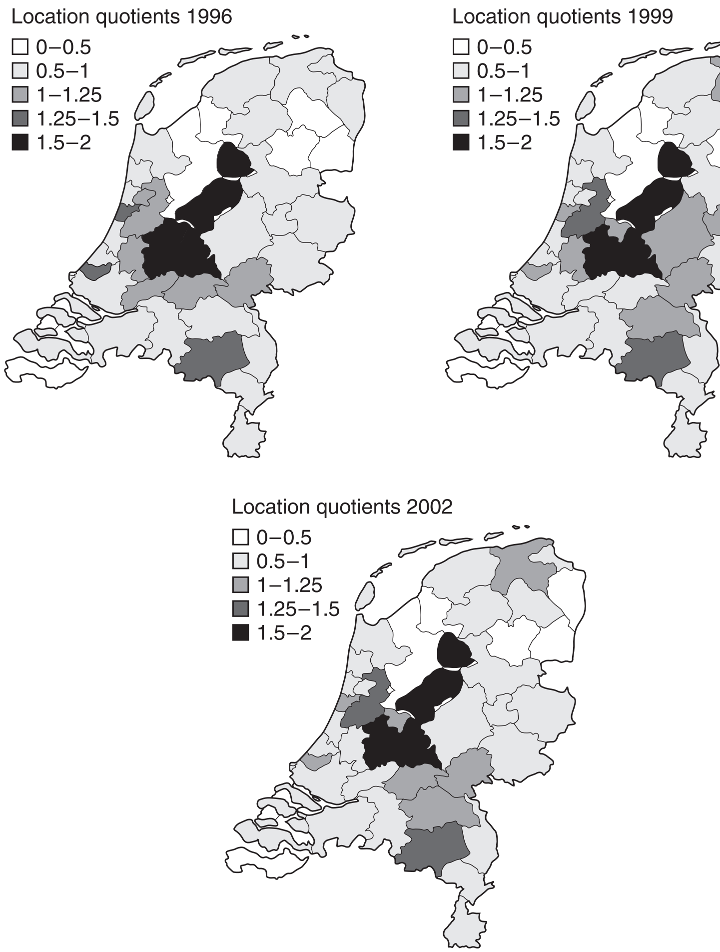

Figure 4.4 Location quotients of the number of software services firms in 40 COROP regions in 1996, 1999 and 2002.
Source: Netherlands Institute for Spatial Research (2003).

further interviewed about their innovative performance. The first variable measures the innovation input of firms. That is, we have collected data at the firm level on the average percentage of total employment that contributed to the development of the new product or service between 2000 and 2003. The second dependent variable we used concerns innovation output. This has been measured by the percentage of new products or services in the total turnover of the firm during the last year. The third variable measures innovative productivity by dividing the innovation output and the innovation input of the firm. Often the innovative performance of firms is considered to be higher when the innovation input is higher. However, when a firm invests more in innovations than it gains from it, this negatively affects the performance of the firm. Simply put, when innovation input is higher than innovation output, the innovation efficiency of firms is lower. The third indicator for innovative performance accounts for both the input and output dimensions of innovation (Klepper and Simons, 2000) and, therefore, enables us to measure the efficiency of the innovative behaviour of the firms.[3]

Independent variables

As mentioned before, our analysis aims to assess how agglomeration economies, pre-entry experience and network relationships affect the innovation input, output and innovative productivity of software firms in the Netherlands.

The different types of agglomeration economies have been gauged by five measures on the regional level (i.e. COROP level), which have been subsequently linked to the firm level (see for details, Boschma and Weterings, 2005). As a proxy for urbanisation economies, we have measured the number of inhabitants per region. In order to assess the impact of localisation economies by specialisation, we have constructed location quotients with respect to employment in the software sector per region. To measure localisation economies by related variety, we consider ICT services as being closely related to the software industry. ICT services (NACE 72) are more broadly defined than the software industry alone, incorporating, for instance, ICT consultancy activities. Consequently, we measure localisation economies by related variety with the assistance of location quotients based on employment in ICT sectors per region. In addition, we included a variable that denotes sectoral diversity per region, to account for Jacobs' externalities. This measure of regional diversity of sectors has been computed by Gini coefficients using regional employment figures (see Weterings 2005). A high coefficient means that employment is more unequally distributed across sectors in a region. Finally, we have assessed the effect of local competition by the number of software firms per region.

Having defined these indicators at the regional level for different dimensions of agglomeration economies, it turned out, however, that these indicators suffered from high correlations between the measures for sectoral diversity by region (Gini coefficient), total population per region, and the degree of local competition. To avoid any problems of multicollinearity, we have limited the variables for agglomeration economies to urbanisation economies (population per region), localisation economies by specialisation, and localisation economies by related variety.

As stated above, we expect the pre-entry experience of the founders positively to affect the innovative performance of their firms. We have constructed three dummy variables that take this issue of previous working experience into account. First, we have constructed a variable that measures whether at least one of the founders of the firm had working experience in the software sector, and thus, could be considered a spin-off firm or not. Being a dummy variable, it can be

Table 4.1 Descriptive statistics of the dependent and independent variables in the model

	Mean	*Std. Dev.*	*Minimum*	*Maximum*	*N*
Innovation input	50.14	28.28	0.10	100.00	184
Innovation output	41.11	31.31	0.00	100.00	169
Localisation economies by specialisation	1.13	0.73	0.22	2.71	184
Localisation economies by related variety	1.24	0.67	0.31	3.80	184
Population per region	629,941	372,797	104,168	1,356,393	184
Pre-entry experience in software industry	0.30	0.46	0.00	1.00	184
Relationship with previous employer	0.34	0.48	0.00	1.00	181
Location near previous employer	0.61	0.49	0.00	1.00	181
Relationship with customers	0.64	0.48	0.00	1.00	184
Regular contact with competitors	0.63	0.49	0.00	1.00	184
Type of innovation	0.74	0.44	0.00	1.00	176
Size of the firm	14.82	23.28	2.00	230.00	184
Age of the firm	10.95	5.86	4.00	28.00	184

observed in Table 4.1 that 30% of all firms are established by at least one founder who had previously worked at a software company. The two other variables account for the questions whether the founder retained a close relationship with the previous employer, and whether the firm was located near the previous workplace. As shown in Table 4.1, this was true for 34% and 61% of the firms that were established by founders who used to work at another firm (not limited only to working experience at software firms). In our models, no working experience at all was also set at a value of 0. However, it made no difference to the estimation results whether or not firms with founders who have no working experience were included in the analysis.

To probe the effect of network relationships, we made two dummy variables considered particularly relevant for the software sector. The first variable concerns the type of relationship with customers, because customer demand is often regarded as the main incentive for new product development in the software sector. A value of 1 means that the firm has a relationship with customers in which they develop software together, or regularly discuss face-to-face the product design to adapt it to their needs. The second variable concerns regular contact with competitors. We expect regular contacts with other software firms to be highly beneficial, because it is common in the software sector to work together in a project, resulting in inter-firm learning (Grabher, 2002). As mentioned before, network relationships with suppliers were not included in the analysis, because they often involve standardised relationships.

Finally, we included three control variables that may affect the dependent variable. The first variable measures the type of innovation strategy. Following the innovation literature, we made a clear distinction between incremental and radical strategies, measuring whether a firm focused mainly on developing totally new products, or whether it aimed at building on existing products. The second variable concerns the size of the firm, measured as number of fulltime employees per firm. The third variable measures the number of years the firm exists, as a proxy for the age of the firm.

Empirical results

The objective of the analysis is to assess whether different dimensions of agglomeration economies, pre-entry experience and network relationships affect the innovation input, innovation output and innovative productivity of software firms in the Netherlands. Since all three dependent variables cannot take a value below zero and innovation input and output not above 100, we have used a Tobit model, instead of Ordinary Least Squares. This is because a Tobit model can cope with dependent variables above or below some limit value (McDonald and Moffit, 1980).[4]

In Table 4.2, the main results are presented. We estimated three models, each with a different dependent variable (innovation input, innovation output and innovative productivity, respectively). In Table 4.2, we have indicated the coefficients of all the explanatory variables and one interaction effect. In the model with innovation output as dependent variable (model 2), we have added the variable innovation input, in order to determine its impact on innovation output.

As far as the different dimensions of agglomeration economies are concerned, only the indicator for localisation economies by related variety had a significant effect. Contrary to our expectation, this factor affects the innovation input of software firms in a negative way: software firms in regions with many closely related computing services firms develop new products or new services with less employees. However, since this indicator does not affect innovation output, the firms in those regions have higher innovation efficiency, as demonstrated by its positive and significant coefficient in model 3. The results also confirm our hypothesis that localisation economies by specialisation do not play a role at this stage of the life cycle of the software industry. Contrary to our expectation, urbanisation economies do not have any influence either: densely populated areas do not offer an environment that enhances the innovative performance of software firms.

The effect of the pre-entry experience of firms on their innovative performance shows up in different ways. First, as expected, pre-entry working experience of the founder in the software industry has a positive and significant effect on the innovative productivity of software firms (see model 3). In addition, while continued involvement with the previous employer did not affect the innovative performance of firms, remaining located in the same region as the founder previously worked had a positive, significant effect on innovation output. However, when including an interaction effect, Table 4.2 shows that there is a negative and significant interaction between being located near the previous employer and remaining closely linked with the parent firm on innovation output. In other words, being located near the previous employer turns into a negative effect when the software firms also maintained contacts with the parent. This outcome lends support to the proposition that local relationships with the previous employer may become over-embedded, having a negative effect on the innovative performance of firms.

Contrary to our expectations, the variables measuring the effect of network relationships do not play any role in the model. Table 4.2 also shows that the control variables (measuring firm-specific features) affect the innovative performance of software firms. Confirming other studies (Kleinknecht, 1996), we found

Table 4.2 Estimation results, explaining the innovation input, innovation output and the innovative productivity of Dutch software firms (standard errors in parentheses)

	Model 1	*Model 2*	*Model 3*
Dependent variable	Innovation input	Innovation output	Log (innovative productivity + 1)
Constant	75.22***	−9.32	1.27***
	(8.795)	(12.34)	(0.22)
Log (localisation economies by specialisation)	2.23	−10.01	−0.15
	(11.26)	(12.35)	(0.27)
Localisation economies by related variety	−7.48**	3.00	0.14*
	(3.44)	(3.80)	(0.08)
Number of inhabitants per COROP region	−0.00	−0.00	−0.00
	(0.00)	(0.00)	(0.00)
Pre-entry experience in software industry	−1.54	4.50	0.18*
	(4.27)	(4.76)	(0.10)
Relationship with previous employer	−6.11	−0.49	−0.06
	(6.84)	(7.47)	(0.16)
Location near previous employer	−2.00	11.81**	0.08
	(4.77)	(5.26)	(0.12)
Relationship with customers	6.47	2.48	0.03
	(4.01)	(4.49)	(0.10)
Regular contacts with competitors	5.11	0.38	0.05
	(3.92)	(4.38)	(0.10)
Location near previous employer* relationship with previous employer	14.15*	−14.94*	−0.16
	(8.08)	(8.97)	(0.19)
Innovation input		0.67***	
		(0.09)	
Incremental innovation	−3.28	16.40***	0.42***
	(4.66)	(5.19)	(0.11)
Log (full-time employment)	−27.07***	6.92	0.18
	(5.34)	(6.62)	(0.13)
Firm age	0.42	−1.00***	−0.02**
	(0.34)	(0.38)	(0.01)
Number of observations	*171*	*164*	*164*
Sigma	*24.50****	*26.29****	*0.58****
-2 Log likelihood	*1579.20*	*1456.51*	*301.00*
Pseudo R square	*0.206*	*0.326*	*0.162*

Note
*$p < 0.10$; $p < 0.05$; $p < 0.01$.

evidence that an innovation strategy aimed at developing incremental innovations has a positive, significant effect on innovation output and innovative productivity. The results also show that the size of firms has a negative effect on innovation input only: the larger the software firm, the less inputs are devoted to developing new products or services. Finally, firm age has a significant and negative impact on innovation output and innovative productivity, meaning that younger firms perform better.

Conclusions

Inspired by evolutionary thinking, the aim of this chapter was to test whether, and to what degree, different dimensions of agglomeration economies, pre-entry experience and networks relationships, when controlling for some firm-specific features, affected the innovative performance of firms in the Dutch software sector. Being a sector in the midst of its expansion phase, we expected that urbanisation economies, localisation economies by related variety, and network relationships with customers and competitors would matter more. By contrast, other factors, like localisation economies by specialisation and spin-off dynamics, were assumed to matter less at this stage of development.

Some outcomes confirmed our expectations. First, software firms indeed performed better in locations with much related variety (i.e. ICT sectors). Second, localisation economies by specialisation did not matter, at least not at this stage of the life cycle of the software industry. This might of course change in the near future, when the sector is more likely to be confronted with processes of market concentration and, thus, spatial concentration. It was unexpected, though, that firms do not perform better when they are located in densely populated areas, or when they have strong network relationships with customers (and competitors). In other words, having access to large potential and critical markets does not enhance the innovative performance of software firms. In addition, the outcomes suggest that software firms perform better when founded by someone who previously worked in the software sector. This outcome suggests that the software sector has already developed to such an extent that spin-off dynamics make a difference.

What conclusions can we draw from these results as far as the impact of geography is concerned? Our outcomes suggest that geography plays a crucial role in various ways. First, a key result is that localisation economies by related variety matter. It is yet uncertain, however, how locations endowed with related sectors affect the innovative performance of software firms: does it function through knowledge spillovers, entrepreneurial dynamics, or is it because of labour market mobility? Second, our results confirm that the spin-off process may indeed be regarded as a powerful mechanism through which knowledge diffusion takes place in a rather limited geographical area. In fact, since most spin-off firms in the software sector (about 60%) locate where their parents are based, and because spin-offs perform better than average, inter-firm transfer of knowledge through spin-offs mostly takes place at the local level. Third, an interesting result was that being located near the previous employer turned into a negative effect when the software firms also maintained a strong relationship with the parent. This lends strong support to the proposition that local relationships with the previous employer may become over-embedded, having a negative effect on innovative performance of firms.

Notes

1 When the product and production process standardises, relations with suppliers and customers will require less interaction and highly educated employees become less important: the more standardised activities will move to lower-cost peripheral areas (Vernon, 1966).

2 These data are based on the total number of firms registered at the 2-digit NACE code 72 because Statistics Netherlands only provides these data on the 2-digit level. Data on the number of entrants in 2002 are not yet available.

3 46 firms younger than 3 years were not included in the analysis, to avoid any bias in the data set. Another 16 firms were excluded from the analysis due to missing values.

4 Since tobit models do not include a R square, we have used a modified version of the McKelvey–Zaviona statistic to calculate a pseudo R square.

References

Agarwal, R., Echambadi, R., Franco, A.M., Sarkar, M.B. (2004), Knowledge transfer through inheritance: spin-out generation, development and survival, *The Academy of Management Journal*, 47 (4): 500–21.

Arthur, W.B. (1994), Urban systems and historical path-dependence, in: Arthur, W.B., *Increasing Returns and Path Dependence in the Economy*. Ann Harbor: Michigan Press, chapter 6.

Boschma, R.A. (2005), Proximity and innovation. A critical assessment, *Regional Studies*, 39, 1, pp. 61–74.

Boschma, R.A. and K. Frenken (2003), Evolutionary economics and industry location. *Review of Regional Research*, 23, pp. 183–200.

Boschma, R.A. and J.G. Lambooy (1999), Evolutionary economics and economic geography, *Journal of Evolutionary Economics*, 9, 3, pp. 411–29.

Boschma, R.A. and R. Wenting (2004), The spatial evolution of the British automobile industry, *papers in Evolutionary Economic Geography*, no. 05.04, Utrecht: Faculty of GeoSciences, Utrecht University.

Boschma, R.A. and Weterings (2005), The effect of regional differences on the performance of sofware firms in the Netherlands, *Papers in Evolutionary Economic Geography*, Utrecht: Faculty of GeoSciences, Utrecht University.

Breschi, S. and F. Lissoni (2002), *Mobility and Social Networks: Localised Knowledge Spillovers Revisited*. Paper presented to the Workshop 'Clusters in high-technology: aerospace, biotechnology and software compared'. Montreal, 1 November.

Brüderl, J. and P. Preistendörfer (1998), Network support and the success of newly founded businesses. *Small Business Economics*, 10 (3), pp. 213–25.

Buenstorf, G. and S. Klepper (2004), The origin and location of entrants in the evolution of the US tire industry (mimeo).

Cantner, U., K. Dressler and J.J. Kruger (2004), Firm survival in the German automobile industry, *Jenaer Schriften zur Wirtschaftswissenschaft*, 8, pp. 1–14.

Casper, S. and R. Whitley (2004), Managing competences in entrepreneurial technology firms: a comparative institutional analysis of Germany, Sweden and the UK, *Research Policy*, 33 (1), pp. 89–106.

Cooke, P. and K. Morgan (1998), *The Associational Economy. Firms, Regions, and Innovation*. Oxford: Oxford University Press.

Cooke, P., M.G. Uranga and G. Extebarria (1998), Regional innovation systems: an evolutionary perspective, *Environment and Planning A*, 30 (9), pp. 1563–84.

Feldman, M.P. (1994), *The Geography of Innovation*. Kluwer Publishers, Dordrecht.

Feldman, M.P. and D.B. Audretsch (1999), Innovation in cities: science-based diversity, specialisation and localized competition. *European Economic Review*, 43 (2), pp. 409–29.

Frenken, K., F.G. van Oort, T. Verburg and R.A. Boschma (2004), *Variety and regional economic growth in the Netherlands*, final report to the Ministry of Economic Affairs, research programme Space and Productivity, December, pp. 1–58.

Gertler, M.S. (2003), Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there), *Journal of Economic Geography*, 3, pp. 75–99.

Glaeser, E.L., H.D. Kallal, J.A. Scheinkman and A. Schleifer (1992), Growth of cities, *Journal of Political Economy*, 100 (6), pp. 1126–52.

Grabher, G. (2002), The project ecology of advertising: tasks, talents and teams, *Regional Studies*, 36 (3), pp. 245–62.

Granovetter, M. (1985), Economic action and social structure: the problem of embeddedness, *American Journal of Sociology*, 91 (3), pp. 481–510.

Grimaldi, R. and S. Torrisi (2001), Codified-tacit and general-specific knowledge in the division of labour among firms. A study of the software industry, *Research Policy*, 30 (9), pp. 1425–42.

Helfat, C.E. and M.B. Lieberman (2002), The birth of capabilities: market entry and the importance of pre-history, *Industrial and Corporate Change*, 11 (4), pp. 725–60.

Henderson, J.V., A. Kuncoro and M. Turner (1995), Industrial development in cities, *Journal of Political Economy*, 103 (5), pp. 1067–85.

Jacobs, J. (1969), *The Economy of Cities*. New York: Vintage Books.

Jacobs, J. (1985), *Cities and the Wealth of Nations*. New York: Vintage Books

Kleinknecht, A. (1996), New indicators and Determinants of Innovation: an introduction. In: Kleinknecht, A. (Ed.), *Determinants of Innovation. The Message from New Indicators*. London: Macmillian Press ltd.

Klepper S. (1996), Entry, exit, growth and innovation over the product life cycle, *American Economic Review*, 86 (3), pp. 562–83.

Klepper, S. (2002), *The evolution of the US automobile industry and Detroit as its capital*. Paper presented at the 9th Congress of the International Joseph A. Schumpeter Society, Gainesville, Florida, March.

Klepper, S. and K.L. Simons (2000), Dominance by birthright: entry of prior radio producers and competitive ramifications in the US television receiver industry, *Strategic Management Journal*, 21 (10/11), pp. 997–1016.

Koerhuis, H. and W. Cnossen (1982), *The Software and Computing Services Firms*. Groningen: Geografisch Instituut Rijksuniversiteit Groningen (in Dutch).

Lambooy, J.G. (2002), Knowledge and urban economic development. An evolutionary perspective, *Urban Studies*, 39(5/6), pp. 1019–35.

Lundvall B.A. (1988), Innovation as an interactive process: from user–producer interaction to the national system of innovation. In: G. Dosi, C. Freeman, R. Nelson, G. Silverberg, L. Soete (Eds), *Technical Change and Economic Theory*. London: Pinter Publishers, pp. 349–69.

McDonald, J. and R. Moffit (1980), The uses of Tobit Analysis, *Review of Economics and Statistics*, 62 (2), pp. 318–21.

Nelson, R.R. and S.G. Winter (1982), *An Evolutionary Theory of Economic Change*. Cambridge: Harvard University Press.

Netherlands Institute for Spatial Research (2003), Work. In: Netherlands Institute on Spatial Research, *The Unknown Space Explored*. Den Haag: RPB en NAi-uitgevers (in Dutch), chapter 3.

Nooteboom, B. (2000), *Learning and Innovation in Organizations and Economies*. Oxford University Press, Oxford.

Porter, M. (1990), *The Competitive Advantage of Nations*. New York: Free Press.

Sorensen, O. (2003), Social networks and industrial geography, *Journal of Evolutionary Economics*, 13 (5), pp. 513–27.

Statistics Netherlands (2003), The digital economy 2003. http://www.cbs.nl (in Dutch).

Storper, M. (1997), *The Regional World. Territorial Development in a Global Economy*. London: Guilford Press.

Storper, M. and R. Walker (1989), *The Capitalist Imperative; Territory, Technology and Industrial Growth*. New York: Basil Blackwell.

Stuart, T.E. and O. Sorenson (2003), The geography of opportunity: spatial heterogeneity in founding rates and the performance of biotechnology firms, *Research Policy*, 32 (2), pp. 229–53.

Uzzi (1997), Social structure and competition in interfirm networks: the paradox of embeddedness, *Administrative Science Quarterly*, 42 (1), pp. 35–67.

Vernon, R. (1966), International investment and international trade in the product cycle, *Quarterly Journal of Economics*, 80 (2), pp. 190–207.

Weterings, A. (2005), The spatial clustering of knowledge-intensive services: computing services in the Netherlands. In: Boschma, R.A. and R. Kloosterman (Eds), *Learning from Clusters. A Critical Assessment*. Dordrecht: Springer Verlag, pp. 361–87.

Appendix 4.1 Correlation matrix between the independent variables

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1. log software specialisation of the region	–										
2. localisation economies by related variety	0.50***	–									
3. population per region	0.15**	0.49***	–								
4. spin-off	−0.06	−0.00	−0.11*	–							
5. relationship prev. employer	−0.02	−0.07	−0.04	0.07	–						
6. location near parent firm	0.12*	0.09	0.17**	0.02	0.31***	–					
7. Relationship with customers	−0.10*	−0.07	−0.04	−0.06	−0.08	0.01	–				
8. Regular contact competitors	0.07	0.06	0.01	0.00	0.14**	0.12*	−0.03	–			
9. Type of innovation	0.06	0.08	0.04	−0.03	0.17**	0.21***	−0.07	0.03	–		
10. Innovation input	−0.08	−0.21***	−0.15**	0.01	0.06	0.03	0.10*	0.05	−0.10	–	
11. Log full-time employment	0.15**	0.13**	0.12**	0.01	−0.02	0.02	−0.01	0.06	0.16**	−0.39***	–
12. Age of the firm	0.04	0.04	−0.04	−0.13**	−0.05	−0.04	−0.03	0.02	−0.01	−0.07	0.24***

Notes
*$p < 0.10$; $p < 0.05$; $p < 0.01$.
Pearson product-moment correlation, one-tailed with pairwise deletion ($n = 184$).

5 Constructing regional advantage at the Northern Edge

Lars Coenen and Bjørn T. Asheim

Introduction

Pressed to secure competitiveness and employment in a globalizing economy, with firms competing for markets around the globe, policy makers in OECD countries have become increasingly interested in concepts related to the learning economy (Lundvall and Johnson, 1994) as well as the knowledge-based economy (OECD, 1996). This arguably paradigmatic change in thinking on 'real' economic development is grounded in two basic ideas: firstly that knowledge is the most strategic resource, and secondly that learning is the most fundamental activity for the competitiveness of firms, regions and nations.[1] According to this rationale, innovation is essential for economic growth, thus, the contemporary economy is understood beyond the perspectives of mainstream economics (Lundvall, 1998). This notion lies at the core of the systems of innovation approach. Characteristic for this approach is the acknowledgement that innovations are carried out through a systemic networking of various actors underpinned by an institutional framework (Edquist, 1997).[2] These actors often belong to the 'triple helix' of industry, university and government (Etzkowitz and Leydesdorff, 2000). Institutions, understood as sets of common habits, routines, established practices, rules or laws, regulate the relations and interactions between these actors (Edquist and Johnson, 1997). Initial and breakthrough work on innovation systems was predominantly carried out on the national level, gathered under the National Innovation Systems (NIS) approach (Freeman, 1987; Lundvall, 1992; Nelson, 1993). In the meantime, a set of varieties of innovation systems have been established taking sectors (Sectoral Innovation Systems), technologies (technological systems) or specific territories (Regional Innovation Systems) as their point of departure.[3]

In fact, one can witness an increased attention for the importance of geography in the learning economy. This is partly due to a set of regional success stories, such as that of the highly innovative Silicon Valley (Saxenian, 1994), as well as the popularity of the cluster concept (Porter, 1990, 2000). Increasingly, a 'concentration of "interdependent" firms within the same or adjacent industrial sectors in a small geographic area' (Isaksen and Hauge, 2002: 14) is seen as *the* source and carrier of competitive advantage. This argument can be traced back to the enhanced capacity of territorial agglomerations to promote innovation among its constituents (Marshall, 1919). The cluster concept has proven to be highly user-friendly, diffusing easily among a wide variety of policy-makers across the world. Even though it has received sharp criticism for being too fuzzy both in terms of its key concepts and its geographical demarcations (Martin and Sunley, 2003), its proliferation has contributed substantially in promoting endogenous regional economic development based on innovation and interactive learning between territorially agglomerated economic agents (Benneworth and Henry, 2003).

At the conjunction of the systems of innovation approach and the cluster concept we find the Regional Innovation Systems (RIS) approach, first introduced by Cooke (1992) and further developed by (among others) Asheim and Gertler (2005), Braczyk *et al.* (1998), Cooke *et al.* (2000) and Nilsson *et al.* (2003). It provides an amalgam of earlier ideas and theories on territorial innovation models in a knowledge-based and learning economy (Doloreux, 2002). A regional innovation system is generally defined as the systemic interaction between (1) the regional production structure or knowledge exploitation subsystem which consists mainly of firms, especially where these display clustering tendencies, and (2) the regional supportive infrastructure or knowledge generation subsystem which consists of public and private research laboratories, universities and colleges, technology transfer agencies, vocational training organizations, etc. The RIS approach takes its vantage point in localized learning processes and 'sticky' knowledge as a source of competitive advantage for firms, regions and countries (Asheim and Isaksen, 2002). It emphasizes the territorially grounded nature of learning processes, either involving local or extra-local knowledge flows (Asheim, 2002). Thereby learning between economic actors is considered an inherently social process (Lundvall, 1992), opposing traditional, neo-classic approaches which have reduced knowledge to ubiquitous free-flowing information. It can be interpreted as situated action in which the organizational and institutional context provides structures and shared meanings for action and communication in which people are able to learn (Nooteboom, 2000).

Similar to clusters, the RIS approach has found considerable resonance among policy-makers, particularly as a tool to promote innovativeness among small and medium-sized enterprises (SMEs) by connecting them with the regional innovation support infrastructure (Asheim *et al.*, 2003a). Compared to cluster-based policy tools, the RIS approach employs more explicitly a systemic perspective on innovation (Edquist, 1997) as its guiding principle. As such it seeks to enhance stronger collaboration and association between innovating partners (Cooke and Morgan, 1998) recognizing that innovation is fundamentally a localized (though not exclusively local), path-dependent and interactive process between the triple helix of industry, government and university (including other higher education and research institutes). In the introduction to the second edition of the book *Regional Innovation Systems*, Cooke (2004a) explains the continuing Nordic success in the new economic geography of the twenty-first century through sectoral specialization in an increasingly entwined and interdependent regional triple helix. This could partly be attributed to the typical 'coordinated' (Hall and Soskice, 2001) or 'social-democratic' (Amable, 2000) variety of capitalism, which fosters economic coordination and collaboration, typically found in these countries and its regions. Following the aforementioned argument that learning is an inherently socially situated process, we argue that it is important to acknowledge and analyze how the knowledge dynamics of the triple helix within regional innovation systems can be shaped differently because of industry-specific and territorial-institutional (multi-level) dimensions.

In previous work we demonstrated how there is a different logic in constructing regional innovation systems dependent on the predominant industrial knowledge base (Asheim and Coenen, 2005). In a synthetic knowledge base, innovation takes place by application or novel combination of existing knowledge which highlights the importance of applied, problem-related, engineering knowledge often produced through inductive processes. In industries drawing on a synthetic knowledge base the main aim is to support and strengthen localized learning of an existing industrial specialization, i.e. to promote historical technological trajectories based on 'sticky' knowledge. In an analytical knowledge base, innovation is more strongly shaped through the creation of truly new knowledge which highlights the importance of scientific knowledge often based on deductive processes and formal models. In industries drawing on an analytical knowledge base it is a question of promoting new economic and technological activity at the start of an industrial life-cycle requiring close and systemic industry–university cooperation and interaction in the context of e.g. science parks, located in proximity to knowledge-creating organizations (e.g. (technical) universities).

Especially now that RIS and cluster policy have become more and more common and widespread, it has become increasingly important to address industrial and territorial differences in order to make such policy more effective (and avoid best practice models). Taking an actor-based vantage point, this chapter addresses the question how a dynamic and contextualized triple helix model can contribute in constructing regional innovation systems that are sensitive to their industrial and territorial preconditions. In doing so it dismisses a static perspective on RIS but acknowledges Etzkowitz and Leydesdorff's (2000) argument that within an innovation system 'the subdynamics and the levels are . . . reflexively reconstructed through discussions and negotiation in the Triple Helix' (p. 113). Thus, a dynamic triple helix model refers not only to changing relationships between university, industry and government but also to internal transformations within each of the spheres (e.g. university's 'third mission' of direct contribution to industry as well as to society in general). The objective of this chapter is to take a closer look at how localized learning processes and interactive innovations are shaped differently among industry, university and research centres and the public sector in different regional innovation systems by comparing three contrasting RIS. For this purpose we choose to compare a typical synthetic knowledge-based, market-driven, grass-roots RIS – furniture production in Salling, Denmark – a typical analytical knowledge-based, science-driven dirigiste RIS – agrofood in Saskatoon, Canada – as well as current efforts to construct a networked RIS for the food industry in Scania, Sweden.[4] The following section elaborates further on the rationale and form of RIS policy. This is followed by a closer look at social capital and collective learning in communities of practice as specific conceptual tools underlying the construction of RIS. The last section provides the case study-based comparison between the Salling, Saskatoon and Scania regional clusters followed by the conclusions.

The added value of regionalizing innovation policy

Before we start addressing how RIS could be constructed, it would be necessary to discuss the arguably increasing popularity of the regional level for innovation policy. In other words, what is the added value of a regionalization of innovation policy? Even two typical proponents of the national innovation systems approach 'admit' that 'the region is increasingly the level at which innovation is produced through regional networks of innovators, local clusters and the cross-fertilizing effects of research institutions' (Lundvall and Borràs, 1999: 39). Edquist *et al.* (2002) are, however, more cautious with regard to the importance of collaboration between firms and the regional knowledge infrastructure based on disappointing results in their survey on product innovators in the Swedish East Gothia region. Various other empirical studies across a range of industries and regions observe that both local and distant networks are often needed for successful cooperative innovation projects (e.g. Cooke *et al.*, 2000; Gertler and Levitte, 2003; Lagendijk and Oinas, 2005).

To simply assume that collaboration in innovation is best facilitated within the confines of a region due to the virtues of spatial proximity between co-located enterprises would not reflect the realities of on-going globalization processes in the learning and knowledge-based economy (Cooke, 2005). While the presence of social interaction, trust and local institutions represents important supporting conditions for clustering (Maskell *et al.*, 1998) this does not necessarily exclude that both local and non-local knowledge is needed for successful cooperative, innovative projects, in order to go beyond the limits of the region (Asheim and Herstad, 2003; Cooke *et al.*, 2000; Isaksen, 2005; Tödtling and Trippl, 2005). Similarly, the 'local buzz, global pipeline' metaphor stresses the complementary non-local connections that clusters need to tap into to absorb new and valuable knowledge created in other parts of the world and which prevent an adverse cognitive and economic lock-in (Bathelt *et al.*, 2004). This affirms that interactive learning does not need to be territorially confined as the actual explanatory power of proximity does not pertain to its quality of being physically close together as such but because of closeness in terms of relations (e.g. through organizations and networks), reference and knowledge (e.g. norms, values, rules of thought and action) (Coenen *et al.*, 2004; Torre and Gilly, 2000). Rather, the inherently interlocked character of a regional system in overarching structures and institutions refers to a state of *multi-level interdependence* (Howells, 1999). This does not imply any claims for total regional economic sovereignty yet allows for core economic activities within a value chain (including their governance structure) to be concentrated in specific regions (e.g. in the form of clusters) (Asheim and Coenen, 2006). In this light, the systems of innovation approach offers a more pragmatic and policy-benign interpretation of systems as innovation networks underpinned by an institutional framework (Kaufmann and Tödtling, 2001) compared to a Luhmanian social systems interpretation (Bathelt, 2003) which tends to 'over-abstract' the substantial and material content of innovative interaction (Asheim and Coenen, 2006; Miettinen, 2002). As such, regional innovation systems are conceived as open, socially constructed and linked to global, national and other regional systems of innovation within a multilevel governance perspective (Cooke *et al.*, 2000).

Thus it is important not to interpret a RIS as a NIS writ small. Even though the definition of a RIS certainly resembles that of a NIS, i.e. the specific national interplay between the prevailing economic structure and the institutional set-up (Lundvall and Maskell, 2000: 362), an important distinction lies in the notion of embeddedness. This refers to the importance of personal relations and networks for economic action and outcomes ingrained in a social and cultural context through social integration (Granovetter, 1985). Innovation system analyses on the national level often involve a plethora of actors and institutions (i.e. system integration). This makes it difficult to study how embedded learning processes actually take place across the totality of the national system. The problem is sometimes resolved by focusing on specific, important and innovative sectors in the national economy (see for example Edquist and Lundvall, 1993), which, in turn, are often regionally concentrated (e.g. the industrial district of Sassuolo in Emilia-Romagna in the Third Italy (Russo, 1989)). Against this background, Mietinnen (2002) concludes in his review of NIS literature to employ more disaggregated 'reduced-form innovation systems' as the basic unit of analysis. This does not conflict with received wisdom that the national environment remains highly significant for innovating firms (Asheim and Gertler, 2005; Cooke, 2004b; Gertler, 2004) nor does it downplay the importance of extra-local knowledge. It can be argued, however, that RIS provides a more grounded approach to situate socially and institutionally contextualized empirical analysis of innovation systems acknowledging the role of embeddedness to its full right.

In this context it is crucial not to treat geography as simply referring to physical space but to socially constructed, relational space (Morgan, 2004). In a regional innovation system it is therefore insufficient to only rely on the static assemblage of innovating agents and institutions. The system derives its salience from localized and dynamic patterns of communication, search, learning, knowledge-sharing and innovation. For this the regional innovation system leans on its clusters' scope for enhanced knowledge creation and circulation.

> When firms co-locate, a spatially defined community is usually formed that makes it easier for them to bridge communication gaps resulting from heterogeneous knowledge endowments. The innovative capabilities of firms

> are enhanced because co-location can provide them with an arsenal of instruments to obtain and understand even the most subtle, elusive and complex information of possible relevance.
>
> (Malmberg and Maskell, 2002)

The term 'community' acknowledges that the innovative milieu should not be taken for granted but recognizes its deeply constructed nature. However, the assemblage of actors can be extended to include the two other constituents of the triple helix, namely university and government, as important players.

Following insights gained from economic geography and regional studies, regions are more and more seen as starting points for national and supranational (e.g. EU) policy measures pursuing not only traditional redistribution targets (exogenous regional development) but progressively also as active arenas of economic force and growth in their own right (endogenous regional development) (Cooke *et al.*, 2000). From an innovation policy point of view, the latter rationale is of course most relevant. In line with our previous argument about the sharper analytic focus of the RIS approach, regionalization holds the potential for improved 'on-the-ground' policy know-how about the specific conditions of the regional action level. Measures can thus be formulated, implemented and monitored in a more targeted way. As Nauwelaers and Wintjes (2002: 205) argue:

> The non-anonymous relations, the complementarity of activities and the historical setting are stressed in the regional context. . . . Further, in order to find out and articulate what a particular region or firm needs, or what is lacking concerning innovation, regional proximity and communicative interaction may be needed to address the tacit and latent aspects of such needs.

However, all this stands or falls with the capacity of the policy apparatus to embrace a more discursive and interactive approach to policy-making, which aims to bring about a process of collaborative problem-solving between the public and private sectors within the region (Cooke and Morgan, 1998; Henderson, 2000). As such it is crucial not to merely lean back and assume that the regional level is 'the basic level at which there is a natural solidarity and where relations are easily forged' (EC, 1994 quoted in Henderson and Morgan, 2001) but to recognize the need for deliberate and conscious efforts on the part of firms, public agencies and research and education institutes.

In sum, when accepting that the regional level qualifies as an effective starting point to enhance innovation, the RIS approach is regarded as the most comprehensive intellectual framework to guide policy action (Asheim *et al.*, 2003a; Landabaso, 1997) because it provides an amalgam of earlier ideas and theories on territorial innovation models in a knowledge-based economy (Doloreux, 2002).

Approaches to regional innovation policies

Drawing on findings from the SMEPOL[5] project, SME innovation policy tools can be classified in two dimensions, resulting in a four quadrants table (Table 5.1) (Asheim *et al.* 2003a). The table distinguishes between two main aims of the support tools. Some tools aim at giving firms access to resources that they lack to carry out innovation projects, i.e. to increase the innovation capacity of firms by making the necessary resource inputs available, such as financial support for product development, help to contact relevant knowledge organizations or assistance in solving specific technological problems. The other type of instruments have a larger focus on learning, trying to change behavioral aspects, such as the innovation strategy, management, mentality or the level of awareness in firms.

Following a more pro-active and dynamic perspective to innovation policy, the objective of policy instruments is not solely to provide scarce resources (such as financial assistance) to innovating firms *per se*, but also to promote learning about R&D and innovation and the acquisition of new routines within firms. Lack of demand is often a bottleneck for financial incentives to innovation activity, i.e. that firms initially do not see the need to innovate, or alternatively, that firms do not have the capability to articulate their need for innovation. Some policy instruments should, therefore, also attempt to enhance demand for initial innovation activity of firms (i.e. apply a learning perspective), and, thus, must include an explicit behavioral aspect with an ultimate policy target of promoting the endogenization of innovation activity of enterprises.

The other dimension includes the target group of instruments. Some tools focus on innovation and learning within firms, to lower the innovation barriers of firms, such as lack of capital or technological competence. Other instruments to a larger extent have regional production and innovation systems as their target group, aiming at achieving externalities or synergies from complementarities within the regions. The barriers may, for example, be lack of user–producer

Table 5.1 Two-dimensional classification of main innovation policy instruments (Asheim *et al.*, 2003a)

Aim of innovation support		
Target level of support	*Assign lacking resources to firms: Support the accomplishment of innovation projects*	*Learning to innovate: Change behavior*
Firm-oriented		
	Financial support Brokers	Mobility schemes
(Regional) system-oriented		
	Technology centers	Upgrading of regional innovation Systems

interaction or lack of relevant competence in the regional knowledge organizations to support innovation projects.

In the SMEPOL project the need for a more system-oriented as well as a more pro-active innovation-based regional policy was emphasized. A re-orientation of what was called *the target level of support*, changing innovation policies towards SMEs from being firm-oriented to *a (regional) system-oriented* perspective has already gained a growing attention among researchers and policy-makers (see e.g. the research project 'Nordic SMEs and regional innovation systems' funded by Nordic Industry Fund (Asheim *et al.*, 2003b)). However, the second part of the recommendation concerning the *form and focus of support*, which is crucial for more pro-activity and implies a change of focus from allocation of resources for innovation to focusing on *learning aiming for behavioural value-added*, has not been implemented to the same degree.

Constructing RIS: social capital and community-based learning in a triple helix

We argue that the shift towards more pro-active policy fits well with a (dynamic) triple-helix perspective, which has been given an increased attention among policy-makers as well as researchers within innovation research. However, so far this perspective has been applied in a rather static way, more like a heuristic device than as a basis for actual policy formulations. This is also the weakness of the approach, as it does not give much guidance concerning how a triple-helix-based collaboration could be functional, operational and implemented in concrete policy settings in order to contribute to constructing regional advantage. In order to achieve this, theoretical and practical advice must be developed partly with respect to how collaboration between the three actors of the triple-helix, i.e. the industry, university and government, should be externally organized, and partly with respect to how knowledge creation and innovation-oriented work should be organized internally among the different actors, thus turning the macro-, meso-, and micro-levels of the triple-helix into knowledge creative environments (Hemlin *et al.*, 2004). Independent of the specific triple-helix context policies have been formulated and implemented promoting SME's contacts with R&D institutes and more frequent use of R&D, while universities at least in Finland and Sweden for some years have been given a so-called 'third role', i.e. to cooperate externally with the surrounding society in addition to doing research and teaching. However, so far little or nothing has been done concerning changing behavior of the third actor of the triple-helix, i.e. the government, as well as with the triple-helix system as a whole. An important part of this is to develop a more innovation-oriented public sector in a sustained fashion, which means focusing on pro-active learning to innovate at both universities and government at different geographical levels (national, regional and local), in addition to doing the same with the private sector.

However, surprisingly little work has been conducted on the interactions in terms of knowledge flows and learning linkages connecting the (triple-helix) actors in a network of an innovation system (Archibugi *et al.*, 1999). This fits uncomfortably with the dynamic perspective implied in the learning economy and calls for a shift from a static position of possession of knowledge to a more dynamic position of practice of knowledge (Amin and Cohendet, 2004; Brown and Duguid, 2002). In policy terms such a shift towards a pro-active, learning-to-innovate-based policy is recognized in the concept of 'regional experimentalism' (Sabel, 1996 in Henderson, 2000: 349) in which the triple helix of industry, government and university

> work in small-scale repeated interactions in an attempt to (re)define regional development support services and priorities in a collective manner, establish specific targets and responsibilities, and monitor outcomes in a way that facilitates learning on the part of those in a position to respond. This regional development agenda relies less on learning as a means of incremental adaptation to existing routines, than as a form of strategic and experimental goal-setting which, it is argued, can help firms and regional support organizations question the validity of existing support structures and adapt to future challenges.

In this, regional experimentalism bears close resemblance to the notion of regional development coalitions (Asheim, 2001; 2002) and system-oriented, learning-based policy tools (Nauwelaers and Wintjes, 2002). Examples of such regional innovation policy can be found in the European Commission's article 10 programs: RTP (Regional Technology Plan), RIS (Regional Innovation Strategies), RITTS (Regional Innovation and Technology Transfer Strategies) and the most recent Innovative Actions. Also the Norwegian REGINN program as well as in the Swedish VINNVÄXT program (a more detailed account is presented in the last section) have incorporated a more comprehensive innovation policy approach building on broad participation and engagement and with emphasis on collective learning.

Henderson and Morgan (2001) argue that the regional level is particularly apt for this new kind of policy paradigm because it allows all stakeholders to act on *local knowledge* and because this level is deemed most appropriate for building *social capital* by which they refer to 'a relational infrastructure for collective action predicated on trust, reciprocity and the disposition to collaborate to achieve mutually beneficial ends' (p. 19) sustained through regular face-to-face interaction. Taken together, these assets are considered to be conducive to collective learning processes. In this context, the authors employ a modest (and one may even argue, circumscribed) understanding of learning as 'new and more purposeful conversations about joint solutions to common problems as a prelude to building more robust and more sophisticated forms of institutionalized voice' (p. 19). In his evaluation of the Welsh RTP policy program Henderson (2000) critically questions whether this predominantly discursive approach will result in truly new and path-breaking strategies due to vested interests and the risk for parochialism on behalf of the stakeholders. Indeed, social capital, as defined above, provides important positive associative effects for networks of heterogeneous agents in the triple helix geared to interactive innovation (Cooke, 2003) but it also involves risks and disadvantages (Woolcock, 1998). On the positive side Adler and Kwon (2002) mention that social capital facilitates broad access to relevant knowledge and information-sharing. However, the strong solidarity with in-group members, in itself considered a positive feature, may backfire through institutional and cognitive lock-in. 'The ties that bind may also turn into ties that blind' (Powell and Smith-Doerr, 1994: 393). Moreover there is a lot of confusion around the sources and consequences of social capital. In a policy context it would be pragmatic to acknowledge that trust and reciprocity are an indirect result of sociability rather than a primordial cultural and institutional disposition (Amin and Cohendet, 2004). This distinction is somewhat similar to the one made by Wolfe and Asheim (2003) between social capital based on organizational and institutional innovation (i.e. bridging) and social capital rooted in civicness (i.e. bonding) (Putnam, 1993). Nonetheless, as regards 'building' social capital the question remains whether trust, reciprocity and associative norms and values are prerequisites for collective action or whether the causality runs the other way around. This provides challenges to RIS policy both in terms of its aim (towards changing behavior) and target level (towards the system level).

Given the possible limitations to intentional social capital building, it could be more useful to focus on collective learning and innovation processes in the triple helix allowing social capital to be built along the way. In this, broad participation and engagement remains a guiding principle but, arguably, more closely coupled to the principle of collective learning. Without discounting the importance of trust, reciprocity and associative norms and values for collaboration we therefore concentrate on the concept of 'communities of practice' as this shifts attention primarily to what groups do (Bowles and Gintis, 2000). Communities of practice are defined by the communal (shared) practice of its members, by which is meant undertaking and engaging in a task, job or profession while communicating regularly with one another about their activities (Brown and Duguid, 2002). Its members are informally bound together by shared experience, expertise and commitment to a joint enterprise (Gertler, 2004). They are able to produce and internalize shared understandings through collaborative problem-solving. Furthermore, these communities are increasingly seen as the key sites of knowledge formation, exchange and learning. They seem to accommodate the situated, pragmatic and interactive nature of learning processes 'in action' within and across organizations in a more realistic way than individual-centered or classical organization-centered approaches (Amin and Cohendet, 2004). Moreover, the notion of communities overlaps with the growing prevalence of alternative organizational forms, especially of temporary, flexible, project- or task-focused groupings, noted by Grabher (2002).

It would be fair to say that the community-of-practice literature has provided a way forward in drawing attention to the social platforms, where collective learning takes place and is carried out. As such, communities can stretch across organizations and can thus be regarded as an important boundary spanner in the triple helix of a RIS. Similar to social capital, however, there are limitations to the feasibility to construct learning communities, highlighting the strength in their unintentionality and by-product character (Swan *et al.*, 2002). Before we continue with a discussion of the case studies of three RIS to analyze their triple-helix dynamics as well as the importance of social capital and community of practice-based learning, it is important to contextualize these RIS in their national frameworks.

The national frameworks of regional innovation systems and policies

In order to further deepen the understanding of what types of innovation policy and collaboration to promote in different environments, the question of national governance structures and supporting regulatory and institutional frameworks has to be taken into consideration (Asheim and Gertler, 2005). For this we draw on a Nordic project carried out by the STEP group in Oslo, aimed at identifying differences in innovation profiles among the Nordic countries, with precisely a focus on the relations between national institutional conditions and innovation policies and strategies. This analysis gave the following differences of innovation strategies (Mariussen, 2005)[6]:

- The *technology-based* strategy of *process innovations* and *complex product improvements*, through R&D investments in large industries, characteristic of the heterogeneous economy of Sweden.
- The *research-driven* high-tech strategy focusing on *radical product innovations*, in Finland with Nokia as the entrepreneurial champion.
- The *market-driven entrepreneurialism* of Denmark characterized by *non-R&D-based, incremental product innovations* especially within consumer goods sectors.

The two most contrasting nations with respect to innovation policy among the Nordic countries are Finland and Denmark. Swedish innovation policy is strongly inspired and influenced by, and, thus, at least in part resembles the Finnish policy, however, it lacks the strong, top-down governmental based and coordinated initiatives and implementation strategy. On the other hand the Swedish policy has ambitions of finding a better balance between top-down and bottom-up initiatives implying a stronger regional focus (i.e. the strategy of constructing regional innovation systems through the VINNVÄXT program (see last section for a more detailed presentation)). Finland's innovation policy is to a large extent rooted in the economic crisis in the beginning of the 1990s, when the government started to invest heavily in science-based R&D and education in order to promote a restructuring of the economy away from the heavy dependence on natural resources towards R&D as the basis for future economic growth. Finland is, thus, internationally perhaps the most significant example of a country implementing an endogenous, top-down planned, systemic innovation policy. Innovation policy in Finland has primarily been a national policy with a very strong science and technology orientation. Typically, the Finnish innovation policy is strongly embedded at the highest governmental level through the Science and Technology Policy Council, where also top managers from private business (e.g. Nokia) take part, and with TEKES as the main operating agency. This guarantees the legitimacy of the policy as well as underlines how important it is considered to be, and also secures that the innovation policy initiatives are well coordinated and orchestrated between the various ministries within the government. Finnish policy makers see the industry–university relations as a crucial edge in global competition, and more innovative firms in Finland than in other European countries cooperate with universities.[7,8]

In addition to Finland, Canada has been an object for policy learning by VINNOVA (Swedish Agency for Innovation System responsible for the majority of innovation policy initiatives in Sweden, among them the VINNVÄXT program), which is the Swedish counterpart to the Finnish TEKES, however, with a much smaller budget. The Canadian government has wholeheartedly endorsed innovation as key to its economic and social performance in the recently published 'Canada's Innovation Strategy' which serves as a blueprint for the country's innovation policy. It builds on four pillars:

- 'Knowledge Performance': raising Canada's R&D performance.
- 'Skills': targeted at education and human capital.
- 'The Innovative Environment': innovation and upgrading within the public sphere.
- 'Strengthening Communities': regionalization of innovation policy and cluster policy.

Considering the last pillar, a convergence between regional innovation and cluster policy can be witnessed. In this, collaboration spanning across the triple helix of business, university and public sector is advocated. Moreover, the provinces have already gained quite a lot of authority in designing their own innovation policies through the considerable extent of devolution in the Canadian federal–provincial system. Canada's innovation policy distinguishes itself also through a firm emphasis on human scientific capital, targeting new sectors of the economy (e.g. agricultural biotechnology).

Thus, Finland and Canada have pursued a supply-driven innovation policy with the government playing a strong role (more so in Finland than in Canada partly due to its federal–provincial system) as the initiating and coordinating decision-maker. In contrast, Denmark has followed a demand-driven innovation strategy. This means that the (mostly) sectoral innovation systems found in Denmark are not constructed (or built) through explicit innovation policy initiatives, such as in Finland (and which Sweden is aiming to do) but are a result of more or less systemic pattern of cooperative behavior developed over time between firms, the knowledge infrastructure and public authorities in an institutional framework that could be characterized as a 'coordinated industrial district' (Whitley, 1999) (in contrast to the 'collaborative national business system' found in Sweden (Whitley, 1999)). This could only partly be explained by the dominance of SMEs in the Danish economy compared to Finland and Sweden.[9] As indicated above, this has resulted in non-R&D-based, incremental product innovations with a relative low knowledge content, and only infrequently based on original design development. Already in 1993 Edquist and Lundvall noted that

> the survival of small scale and artisan-like production has fostered a kind of corporatism, very different from the Swedish. Small, independent entrepreneurs in Denmark will often be quite negative to central union power, but at the same time, often willing to cooperate locally with their workers and their representatives. . . . This small-scale corporatist model often involving a flexible use of reasonable advanced production equipment and a continuous development of incremental product innovations has its strength in flexible adaptation.
>
> (Edquist and Lundvall, 1993: 275)

This 'decentralised industrial creativity' (Bellandi, 1994) has so far produced solid economic results with a relatively low unemployment rate (lower than in Finland). However, the unknown future challenge facing Denmark is if its knowledge base is sufficient to cope with the increasing knowledge intensity of products and processes in the globalizing learning economy.

Three examples from the Northern Hemisphere

In this empirical section three case examples of regional innovation systems located in the Northern Hemisphere are given. The discussion of the two already 'working' regional innovation systems is followed by an analysis of current efforts to construct a regional innovation system for the food industry in Scania, Sweden, through the aforementioned VINNVÄXT program.

Saskatoon, Canada: a dirigiste RIS based on analytical knowledge

The first case deals with the agricultural biotechnology cluster in and around Saskatoon, the largest city in the Canadian province of Saskatchewan. We chose this case study, which mainly draws on the original work by Cami Ryan and Peter Philips because it illustrates the strong interdependence between the players of the triple helix in an analytical knowledge base setting. This peripheral region located on the prairies of central Canada hosts only 5% of all biotech companies in Canada yet generates 61% of the gross revenues from biotechnology in the agrofood sector in 1999 (Ryan and Philips, 2004). In fact, Saskatchewan's success can be directly attributed to its self-defined agricultural biotechnology cluster in Saskatoon hosting about 35 companies which represent 30% of Canada's total agricultural biotechnology industry (Ryan and Philips, 2004). Confirming our argument about constructing an analytical knowledge-based RIS through close and systemic industry–university cooperation and interaction at the start of an industrial life-cycle and technological regime, it is argued that the RIS originated in the research efforts of two regionalized national research institutes: Agriculture and Agri-Food Canada (AAFC) and the National Research Council's Plant Biotechnology Institute (NRC-PBI). NRC-PBI originated from the Prairie Regional Laboratory which was established in 1948 by the federal government on the grounds of the University of Saskatchewan campus to do research aligned to the agricultural needs of the prairie region (e.g. oilseed crops). In 1983 the federal government, recognizing the emergence of biotechnology as a potential growth sector, decided to concentrate all its plant biotechnology activities in Saskatoon transforming the Prairie Regional Laboratory into the NRC-PBI. This strategy of creating a 'niched' critical mass of research capacity and scientific excellence sparked, though arguably without any direct intentions, a process of cluster building by attracting agrochemical and seed companies into the region (e.g. Becker Underwood, Bioriginal and Philom Bios) and stimulating new, technology-intensive firm start-up in agrofood biotechnology. Philips *et al.* (2004) report that, while large multinationals play an important role as global listening posts, the majority of the cluster's private enterprises are small (only three establishments employ more then 50 people) and relatively young (73% has been established since 1990). Based on a survey among the clusters' firms, the authors also find that skilled locally available human capital and the presence of specialized research institutes and universities serve as the most important cluster advantages identified.

Ryan and Philips (2004) argue that the success of Saskatoon's agricultural biotechnology cluster can be explained by a twofold knowledge management strategy on behalf of the actors characteristic for typical triple-helix dynamics. Partly, it has been up to each of the actors, i.e. university, research institutes and business, to exploit its key competences and focus on its 'primary activities', namely research and teaching, development and commercialization. At the same time, there has been a development towards hybrid, overlapping activities through collaborative efforts between university, research institutes and business. Exemplar innovations based on this model are the development of the renowned 'canola' crop, a new rapeseed variety with low erucic acid and low glucosinolate levels making it suitable for food applications, and the development of herbicide-tolerant canola, a 'world-first' among transgenic crops. In fact, canola can be considered as a strategic platform technology for the cluster enabling further crop performance improvements and crop diversification. Moreover, the collaborative efforts that underpin these innovations are often brought into practice by means of research teams that consist of members of the various organizations each bringing in their specific sets of competences.

Thus, the Saskatoon case provides a clear example of how unintended cluster development evolved into patterns of more institutionalized, localized interactive innovation. Business was initially attracted to Saskatoon primarily because of its scientific reputation rather than because of its reputation of being 'an entrepreneurial university' (Etzkowitz and Leydesdorff, 2000). Nonetheless, collaborative research in applied fields as envisaged in the triple helix soon started to lift off. It can be argued that on the operational level, the communities of scientists and engineers[10] brought together in concrete research teams serve as organizational boundary spanners 'translating' science into technology and vice versa. A recent example is the strategic research alliance between NRC-PBI and Dow AgriSciences Canada signed in 1999 worth Canadian $10 million over a five-year period (PBI, 2002). In a gradual, bottom-up, path-dependent process (canola served as the guiding technological regime) the communities of scientists and engineers across firms and research centers generated the scientific and commercial localized success stories fuelling reciprocity and collective understanding and respect (i.e. broadly defined social capital). Thus, it is important to recognize that the regional innovation system took a long time (a few decades) to be constructed through active, practice-related collaboration between (communities in) heterogeneous organizations of the triple helix.

The role of the national government has also been an important one because of its historic decision to localize the country's scientific capacity in plant biotechnology through the establishment of the AAFC and NRC-PBI labs and their scientific personnel thereby providing a crucial sticky (yet at that time unanticipated) cornerstone for the cluster (Malmberg, 2003). Furthermore it can be observed that in recent times the various strata of government, including the Province of Saskatchewan, have started to operate in closer triple-helix collaboration in order to continue Saskatoon's previous success. These policy actions can be seen in the light of two potential risks for the further growth and development of the cluster. The establishment of Innovation Place, Saskatoon's science park, with strong support from the regional government, the National Research Council's Industrial Research Assistance Program (IRAP) primarily aimed at aligning scientific and commercial competences as well as the recent opening of NRC-PBI's Industry Partnership Facility (built in partnership with the Province of Saskatchewan), all seek to foster the start-up and growth of small, knowledge-intensive firms in order to prevent an unbalanced dominance of large multinationals. Moreover, these initiatives clearly seek to provide pro-active, systemic innovation support at the regional level. The second risk involves the dependence on canola as the dominant scientific and technological regime. Against this background the construction of the Canadian Light Source Synchroton is aimed to add a new configuration to the existing cluster structure. It is expected to attract more than 2000 scientists from all over the world, diversifying the local, scientific knowledge base. Time will tell to what extent these programs will help the cluster in Saskatoon to sustain its former success in constructing a science- and research-based, dirigiste RIS.

Salling, Denmark: a grass-roots RIS based on synthetic knowledge

The second case entails the Danish furniture cluster in Salling located in the North West of Jutland, which is based on the original work of Mark Lorenzen. We choose this study as it clearly illustrates triple-helix interaction against a synthetic knowledge base (on which the production of wooden and upholstered furniture and related wood products in the basic/home market segment is clearly founded). Lorenzen (2003) reports on an impressive economic growth in the cluster over the past decades despite high factors costs. Between 1972 and 1992 the number of firms grew with approximately 80% and employment in the cluster tripled while overall employment in Denmark decreased. In 1996, 54 firms employed 2388 employees, the majority of which are small and medium-sized. This successful performance is ascribed to a high degree of flexible specialization within the cluster; a phenomenon typical for industrial districts (Asheim, 2000). Each of the firms has developed its own dedicated niche through specialization in specific parts of the value chain in combination with an extensive local network of stable yet flexible embedded inter-firm relationships allowing for economies of scope. This combination allows for sustained gradual innovation often involving relations across firm boundaries. In terms of product innovations the firms in Salling mainly design varieties with regard to style, materials and colors based on the existing product line. Completely new product types are typically introduced only once a year. Process innovations necessarily follow these new product designs. Here, the shift from hardwood to other materials, notably plywood, is considered as the most dramatic shift that the cluster witnessed. Internally, experimentation on the factory floor and product revision based upon employees' ideas are key mechanisms for the firms to innovate. More important, however, are interactive innovation activities which take place through vertical networks between producers and their suppliers (in collaboration with existing suppliers or by reshuffling inputs from other suppliers) as well as through horizontal networks (e.g. matching product designs in order to offer fuller product lines). Lorenzen (2003) highlights the importance of shared values, common norms and trust among managers to sustain local, inter-firm relationships (i.e. social capital) as a crucial local asset for the cluster's success. Characteristic local conventions are (Lorenzen, 2003: 20):

- Craftsmanship: Most managers take great pride in their artisan skills developed through engagement with furniture production for most of their career.
- Entrepreneurship: To be the owner of the firm and to maintain control over it is the norm among Salling managers.
- Economic interdependence: 'Most producers see themselves as a part of a economic community with other furniture producers, and are eager to signal that they take seriously the necessity' (Lorenzen, 2003: 20).
- Local solidarity: Many producers adhere to being an active member of a local social community and support its existence and continuation actively through e.g. the local Cabinetmakers' Guild.

In general, the local Cabinetmakers' Guild, the local branch of the national Association of Danish Woodworking Industries, provides a crucial socializing venue for the (managers of the) firms to exchange information, coordinate inter-firm relationships and reproduce the above norms and values.

Contrasting the more dirigiste-inclined Saskatoon case, the Salling case makes a typical example of an SME-based, grass-roots regional innovation system strongly embedded in its local territory with a clear inclination towards market-driven incremental innovation. Nearly all firms have originated from the region and behavior in line with the above norms and values seems indispensable for new (and existing) firms to 'fit' into the cluster. Typical for a RIS based on a synthetic knowledge base, innovation is strongly shaped by the existing industrial specialization. Firms are the most important players and most of the learning processes are thus intra- and inter-firm based. As mentioned above, social capital is considered an important feature to explain this cluster's success. However, it is important to point out that the high level of local community-based mutual dependence and its underpinning social conventions have been actively created over the past 15–20 years. Lorenzen (2003: 25) emphasizes the role of 'cumulative causation' through repeated and intense interaction in dyadic firm relationships (e.g. producer–supplier) and, on a collective basis, through participation in the Cabinetmakers' Guild. Taking a closer look at these collective social learning processes it is important to note that most of the real interaction is embedded in the actual network of firm managers/owners. In the intense, socializing activities of this local community, group identity is created and reproduced (cumulative causation). Most of the collective social learning is informal, based on gossip, advice and information sharing. Against this perspective, the managers function as effective boundary spanners between the firms.

Adopting a triple-helix perspective, it thus needs to be acknowledged that in this case the role of university and government is limited for learning processes which is typical for a grass-roots RIS compared to a dirigiste RIS such as the one in Saskatoon. Interestingly though, the local technical school plays an important role in producing an immobile local labor force trained with the particular artisan skills needed to work in the furniture industry. In fact, the school has been concerned with the demands of the industry right from its establishment in 1871. Also the role of the local government is mainly directed to 'hands-on' support for the existing structure of the cluster (e.g. the local economic development office's help in attracting more trainees as cabinetmakers). To conclude, at face value it could be assumed that mere physical proximity between firms stimulates the localized learning processes underpinning the cluster's innovative success. But when going beyond the surface, a strong case is made for the more bounded communities of managers (and partly the workers) as the real embedding mechanisms of this cluster. Through broad and active participation and engagement in this local community of practice, facilitated in the Cabinetmakers' Guild, social capital is actively created and maintained. Based on own observations and extensive interviewing Lorenzen (2003) in fact opposes the idea that the norms and conventions were learned in the pre-industrial past.

He stresses that the community-based social capital is heavily interdependent with inter-firm and collective learning through cumulative causation over a relatively long but recent period of time (the last 15–20 years).

Scania, Sweden: a networked RIS under construction

While the above two examples are based on existing and well-documented working RIS, the following example concentrates on a RIS 'under construction'. It comprises the VINNVÄXT program 'Innovation i Gränsland' (Food Innovation at Interfaces) aimed to construct a regional innovation system in and around the food industry in the Southern Swedish province of Scania. VINNVÄXT resides under the Swedish Agency for Innovation Systems, VINNOVA. The purpose of 'VINNVÄXT: Regional growth through dynamic innovation systems' is

> to promote sustainable growth in the regions based on international competitive ability, by successively developing or further developing the functioning, dynamics and effectiveness of innovation systems in functional regions at an international level.
>
> (VINNOVA, 2001: 4)

By 'functional regions' the program defines the geographical boundaries of its projects based on the location of those groups/coalitions/partnerships that apply to the program and their core activities instead of defining them on the basis of given administrative regions. The program requires explicitly that such a functional region has to be constructed around a triple helix involving active participation from the business community, research organizations, politics and public administration. This specific focus on triple-helix collaboration originates in the program's central problem identification *vis-à-vis* Swedish regional economic development: the asserted lack of a system-based approach to innovation among politics and public administration, the business community and research organizations. The main 'accusations' are that regional politicians and public administrators are insufficiently engaged in harnessing active economic growth and development, relying too much on redistributive regional policy. Colleges and universities have been aligning their research and education programs insufficiently to the needs of their region. Companies have been paying insufficient attention to the assets available in their regional environment. By constructing regional innovation systems, VINNVÄXT seeks to overcome this perceived lack of systemicness. The general characteristics of the program are:

- Competition-based selection procedure.
- On-going process support, education, monitoring and evaluation.
- Long-term perspective (the program runs for 10 years).

VINNVÄXT's total budget comprises 600 million Swedish crowns (approx. €70 million) built on the principle of co-financing (the applicants stand for

50% of the budget). VINNOVA provides each selected regional program 10 million Swedish crowns per year (total budget 20 million) over a maximum period of 10 years. It has identified a set of critical factors and attributes as guiding principles for its regional programs. These overlap significantly with the guiding principles of regional experimentalism. We shall illustrate this by means of the 'Food Innovation at Interfaces' application.

'Food Innovation at Interfaces' has been granted funding as a VINNVÄXT program in 2003. The application was written by the network organization 'Skånes Livsmedelsakademi' (Scania's food and beverages academy[11]) whose members are from the triple helix of business, research organizations and regional public administration. The application builds on the shared strategic vision to increase the added value of the region's food industry's products and services. It intends to do so through a focus on 'multi-disciplinary innovation projects in the borderland between different knowledge bases' (SL, 2003, 3). The project builds on the recognition that the Swedish food industry as well as important related areas such as logistics and machinery is heavily concentrated in the country's most Southern region of Scania (see also Porter (1990)). A strong case can in fact be made for a Scanian food cluster in terms of a geographical concentration of similar or related industries. The total growth of the cluster is, however, rather low as parts of the sector are dominated by typically Fordist bulk production aimed at price competition and economies of scale (Nilsson *et al.*, 2002). The program acknowledges that this is not an economically sustainable situation and, hence, aims to access new, more specialized and knowledge-intensive segments of the market such as high-quality niche products, convenience foods, ecological foods and functional foods (defined as artificially developed food with added ingredients that demonstrate scientific evidence of positive health-related effects). To make this shift, it is conceived that companies need to collaborate more actively with the existing knowledge infrastructure found in Scania. Both Lund University and the Swedish Agricultural University in Alnarp (located between Lund and Malmö) have indeed aligned parts of their education and research activities to the historical presence of the food industry in Scania. For example, already early in the twentieth century firms and organizations in the regional farming community as well as the Swedish state supported and collaborated with scientists in plant breeding through the Svalöf Institute (which was part of Lund University) to develop better seeds for the agricultural conditions prevalent in Sweden (Holmberg, 2003).

Within 'Food Innovation at Interfaces', triple-helix collaboration is organized both on a strategic and operational level. The board of the program consists of representatives from the regional food industry, universities as well as regional government and serves as a reference group for the program as a whole. On an operational level, the program is divided in four main project areas: Food and Health – Functional Foods, International Consumer Marketing, Good and Convenient Food on a Large Scale, Innovations in Theory and Practice. These project areas reflect the broad scope of activities that the program aims to cover, targeting analytic knowledge-based innovation (e.g. in Food and

Health – Functional Foods) as well as synthetic knowledge-based innovation (e.g. in Good and Convenient Food on a Large Scale). Within these project areas, various projects are carried out drawing on collaboration in a public–private or triple-helix context coordinated by project managers which often are affiliated with organizations that have substantial previous experience with such collaboration.

Of course, 'Food Innovation at Interfaces' is still at the start of its program and it is therefore impossible to assess its actual impact for the Scanian food cluster. However, it is clearly underpinned by the principle of broad participation and engagement because of the stipulated involvement of all players in the triple helix. By jointly endorsing a strategic vision for the industry in the region a platform for action is created. This strategic vision (a shift towards more knowledge-intensive food production) is put into practice by concrete projects in which all partners are brought together to stimulate collective learning processes by interacting. The combination of both top-down and bottom-up associative innovation activities clearly point to the ambition of the program to construct a networked RIS. In fact, the majority of the actors are already in place. It is therefore mainly a question of forging linkages between the firms in the cluster and the knowledge infrastructure in order to strengthen these currently fragmented sub systems. In this, the different projects serve as temporary alliances to facilitate collective (community-of-practice based) learning and increased mutual understanding and reciprocity. Moreover, the actual mix of actors involved strongly depends on the nature of the innovation project in terms of knowledge profiles and competences needed.

Conclusion

In this chapter we have analyzed how a territorially contextualized triple-helix model can contribute to the formation of regional innovation systems. We have argued for the need to change target levels, towards a more systemic approach based on collective, community-of-practice based learning, as well as aim of innovation support, towards more pro-active behavioral change based on associative governance. As empirical illustrations we have made comparisons between three contrasting clusters representing different knowledge basis and national policy contexts, and their actual and potential linking to regional innovation systems of different types. The three clusters were the furniture cluster of Salling in Denmark with a synthetic knowledge base and a market-driven, grass-roots RIS; the agrofood cluster in Saskatoon, Canada, typically analytical based with a dirigiste, science-driven RIS; and lastly the food cluster of Scania, Sweden, currently under construction but with the ambition to shape a networked RIS, drawing on both analytical and synthetic knowledge bases.

All cases show that the construction of a RIS takes place within a dynamic triple helix set-up but with differing roles for the actors dependent on the industrial and territorial-institutional context. The Canadian case is a clear example of initially unintented cluster development following the decision by the federal government to regionalize specific public research facilities and activities, which in turn attracted the attention and presence of agrochemical and seed firms and spurred the establishment of new, knowledge-intensive firms in agricultural biotechnology. Given the analytical knowledge base of this industry, the catalytic role played by the regionalized research infrastructure is characteristic for this dirigiste RIS. Drawing on successful collaboration in public–private research communities, federal and provincial government, university and research centers and industry have subsequently decided to initiate a formal regional innovation system policy. In the Danish furniture cluster, collaborative innovation is much more rooted in market-driven relations between firms. Typical for Denmark, the (grass-roots) RIS is characterized by non-R&D based, incremental product innovations where the technical school and local government play a more indirect but still supportive role. In line with the synthetic knowledge base of the furniture industry, this support is mainly demand-led following historical path dependencies. This case also clearly shows how social capital is created as an indirect result of collective learning processes (predominantly between firms) underpinned by a strong sense of belonging to a local community of practice. At present the Swedish policy program 'Food Innovation at Interfaces' cannot be conclusively assessed on its aim to construct a networked regional innovation system. Yet it clearly provides evidence that preconditions for a systemic perspective and learning-to-innovate framework through frequent and continuous collaboration between national and regional public bodies, universities and research centers and industry are in place, fostering a shared strategic vision (top-down) and joint innovation projects (bottom-up).

This brings us back to the aforementioned issue whether social capital and community-of-practice based learning can be actively mobilized in a triple helix. On the one hand, they are important ingredients for a new, pro-active and systemic understanding of regional innovation policy. On the other hand, the strength of these ingredients lies in their unintentional and informal character. This dilemma could be resolved by recognizing that a more dynamic perspective on RIS requires a stronger recognition of the fact that innovation policy is inherently tied to the uncertainty surrounding the development of new knowledge (Eriksson, 2005) which is at odds with a rigid planning strategy. Adopting such an approach implies a stronger focus on the process perspective of innovation policy. Moreover it opens up possibilities to adjust policy programs and measures along the way to its completion. As a necessary condition for this approach it requires nonetheless broad and active participation of all the stakeholders (i.e. the triple helix) in order to collectively learn to innovate in a systemic perspective. Also in this perspective, all policy stakeholders need to be aware of the fact that the construction of RIS takes place within its industrial and territorial-institutional context. This does not mean that policy learning cannot take place, yet it acknowledges the need to actively monitor changes as well as to reflect and act on these. Taking respective overarching national frameworks into consideration, such developmental learning thus provides a possible remedy to institutional borrowing or learning-by-cloning which involves a more passive and unimaginative adaptation to changed conditions (Cooke, forthcoming; Eriksson, 2005).

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Notes

1 As suggested in the term, the learning economy puts more emphasis on the activity of (both adaptive and developmental) learning while the knowledge-based economy is more concerned with the stock of knowledge as well as with new knowledge creation. In Asheim and Coenen (2006) we argue that the former is more inclusive as it encompasses all sectors in an economy (as opposed to the latter which has a heavy focus on high-tech sectors).

2 The distinction between learning and knowledge-based economies, furthermore, implies the use of different definitions of innovation systems. In a learning economy a broad definition of innovation systems as constituted by D(oing), U(sing) and I(nteracting) is applied. Such innovation systems are typically found in non-R&D based learning economies (e.g. Denmark), mainly producing incremental innovations. On the other hand, in a knowledge-based economy a narrow definition of innovation systems characterized as a S(cience), T(echnology) and I(nnovation)-based system is favored. This type of innovation system more often generates radical (product) innovations than a broadly defined innovation system (Jensen *et al.*, 2005).

3 For a state-of-the-art overview see Fagerberg *et al.* (2004).

4 The concepts grass-roots, dirigiste and networked RIS originate from Cooke (1998).

5 SME policy and the regional dimension of innovation. SMEPOL was financed by the EU Commission's TSER (Targeted Socio-Economic Research) program.

6 Mariussen, Å. (2004): From regional coalitions to commercial innovations. Presentation at seminar on 'Future challenges and institutional preconditions for regional development policy' – Nordic program for regional research 2000–2004, Nordregio, Stockholm, September 2004. In our context we primarily focus on Denmark and Sweden, as two of our cases are located in these countries; however, we are also shortly referring to Finland partly because its innovation policy most sharply differs from the Danish one, and partly because Finnish innovation policy for a long time has been an inspiration for Swedish policy, and for the last couple of years also for the Danish one. The report also contains analyses of innovation policies in Norway and Iceland.

7 The information on Finland is taken from a publication from Science and Technology Policy Council of Finland: 'Knowledge, innovation and internationalisation', Helsinki, 2003.

8 An interesting aspect concerning the role of universities in Finnish innovation policy is the fact that they have taken up the role of knowledge transfer organizations.

9 Additionally, Danish public policy has the strongest tradition in non-interventionism among the Nordic countries.

10 Even though biotechnology can be considered as a predominately analytic knowledge-based industry, some of its applications in agriculture have a more synthetic nature.

11 Translation by authors.

References

Adler, P. and Kwon, S. (2002) Social Capital: Prospects for a New Concept. *Academy of Management Review*, 27 (1): 17–40.

Amable, B. (2000) Institutional Complementarity and Diversity of Social Systems of Innovation and Production. *Review of International Political Economy*, 7 (4): 645–87.

Amin, A. and Cohendet, P. (2004) *Architectures of Knowledge: Firms, Capabilities and Communities*. Oxford: Oxford University Press.

Archibugi, D., Howells, J. and Michie, J. (eds.) (1999) *Innovation Policy in a Global Economy*. Cambridge: Cambridge University Press.

Asheim, B. T. (2000) Industrial Districts: The Contributions to Marshall and Beyond, In: Clark G. L., Feldman M. P. and Gertler M. S. (eds.), *The Oxford Handbook of Economic Geography*. Oxford: Oxford University Press, pp. 413–31.

Asheim, B. T. (2001) Learning Regions as Development Coalitions: Partnership as Governance in European Workfare States? *Concepts and Transformation. International Journal of Action Research and Organisational Renewal*, 6 (1): 73–101.

Asheim, B. T. (2002) Temporary Organisations and Spatial Embeddedness of Learning and Knowledge Creation. *Geografiska Annaler: Series B Human Geography*, 84: 111–24.

Asheim, B. T. and Coenen, L. (2005) Knowledge Bases and Regional Innovation Systems: Comparing Nordic Clusters. *Research Policy*, 34: 1173–190.

Asheim, B. T. and Coenen, L. (2006) Contextualising Regional Innovation Systems in a Globalising Learning Economy: On Knowledge Bases and Institutional Frameworks. *Journal of Technology Transfer*, 31(1): 163–73.

Asheim, B. T. and Gertler, M. (2005) Regional Innovation Systems and the Geographical Foundations of Innovation. In: Fagerberg, J., Mowery, D. and Nelson, R. (eds.), *The Oxford Handbook of Innovation*. Oxford: Oxford University Press, pp. 291–317.

Asheim, B. T. and Herstad, S. (2003) Regional Innovation Systems, Varieties of Capitalism and non-Local Relations: Challenges from the Globalising Economy. In: Asheim, B. T. and Mariussen, Å. (eds.) *Innovation, Regions and Projects*. Stockholm: Nordregio, R, 2003(3): 241–74.

Asheim, B. T. and Isaksen, A. (2002) Regional Innovation Systems: The Integration of Local 'Sticky' and Global 'Ubiquitous' Knowledge. *Journal of Technology Transfer*, 27 (1): 77–86.

Asheim, B. T., Isaksen, A., Nauwelaers, C. and Tödtling, F. (eds.) (2003a) *Regional Innovation Policy for Small–Medium Enterprises*. Cheltenham: Edward Elgar.

Asheim, B. T., Coenen, L. and Svensson-Henning, M. (eds.) (2003b) *Nordic SMEs and Regional Innovation Systems – Final Report*. Oslo: Nordic Industrial Fund (http://www.nordicinnovation.net).

Bathelt, H. (2003) Geographies of Production: Growth Regimes in Spatial Perspectives 1 – Innovation, Institutions and Social Systems. *Progress in Human Geography*, 27 (6): 789–804.

Bathelt, H., Malmberg, A. and Maskell, P. (2004) Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation. *Progress in Human Geography*, 28 (1): 31–56.

Bellandi, M. (1994) Decentralised Industrial Creativity in Dynamic Industrial Districts. In: UNCTAD (ed.) *Technological Dynamism in Industrial Districts: An Alternative Approach to Industrialization in Developing Countries*? New York and Geneva: UNCTAD, pp. 73–87.

Benneworth, P. and Henry, N. (2003) Where is the Value Added in the Cluster Approach? Hermeneutic Theorising, Economic Geography and Clusters as a Multi-perspectival Approach. *Urban Studies*, 41 (5–6): 1011–23.

Bowles, S. and Gintis, H. (2000) Social Capital and Community Governance. Working paper 01-01-003, Santa Fe Institute, http://www.santafe.edu/sfi/publications/Working-Papers/01-01-003.pdf.

Braczyk, H., Cooke, P. and Heidenreich, M. (eds.) (1998) *Regional Innovation Systems* (1st edition). London: UCL Press.

Brown, J. S. and Duguid, P. (2002) Knowledge and Organization: A Social-Practice Perspective. *Organization Science*, 12 (2): 198–213.

Coenen, L., Moodysson, J. and Asheim, B. T. (2004) Nodes, Networks and Proximities: On the Knowledge Dynamics of the Medicon Valley Biotechnology Cluster. *European Planning Studies*, 12 (7): 1003–18.

Cooke, P. (1992) Regional Innovations Systems: Competitive Regulation in the New Europe. *Geoforum*, 23: 365–82.

Cooke, P. (1998) Introduction: Origins of the Concept. In: Braczyk, H., Cooke, P. and Heidenreich, M. (eds.), *Regional Innovation Systems* (1st edition). London: UCL Press, pp. 2–25.

Cooke, P. (2003) Social Capital in the Learning Region. Paper presented at Universita di Lecce Advanced International Summer School: 'Rethinking Regional Development Policies: The Role of Social Capital in Promoting Competitiveness in Less Favoured Regions', Ostuni, Italy, 2–5 July 2003.

Cooke, P. (2004a) Evolution of Regional Innovation Systems – Emergence, Theory, Challenge for Action. In: Cooke, P., Heidenreich, M. and Braczyk, H.-J. (eds.), *Regional Innovation Systems* (2nd edition). London: Routledge, pp. 1–18.

Cooke, P. (2004b) Integrating Global Knowledge Flows for Generative Growth in Scotland: Life Sciences as a Knowledge Economy Exemplar. In: Potter, J. (ed.), *Global Knowledge Flows and Economic Development*. Paris: OECD, pp. 73–96.

Cooke, P. (2005) Regionally asymmetric knowledge capabilities and open innovation: Exploring 'Globalisation 2' – A new model of industry organisation. *Research Policy*, 34 (8): 1128–49.

Cooke, P. (forthcoming) Regional Innovation Systems, Asymmetric Knowledge and the Legacies of Learning. In: Rutten, R., Boekema, F. and Hospers, G. (eds.), *The Learning Region: Foundations, State of the Art, Future*. Cheltenham: Edward Elgar.

Cooke, P. and Morgan, K. (1998) *The Associational Economy: Firms, Regions and Innovation*. Oxford: Oxford University Press.

Cooke, P., Boekholt, P. and Tödtling, F. (2000) *The Governance of Innovation in Europe. Regional Perspectives on Global Competitiveness*. London, Pinter.

Doloreux, D. (2002) What We Should Know About Regional Systems of Innovation. *Technology in Society*, 24 (3): 243–63.

Edquist, C. (1997) Introduction. In: Edquist, C. (ed.), *Systems of Innovation: Technologies, Institutions and Organisations*. London: Pinter, pp. 1–35.

Edquist, C. and Johnson, B. (1997) Institutions and Organizations in Systems of Innovation. In: Edquist, C. (ed.), *Systems of Innovation: Technologies, Institutions and Organisations*. London: Pinter, pp. 41–63.

Edquist, C. and Lundvall, B-Å. (1993) Comparing the Danish and Swedish Systems of Innovation. In: Nelson, R. (ed.), *National Systems of Innovation: A Comparative Study*. Oxford: Oxford University Press, pp. 265–98.

Edquist, C., Eriksson, M-L. and Sjögren, H. (2002) Characteristics of collaboration in product innovation in the regional system of innovation of East Gothia. *European Planning Studies*, 10 (5): 563–81.

Eriksson, M–L. (2005) *Organising Regional Innovation Support: Sweden's Industrial Development Centres as Regional Development Coalitions*. PhD thesis, Department of Technology and Social Change, Linköping University.

Etzkowitz, H. and Leydesdorff, L. (2000) The Dynamics of Innovation: From National Systems and 'Mode 2' to a Triple Helix of University–Industry–Government Relations. *Research Policy*, 29 (2): 109–23.

European Commission (1994) *Regional Technology Plan Guide Book* (2nd edition). Brussels: Commission of the European Communities.

Fagerberg, J., Mowery, D. and Nelson, R. (eds.) (2004) *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.

Freeman, C. (1987) *Technology Policy and Economic Performance: Lessons from Japan*. London: Pinter.

Gertler, M. (2004) *Manufacturing Culture: The Institutional Geography of Industrial Practice*. Oxford: Oxford University Press.

Gertler, M. and Levitte, Y. (2003) Local Nodes in Global Networks: The Geography of Knowledge Flows in Biotechnology Innovation. Paper presented at DRUID's Summer 2003 Conference, Elsinore, 12–14 June.

Grabher, G. (2002) Cool Projects, Boring Institutions: Temporary Collaboration in Social Context. *Regional Studies*, 36 (3): 205–14.

Granovetter, M. (1985) Economic Action and Social Structure: the Problem of Embeddedness. *American Journal of Sociology*, 91 (3): 481–510.

Hall, P. and Soskice, D. (2001) An Introduction to Varieties of Capitalism. In: Hall, P. and Soskice, D. *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*. Oxford: Oxford University Press, pp. 1–68.

Hemlin, S., Allwood, C. M. and Martin, B. (2004) *Creative Knowledge Environments*. Cheltenhan: Edward Elgar.

Henderson, D. (2000) EU Regional Innovation Strategies: Regional Experimentalism in Practice. *European Urban and Regional Studies*, 7 (4): 347–58.

Henderson, D. and Morgan, K. (2001) Regions as Laboratories: The Rise of Regional Experimentalism in Europe. In: Gertler, M. and Wolfe, D. *Innovation and Social Learning*. London: Macmillan.

Holmberg, G. (2003) Functional foods in Scania, Sweden. In: Asheim, B. T., Coenen, L. and Svensson-Henning, M. (eds.), *Nordic SMEs and Regional Innovation Systems – Final Report*. Oslo: Nordic Industrial Fund (http://www.nordicinnovation.net).

Howells, J. (1999) Regional Systems of Innovation? In: D. Archibugi *et al.* (eds.), *Innovation Policy in a Global Economy*. Cambridge: Cambridge University Press.

Isaksen, A. (2005) Regional Clusters Building on Local and Non-Local Relations: A European Comparison. In: Lagendijk, A. and Oinas, P. (eds.), *Proximity, Distance and Diversity: Issues on Economic Interaction and Local Development*. Aldershot: Ashgate, pp. 129–52.

Isaksen, A. and Hauge, E. (2002) *Regional Clusters in Europe. Observatory of European SMEs report 2002*, No. 3, Luxembourg: European Communities.

Jensen, M., Johnson, B., Lorenz, E. and Lundvall, B-Å. (2005) Forms of Knowledge, Modes of Innovation and Innovation Systems. Paper presented at CIRCLE seminar in Lund, 14 September.

Kaufmann, A. and Tödtling, F. (2001) Science–Industry Interaction in the Process of Innovation: The Importance of Boundary-Crossing Between Systems. *Research Policy*, 30 (5): 791–804.

Lagendijk, A. and Oinas, P. (eds.) (2005) *Proximity, Distance and Diversity: Issues on Economic Interaction and Local Development,* Aldershot: Ashgate.

Landabaso, M. (1997) The Promotion of Innovation in Regional Policy: Proposals for a Regional Innovation Strategy. *Entrepreneurship and Regional Development*, 9 (1): 1–24.

Lorenzen, M. (2003) Low-Tech Localized Learning: The Regional Innovation System of Salling, Denmark. In: Asheim, B. T., Coenen, L. and Svensson-Henning, M. (eds.), *Nordic SMEs and Regional Innovation Systems – Final Report*. Oslo: Nordic Industrial Fund (http://www.nordicinnovation.net).

Lundvall, B-Å. (ed.) (1992) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter.

Lundvall, B-Å. (1998) Why Study National Systems and National Styles of Innovation. *Technology Analysis & Strategic Management*, 10 (4): 407–21.

Lundvall, B-Å. and Borras, S. (1999) *The Globalising Learning Economy: Implications for Innovation Policy*. Luxembourg: European Communities.

Lundvall, B-Å. and Johnson, B. (1994) The Learning Economy. *Journal of Industry Studies*, 1 (2): 23–42.

Lundvall, B-Å. and Maskell, P. (2000) Nation States and Economic Development. In: G.L. Clark *et al.* (eds.), *The Oxford Handbook of Economic Geography*. Oxford: Oxford University Press, pp. 353–72.

Malmberg, A. (2003) Beyond the Cluster – Local Milieus and Global Connections. In: Peck, J. and Yeung, H. (eds.), *Remaking the Global Economy: Economic Geographical Perspectives*. London: Sage Publications, pp. 145–62.

Malmberg, A. and Maskell, P. (2002) The elusive concept of localization economies: towards a knowledge-based theory of spatial clustering. *Environment and Planning A*, 34 (3): 429–49.

Marshall, A. (1919) *Industry and Trade*. London: Macmillan.

Martin, R. and Sunley, P. (2003) Deconstructing Clusters: Chaotic Concept or Policy Panacea? *Journal of Economic Geography*, 3 (1), 5–35.

Mariussen, Å. (ed.) (2005) From Regional Development Coalitions to Commercial Innovations, Stockholm, Nordregio Report, 3.

Maskell, P., Eskelinen, H., Hannibalsson, L., Malmberg, A. and Vatne, E. (1998) *Competitiveness, Localised Learning and Regional Development*. Routeledge, London.

Miettinen, R. (2002) *National Innovation System: Scientific Concept or Political Rhetoric*. Helsinki, Edita.

Morgan, K. (2004) The Exaggerated Death of Geography: Learning, Proximity and Territorial Innovation Systems. *Journal of Economic Geography*, 4 (1): 3–21.

Nauwelaers, C. and Wintjes, R. (2002) Innovating SMEs and Regions: The Need for Policy Intelligence and Interactive Policies. *Technology Analysis & Strategic Management*, 14 (2): 201–15.

Nelson, R. (ed.) (1993) *National Systems of Innovation: A Comparative Study*. Oxford: Oxford University Press.

Nilsson, M., Svensson-Henning, M. and Wilkenson, O. (2002) *Skånska kluster och Profilområden: En kritisk granskning*. Malmö: Region Skåne.

Nilsson, J. E. *et al.* (2003) *The Role of Universities in Regional Innovation Systems – A Nordic Perspective*. Oslo: Nordic Industrial Fund. (http://www.nordicinnovation.net).

Nooteboom, B. (2000) *Learning and Innovation in Organisations and Economies*. Oxford, Oxford University Press.

OECD (1996) *The Knowledge-based Economy*. Paris: OECD.

PBI (2002) Plant Biotechnology Institute Bulletin Issue 3 (http://www.pbi.nrc.ca/en/bulletin/2002issue3.htm).

Philips, P., Parchewski, P., Procyshyn, T., Ryan, C., Karwandy, J. and Kihlberg, J. (2004) Agricultural and Life-science Clusters in Canada: An empirical and policy analysis. Report on the Saskatoon ag biotech cluster for Agriculture and AgriFood Canada (AAFC), March. Available online at: http://www.agbio-management.org/.

Porter M. E. (1990) *The Competitive Advantage of Nations*. Worchester: Billing and Sons Ltd.

Porter, M. (2000) Locations, Clusters, Company Strategy. In: Clark G. L., Feldman M. P. and Gertler M. S. (eds.), *The Oxford Handbook of Economic Geography*. Oxford: Oxford University Press, pp. 253–74.

Powell, W. and Smith-Doerr, L. (1994) Networks and Economic Life. In: Smelser, N. and Swedberg, R. (eds.), *The Handbook of Economic Sociology*. Princeton: Princeton University Press, pp. 368–402.

Putnam, R. (1993) *Making Democracy Work*. Princeton University Press, Princeton.

Russo, M. (1989) Technical Change and the Industrial District: the Role of Inter-Firm Relations in the Growth and Transformation of Ceramic Tile Production in Italy. In: Goodman, E. and Bamford, J. (eds.), *Small Firms and Industrial Districts in Italy*. London: Routledge, pp. 198–222.

Ryan, C. and Phillips, P. (2004) Knowledge Management in Advanced Technology Industries: An Examination of International Agricultural Biotechnology Clusters. *Environment and Planning C, Government and Policy*, 22 (2): 217–32.

Sabel, C. F. (1996) Learning-by-Monitoring: the Dilemmas of Regional Economic Policy in Europe. In: OECD (ed.), *Networks of Enterprises and Local Development*. Paris: Organization for Economic Co-operation and Development, pp. 23–51.

Saxenian, A. (1994) *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge (Massachusetts): Harvard University Press.

Skånes Livsmedelsakademin (2003) Innovation i Gränsland. Ansökan till Vinnväxtprogrammet.

Swan, J., Scarborough, H. and Robertson, M. (2002) The construction of communities of practice in the management of innovation. *Management Learning*, 33 (4), 477–496.

Torre, A. and Gilly, J.-P. (2000) On the Analytical Dimension of Proximity Dynamics. *Regional Studies*, 34 (2), 169–80.

Tödtling, F. and Trippl, M. (2005) Networking and Project Organisation in the Styrian Automotive Industry. In: Lagendijk, A. and Oinas, P. (eds.), *Proximity, Distance and Diversity: Issues on Economic Interaction and Local Development*. Aldershot: Ashgate, pp. 89–110.

VINNOVA (2001) Regional Growth Through Dynamic Innovation Systems: Programme Description as a Basis for Internal Support and Decision-Making. Available online at: www.vinnova.se

Whitley, R. (1999) *Divergent Capitalisms – the Social Structuring and Change of Business Systems*. Oxford: Oxford University Press.

Wolfe, D. and Asheim, B. T. (2003) Building social capital and trust and civic entrepreneurship. Miniforum at the 6^{th} TCI conference in Gothenburg, September.

Woolcock, M. (1998) Social Capital and Economic Development: Toward a Theoretical Synthesis and Policy Framework. *Theory and Society*, 27 (2): 151–208.

6 Sourcing of market knowledge in biotechnology

Maija Renko

Introduction

Managing the development of a new technology to be marketed years in the future contrasts with the task of devising a marketing plan for an established product line, and those involved in each task often fail to understand the special challenges the other faces (Berry and Taggart, 1998). Frequently top management in small high-technology firms are heavily biased towards technical disciplines such as science and engineering (Knight, 1986). Marketing and general management skills are often significant areas of weakness within small high-tech firms, where entrepreneurs tend to over-emphasize the purely technological side of their business and neglect other key strategic issues (Knight, 1986; Oakey, 1991). On the other hand, it is over-simplistic to suggest that a clear-cut distinction exists between either technology innovation or market-driven philosophies in such companies. Rather, there is a continuum along which small high-tech firms – as well as industries – progress as they grow, from initial beginnings which are based on the internal technological competencies, towards an outward orientation focusing upon marketing issues (Berry, 1996; Berry and Taggart, 1998).

In conventional markets, acquiring market information comprises collection of primary and secondary information about competitors and the needs and behavior of customers. In markets for technologies (Arora *et al.*, 2001), this initial step in organizational learning should allow for ambiguous information gathering as well. Market information related to new technologies and future products is ambiguous by nature as customers cannot articulate their needs clearly. The approach to market information in markets for technology is more about exploration for new knowledge instead of or in addition to exploitation of established routines (March, 1991; Rothaermel and Deeds, 2004).

The phenomenon studied in this paper is the gathering of market knowledge by young[1] biotechnology firms. Technological and market turbulence underline the importance of innovativeness in the field of modern biotechnology. A number of recent studies have assessed innovativeness in biotechnology from a variety of angles. Deeds and Hill (1996) explored whether a firm's rate of new product development is a function of the number of strategic alliances it has entered into. Greis *et al.* (1995) showed that while partnering is the primary strategy for overcoming barriers to innovation in biotechnology, partnering focus will shift toward commercialization and R&D will be done more internally as the industry reaches maturity. Pisano *et al.* (1988) studied the relationship between in-house R&D and collaboration in biotechnology, and found the two to be complementary. Shan *et al.* (1994) examined the relationship between the number of collaborators and innovative output of a firm. Overall, these studies emphasize the importance of collaborative actions and networking for knowledge creation and its commercial utilization in biotechnology. However, few of these or other studies increase our understanding of collaborations' contribution to market knowledge creation and distribution. Typically, the focus is on technical and technological knowledge, and patents are often used as a proxy for this. Thus, there is a need to take a look at market knowledge instead of technological knowledge and to discuss its development in the biotechnology context.

Research questions

This study at hand concentrates on market knowledge in biotechnology SMEs. The overall research question is *how do biotechnology SMEs source market knowledge?* The topic is approached through two sub questions: (1) Why is market knowledge relevant for biotechnology SMEs?, and (2) What are the sources of market knowledge for biotechnology SMEs? In addition to answering these questions, I also shed some light on the local versus global dichotomy in market knowledge.

The first question is mostly answered in the light of extant literature. The contribution of market knowledge to firm performance has been studied extensively in the marketing domain over the past decades. However, the applicability of most previous research results is yet to be proven in the context of small, knowledge-intensive companies. Thus, the discussion in this paper is not only limited to the analysis of existing literature in the marketing domain; I also apply insights from product development management literature as well as knowledge management studies. There is only scarce empirical research that provides answers to the second research question. Thus, in answering this question I mostly rely on an empirical study that has been conducted in the three biotechnology clusters of Delaware Valley (PA), South Florida (FL), and Bay Area (CA) in the United States.

Defining key concepts

Biotechnology industries

The biotechnology sector comprises biotechnology firms, research institutions, and related industrial companies that discover, develop, and commercialize biotechnological products and processes (Hall and Bagchi-Sen, 2002). The Biotechnology Industry Organization defines biotechnology as 'the use of the cellular and molecular processes to solve problems or make products'. Included in this definition of the industry are firms that use cells and biological molecules for applications in medicine, agriculture and environmental management. Instead of talking about biotechnology industry, Powell *et al.* (2002) choose to use the term 'field'. According to them biotechnology is not a separate industrial sector with well-defined boundaries and 'field' captures the diversity of organizations more aptly than other terms (Powell *et al.*, 2002). An organizational field is a community of organizations that engage in common activities and are subject to similar reputational and regulatory pressures (DiMaggio and Powell, 1983).

Developing biotechnology products or processes from scientific breakthroughs and bringing those products to the market is a long and costly process, with no guarantee of commercial success. The innovation process in biotechnology can be quite complex because basic research, product development, as well as manufacturing and distribution of a commercial product can include several sector players. Strategic alliances and other collaborative agreements among universities, biotechnology firms, and larger industrial companies are widely used methods of achieving innovation (Hall and Bagchi-Sen, 2002). Out of the variety of players in the international biotechnology field, this study focuses on the biotechnology organizations that are smaller, dedicated biotechnology firms, referred to as DBFs in previous research (Powell *et al.*, 2002).

Market knowledge

As economic growth is increasingly driven by 'knowledge-intensive' industries and as our understanding of the innovation process has improved, academics have become increasingly interested in the role that knowledge plays in the innovation process. There is a whole range of studies highlighting the importance of knowledge (see, for example, Prahalad and Hamel, 1990; Nonaka, 1991; Nonaka and Takeuchi, 1995) and learning (Nelson and Winter, 1982; Slaughter, 1993; Levinthal and March, 1993) as a vital aspect of a firm's competence or capability (Teece, 1982; Nelson and Winter, 1982; Prahalad and Hamel, 1990). The role of innovation as a competence or capability enhancer has opened up the issue of the relationship between knowledge and innovation in enhancing firm performance (Howells, 2000).

According to Hammond and Summers (1972), knowledge reflects the extent of a subject's accurate detection of a task's properties. Thus, a manager who can correctly identify customer preferences and competitors is deemed knowledgeable about customer preferences and competitors (Marinova, 2004). Day and Nedungadi (1994: 32) note that 'the two most salient features of a competitive market are customers and competitors'. When delineating the domain of market orientation construct, Narver and Slater (1990) build on customer knowledge, competitor knowledge, and interfunctional coordination. In this research, the term 'market knowledge' implies knowledge about customers and competitors.

The role of market knowledge in biotechnology innovation process

In recent years, the locus of innovation and new product development (NPD) research has shifted from characterizing the process as being a dichotomy between a manufacturer/technology-led, or customer-led, to an *interaction* perspective. According to this perspective, new product development results from the interplay between actors like manufacturers and customers. Integration of customers' needs to product development has been studied extensively in new product development literature. Developing a product that delivers superior value to customers presupposes an understanding of customer needs and wants, a process that should ideally be undertaken prior to the commencement of any actual new product development (Cooper, 1988; Stevens *et al.*, 1999). However, this ideal situation does not always materialize. Information on customer needs can be too costly or complex to access especially for smaller technology ventures. In addition, especially in developing radically new products conventional market research tools are often of limited utility; many firms do not incorporate users' or customers' opinions in their NPD processes because of the customers' limited domains of expertise, because of their inability to articulate their underlying needs, and because of the belief that user developed concepts tend not to be innovative or creative (Leonard-Barton, 1995; Leonard and Rayport, 1997; O'Connor, 1998; Adams *et al.*, 1998). In industrial markets, instead of collecting information on the needs of a large customer base, companies tend to involve individual important customers in the NPD processes (Tidd *et al.*, 2001; Von Hippel and Katz, 2002).

Takayama and Watanabe (2002) divide the pharmaceutical product development process into four stages of (1) Bibliographic survey stage, (2) Discovery research stage, (3) Development stage (including both preclinical and clinical development), and (4) Marketing stage. The same kind of division applies in the case of most other medical biotechnology products as well. Even though the two latter stages are the ones that require most resources, the first two are the ones that determine the probability of success in the process in the first place. The go/no go decision made after the discovery stage is as much influenced by sales forecasts as it is by the technological and scientific details of the research target. The sales forecasts and estimates of the acceptance of the product in the end markets are at this stage typically based on the input the innovator has gathered from its professional network (see Figure 6.1).

Large companies and market leaders are generally in the best position to collect 'technology seeds' and market needs through a network of customers. In the pharmaceutical industry, due to strong contact with professionals like medical doctors as customers or surrogate buyers, market leaders can often utilize their superior position to collect leading information on market and technology (Takayama *et al.*, 2002). This strong relationship with professionals contributes towards keeping a good position for incorporating the market needs and technology seeds into the early stages of new product development processes.

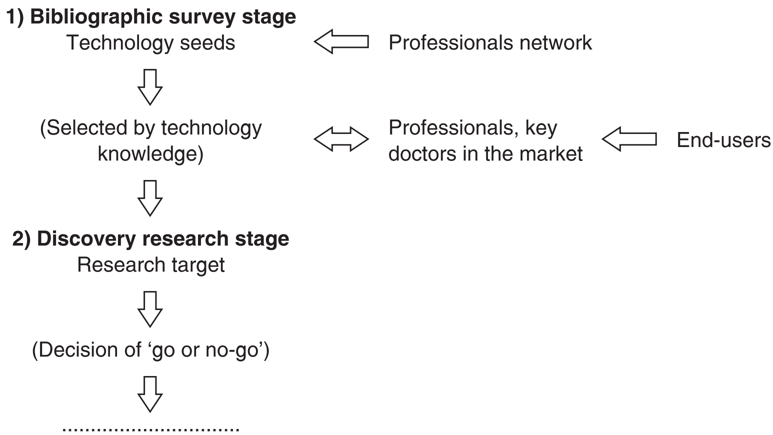

Figure 6.1 Factors for the decision making of early NPD in the pharmaceutical industry (adapted from Takayama and Watanabe, 2002: 355).

For smaller firms, however, the network of existing customers is often non-existent; a large number of small innovator firms operate totally in the field of R&D and have no products on the markets for the time being. This is why the question of integrating market needs into NPD and the whole strategic vision of a company is especially worthwhile in the current research context of small and medium-sized firms.

It has been questioned whether focus on market knowledge that encourages listening to current customers as well as consensus and cohesion within an organization, can produce the flexibility and learning required to adjust to turbulent environments such as high-technology fields (Stewart *et al.*, 2003). Learning achieved through market orientation has been described as incremental, and focused on issues or opportunities that are within the traditional scope of the organization's activities (Kohli and Jaworski, 1990; Slater and Narver, 1995; Baker and Sinkula, 1999). This type of learning is 'impeding the search for unconventional business opportunities' (Hamel and Prahalad, 1991: 83). The adaptability and creativity that drive especially radical innovations cannot be achieved through the components of traditional market orientation like uniformity, cohesion, and adapting the majority view (Nemeth, 1997). Takayama and Watanabe (2002) conclude that in the pharmaceutical context, technology knowledge promotes NPD. In contrast, market knowledge sometimes inhibits NPD. In the case of totally new products, or disruptive innovations, successful NPD is not derived from market knowledge creation but initiated by technology knowledge, while 'freezing' market knowledge (Takayama and Watanabe, 2002: 361).

So far, the discussion has focused on the role of customer knowledge in new product development. In addition to customer intelligence, another central element in market information is competitor intelligence. Identifying competitors within a shifting competitive landscape poses special challenges. Competition is not technology-specific or geographically bounded, but comes in many forms and from many directions; in markets for technology, heterogeneous competitors compete indirectly and on multiple dimensions. When it comes to recognizing rivals, managers are myopic (Levitt, 1960). Left to their own science and technology, they notice only competitors that are relatively close in terms of core technology, product type, geography, and other salient characteristics (Porac and Thomas, 1990). Thus, they are likely to be blindsided by rivalry coming from unexpected directions (Zajac and Bazerman, 1991). Explanations for this blindness include the lack of managerial resources such as time and attention; especially when rivals are heterogeneous and the competitive environment is dynamic, keeping track on potential competition consumes time and other resources. Under conditions of complexity and uncertainty, typical in markets for technology, bounded rationality and cognitive biases are factors as well (Williamson, 1975; Kahneman *et al.*, 1982; Peteraf and Bergen 2003).

Proactive information gathering and analysis are critical to the successful development and execution of innovative strategies and new product development in markets for technology (Barringer and Bluedorn, 1999; Matsuno *et al.*, 2002; Rothwell 1992, Ottum and Moore, 1997). Recent research suggests that the degree to which a firm is involved in new product activity depends on the extent and nature of its market orientation (Athuene-Gima, 1995, 1996; Hurley and Hult, 1998; Tyler and Gnyawali, 2002; Frambach *et al.*, 2003) and that market orientation and innovativeness are complementary rather than conflicting concepts (Slater and Narver, 1995; Becherer and Maurer, 1997). Especially, when market orientation is extended to include technology orientation in addition to the more traditional customer and competitor orientations (Gatignon and Xuereb, 1995, 1997), the links to innovativeness and NPD are clear. On the other hand, R&D and innovativeness have often been contrasted to marketing and market orientation in a firm (Christensen 1997; Hamel and Prahalad, 1994). This contrast, however, is not true if the market orientation of the firm has a strong proactive component in it. Taking into account the concerns about 'customer-led' firms presented by Prahalad and Hamel (1994), Hunt and Morgan (1995) emphasize including potential customers into market intelligence generation, not only the articulated needs, wants and desires of present customers. Also potential competitors in addition to present ones have to be included to 'guard against the hazards of changing technology resulting in new competitors' (Hunt and Morgan, 1995: 11).

The field of biotechnology is characterized by a high rate of formation and dissolution of linkages. Collaborative agreements are often forged with a specific goal in mind, such as taking a company public or selling and distributing a new medicine. There is also a good deal of entry and exit into the field, with new entrants joining at particular times when financing is available and novel scientific opportunities can be pursued. Many of the participants of the biotechnology field are capable of performing multiple activities; those organizations that are more centrally located in the industry have access to more sophisticated and diverse collaborators, and have developed richer protocols for collaboration (Powell *et al.*, 1996, 2002).

Geographical concentration of firms in one industry at a particular location has been and continues to be high (Krugman, 1991) and evidence for geographically concentrated knowledge flows in research-intensive industries is compelling (Saxenian, 1994; Jaffe *et al.*, 1993; Almeida *et al.*, 2003; Almeida and Kogut, 1999). Even though knowledge dissemination is hard to trace, prior research documents the ease of knowledge dissemination within geographical clusters due to the prevalence of formal and informal relationships (see Feldman (1999) for a review). Jaffe *et al.* (1993) find a linkage between the place of a patent and citation of that patent, which suggests that knowledge available in patents is more frequently used by firms within the same locality. In addition to technical knowledge, the knowledge exchanged may be of a tacit nature – i.e. information which is not encoded – or of a business or social nature resulting from local networks of people.

A study by Shan and Song (1997) finds empirical support for the importance of physical proximity in biotechnology; they show that biotechnology firms source knowledge regionally. Zucker and Darby (1996) as well as Audretsch and Stephan (1996) conclude that geographic co-location of biotechnology firms is a function of access to scientific talent and the skills of 'star' scientists, who are active in both academic and commercial research communities. In scientific industries the relevant knowledge may be situated in informal communities of practice that constitute a local technology labour market (Brown and Duguid, 1991). Whereas in the computer industry links are inter-industrial with important communication flowing between engineers within the industry, in biotechnology the important links to foster and sustain have been between the science base and companies (Zucker *et al.*, 1994).

Research on knowledge diffusion in biotechnology has pointed to the role of relationships and networks as knowledge 'channels and conduits'. Owen-Smith and Powell (2004) conclude that the extent to which information transmitted through formal linkages is accessible is a function of the density of ties – both formal and informal – as well as the public versus private goals of a network's anchor firms. The density of ties points to geographical proximity; ties between organizations make it possible for a region to be able to build and keep its distinctive competence. If knowledge is not found everywhere, then where it is located becomes a particularly significant issue.

In conclusion, despite some authors' criticism that listening to customers impedes radical innovativeness, knowledge of both customers' needs and competitors' products is an important part of innovative processes in high-technology firms. Instead of relying on present customers' opinions in new product development, innovative firms listen to more ambiguous market signals and potential future customers. Small, young firms that suffer from liabilities of adolescence may find it challenging to devote resources for proactive sourcing of market knowledge. However, even in the science-driven field of biotechnology, innovativeness is not only based on 'technology seeds'. From the beginning on technological ideas are complemented with knowledge about the applicability and marketability of these ideas, i.e. market knowledge. In the case of small biotechnology firms, previous research suggests that this market knowledge is typically conceived from a network of professionals that have understanding of end users and usage contexts. In addition, previous research in the biotechnology context has demonstrated the importance of geographical proximity for dissemination of tacit knowledge. Market knowledge is often more explicit in nature than technological knowledge. Let us now look at the results of an empirical study that was conducted to understand the sourcing of market knowledge by biotechnology SMEs.

Empirical study

The empirical study was conducted in the US biotechnology (including medical devices) industry clusters of Delaware Valley, Southern Florida, and Bay Area (CA) in July 2003–July 2004. The empirical study reported here is an integrated part of a study conducted to find out about market orientation in small biotechnology firms. The results reported here concentrate on the sourcing of market knowledge, whereas the data collection was carried out to understand the larger concept of market orientation in the firms.

The three geographical areas were chosen because they represent different stages and dynamics of cluster development. The birth of the modern biotechnology industry is often dated to 1973 and a series of patent applications that were filed by Professors Stan Cohen of Stanford University and Herb Boyer of the University of California at San Francisco. In addition to scientific discoveries, other reasons why the biotechnology industry took root around San Francisco are owing to the heritage of the computing industry in Silicon Valley. This high-technology field had created a presence venture capital with expertise in starting and growing technology companies. In addition, high job mobility contributed to the rapid spread of new ideas in the area (Prevezer, 1997). Bay Area is known as a hotspot of technology entrepreneurship, and knowledge spillover effects between firms are a result of the mobility of the workforce as well as communication in social networks. Also, California has implemented legislative initiatives that encourage investments in biotechnology research.

The development dynamics and current stage of biotechnology cluster in the Pennsylvania/Delaware Valley area are rather different from Bay Area. Pennsylvania is an important hub of biotechnology firms in the US, and the center of activities is Philadelphia. The Philadelphia medical district, with its large pharmaceutical firms, was established by the mid-1950s. During the past two decades more than 100 biotechnology firms have sprouted in the greater Philadelphia area. This transformation from a traditional drug and pharmaceutical base into biotechnology is a result of several interrelated elements, such as the concentration of academic, medical, and research-oriented institutions; the presence of large pharmaceutical companies; availability of capital; and coordinated support or government and private organizations. The three-state area around Philadelphia, including Eastern Pennsylvania, New Jersey, and Delaware, accounts for about 80% of the production of pharmaceuticals in the US (Llobrera, Meyer, and Nammacher, 2000; Santomero, 2002).

Compared to Bay Area, Delaware Valley biotechnology firms have suffered from limited venture capital funds and insufficient support for entrepreneurial activities of individuals. Lately, these barriers have been partly overcome by forging partnerships and building networks of collaboration. Coalitions of academia, corporations, and government such as the Ben Franklin Partnership and the Greater Philadelphia Partnership have been hubs in local social networks. They have also given structure and direction to the venture capital accumulation in the area (Llobrera *et al.*, 2000).

In terms of population, Florida is the fourth-largest US state and it is third in consumption of pharmaceutical products. Florida's government officials and state agencies are supportive of expanding the biotechnology industry in Florida, and the state has made investment in and developed the medical infrastructure that is critical for the growth of the industry. Florida is well positioned for the growth in the biomedical industry because of its growing pool of scientific, technical and management labor. A boost to biotechnology in Florida is expected as a result of the decision of the Scripps Research Institute, a California-based non-profit research institute, to open its second facility in West Palm Beach, FL (Abrams, 2004). Scripps' arrival is fueling expectations of growth in the number of new biotechnology companies that will emerge in South Florida. The life science field in Florida is dominated by medical devices. Florida ranks second in the United States for its number of FDA-registered medical device establishments and these companies typically specialize in minimally invasive surgery, disposable devices and supplies, orthopedic and cardiac implants, diagnostic imaging, and sterilization equipment (Enterprise Florida, 2004).

Data collection

The informants of the empirical study were managers (mostly CEOs, some business development managers included) of small or medium-sized firms developing medical (biopharmaceutical or device) innovations from inventions to commercial markets. The data set comprises 64 firms. The empirical research is based on qualitative data collection. Table 6.1 below summarizes the key characteristics of the firms included in the study. Most of the companies classified as medical devices in Table 6.1 could also be classified as biomaterial firms, as their devices integrate e.g. biodegradable parts or similar to small devices used e.g. in surgeries. Most of the companies are young and employ less than 50 people. Most of the drug discovery and development firms do not have products on markets yet, whereas most of the medical devices firms typically do. This is due to the nature of product development in the two fields; pharmaceutical product development and testing is a process that requires typically 12 to 15 years.

Table 6.1 Demographics of companies in the empirical study ($n = 64$)

Firm location		*Field of business*		*Firm age*		*Number of employees*		*Products on markets*	
Delaware Valley, PA	19	Drug discovery and dev.	26	1–2 years	14	1–5	7	Yes	30
South FL	19	Diagnostics	3	3–5 years	24	6–20	26	No	34
Bay Area, CA	26	Medical devices	12	6–10 years	17	21–50	13		
		Technology platform	23	11–20 years	9	51–100	11		
						101–250	7		

Semistructured face-to-face interviews with CEOs of the firms were conducted to find out about market knowledge in their firms. Each interview lasted for about an hour. For the purposes of the research presented in this paper, the managers of the firms were asked open-ended questions about their customers, competitors, dissemination of market information in their firm, and their most important sources of market knowledge.

The firms studied in the three areas of Southern Florida, Delaware Valley (PA), and Bay Area (CA), are independent, small or medium-sized firms. The size of the firms varies from incubator size (firms employing one person) to firms employing a maximum of 250 people. The companies are active in R&D in human therapeutics (drug discovery and development), diagnostics, medical devices, and/or technology research that helps in developing the aforementioned classes of products. The companies are product-oriented, i.e. even if they provide services as a part of their business model, their main lines of business are about researching and developing physical products.

The sample of companies included in this research was derived from the three industry databases of BioFlorida (www.bioflorida.org), Pennsylvania Biotechnology Association (www.pabiotech.org), and the Biotechnology Industry Organization (www.bio.org) member directory of Californian companies. BioFlorida lists 160 companies active in biotechnology in Florida. The companies were assessed for their size and lines of business and the CEOs of the firms that fulfilled the criteria of this research were sent an e-mail and asked about their interest to be included in this research. Twenty-two managers answered and with 19 of them, it was possible to set a time for a face-to-face interview. In a similar way, Pennsylvania Biotechnology Association lists 170 firms. Again, these companies were assessed for their characteristics and the ones that fulfilled the criteria of this research were approached by e-mails. In Pennsylvania, it was possible to set times for 20 interviews with managers of firms in the Delaware Valley area. Finally, out of the 256 firms listed by Biotechnology Industry Organization in California, 64 were evaluated as suitable for the study (size and business focus criteria) and contacted. Out of these firms, interviews were conducted in 26 Bay Area firms.

Data analysis

Initial data analysis was conducted immediately after each interview. The interviews were not tape recorded. Instead, during the interviews I made extensive notes on the answers of the interviewees. The decision not to record the interviews was based on two reasons. Firstly, I was not interested in capturing every single word of the interviewees' speech. Instead, I was interested in the content of their comments and answers. Summarizing the key comments and issues emphasized by the interviewees was possible with a pencil-and-paper approach during the interview. Second, I wanted the interviewees to feel very comfortable and relaxed in the interview situation and to elaborate on their opinions. Even though tape recording is preferred in qualitative research interviews to ensure the reliability of the data, the fact that the recorder is present has been demonstrated to deteriorate the interviewees' willingness to express all of their thoughts. I transcribed my extensive notes from each interview always within three hours after the end of the interview. This way I did not only have the notes but also the actual interview situations fresh on my mind. The notes were coded, that is, divided into analyzable units by creating categories with and from the data in order to characterize what each statement was about in terms of general thematic content (Coffey and Atkinson, 1996). These more general categories or themes were compared and linked together in order to identify similarities, deviances and recurring themes in the interviews. However, the categories were not imposed upon the data arbitrarily; they reflected the data (Dey, 1993). This way the analysis was sensitive to new categories and themes emerging from the data.

Research results

The role of market knowledge in biotechnology SMEs

The role of market knowledge in a firm is determined along two dimensions. First of all, I am interested in the content of market knowledge. The more complicated the market structure of a firm, the more stakeholders there are, and hence the more constituencies the firm should include in its market knowledge. Second, the role of market knowledge in a firm is dependent on the internal distribution of that knowledge within a firm. Previous studies on market orientation have highlighted organizational culture and structures as barriers to generating and disseminating market knowledge (for a review, see Harris, 1999). However, in the small firm context it is likely that these barriers exist on the level of individuals rather than departments.

In order to find out about the role of market knowledge in the study firms, managers were first invited to describe their customers and competition. This was necessary taken the conceptualization of market knowledge employed in the study; market knowledge comprises customer and competitor knowledge. The following Table 6.2 describes the numbers of times that various kinds

Table 6.2 Customers and competitors of study firms ($n = 64$)

Customers of the firm are ...	*Number of managers mentioning this customer group (n = 64)*
Other biotechnology companies	35
Patients	26
Medical doctors	26
Hospitals	12
Investors	9
Regulators	5
Insurance companies/third party payers	4
Both large and small firms	40
Other biotechnology companies	15
Large companies (pharmaceutical/biotech)	9
No competition	5
Attitudes and current practices	4

of customers and competition were mentioned by the interviewed managers. The questions were open-ended, and each interviewee could mention as many groups of customers and competitors as he/she wanted to.

The field of biotechnology encompasses companies operating in a number of traditional industries – like pharmaceuticals and agriculture – and an even larger number of emerging, new technology fields, like nanotechnology, biomaterials, and pharmacogenomics. The companies of the current study were selected from medical biotechnology only so that comparisons of firms in terms of market knowledge would be feasible. However, even within the small number of firms included in this study there are significant differences between the kinds of customers companies are targeting.

A closer look at the types of customers by types of firms[2] reveals that drug discovery and development companies see (1) patients and (2) investors as their customers more often than other types of companies (Chi-square $p = 0.001$). There are no significant differences between the firms studied as far as 'other biotechnology companies' as customers are concerned, but the interviews revealed that whereas technology platform firms typically aim at *selling* their technologies to other companies, drug discovery and development firms mostly aim at *licensing* their innovations to other firms. Medical doctors are an especially important customer group for medical device firms and often also mentioned by drug discovery and development companies, but they are not an important customer group for technology platform firms (Chi-square $p = 0.001$).

These differences in customer groups of various types of biotechnology firms point to the challenges we face when trying to generalize concepts such as market knowledge across firms. As mentioned earlier, market knowledge comprises knowledge of customers and competition. The content of market knowledge is very different for those whose customers are patients versus those who have other businesses as customers.

To understand the distribution of market knowledge within the study firms, I asked the managers to elaborate on 'How would you describe the relations between people working in marketing/sales in your firm and other 'departments'? and 'What kinds of challenges are there when you try to integrate the market intelligence into your R&D?' The answers to these questions basically reflect two critical aspects of market knowledge.

Firstly, in small biotechnology firms the 'departmental' friction arises between individuals involved in R&D work – typically scientists – and those trying to make a business out of that science. At the very early stages of company development the two functions are actually carried out by the same people, the focus being on science. Later on, when dedicated business development and marketing personnel are added to the team, the communication between them and scientists presents challenges. Even though most interviewees described the relations between the two functions as 'close' and 'integrated', they also identified challenges in communication and integration. Typical comments from the interviews that reflect this duality – close relations together with some friction – are listed in Table 6.3.

Second, promising small, technology-intensive firms grow rapidly over their early years of existence. Even if the growth in personnel is well planned out – which it often times is not – the growth brings along challenges for communication within the firm. Dissemination of market intelligence can initially be handled through informal meetings and 'hall-talk', but as the company grows there is more need for formalized channels of knowledge distribution.

Table 6.3 Interview quotes on dissemination of market knowledge

Examples of the role of market knowledge within firms, quotes from the interviews: Dissemination of market knowledge in a firm:

'There is a little bit of friction between the two [marketing and R&D]. Marketing wants to move quickly, science side wants to critically analyze, they are more negative. PhDs are concerned about looking good to their peers, they need to be critical. On the other hand investors are very cautious about negative information and signals'.

'All this [market knowledge] can now be integrated in my head. The biggest challenge is to put everything together, to turn this into priorities is actually easy'.

'At a certain stage NPD [new product development] requires commercial info; we [business development] come together with R&D at proof of concept stage'.

'Our in house marketing is three people. The relationships between them and the rest of us are cooperative but embryonic. The challenge is that depending on the development stage of products, the focus shifts between various departments. First you are concerned about discovery, then development, finally sales'.

'We are a small firm, the relations are good. Still there are some tensions: scientists want to validate everything and they do not want to over-promise. Scientists are actually the best salespeople'.

'Everyone in the firm is a scientist. That is why market information is not disseminated so well. However, when Ben [Business development manager] hears something important about markets he shares it with others and they are normally interested. But scientific info is much better disseminated'.

Going back to the content of market knowledge, I have already shown that even though the firms in the empirical study all represent medical biotechnology firms, still the kinds of customers they aim to reach vary. Furthermore, it is worth pointing out that the long product development timescales and scientific uncertainty of this development are also reflected in the role that market knowledge gets in these firms. Overall, the less developed the product concept of the firm, the more difficult it is to talk about rigorous market research. At an extreme, it may well be that the company does not initially know the potential its technologies have when applied into commercial purposes. When the goal of product development is not clear, it is naturally very difficult to gain knowledge of the markets for that product. However, even though there are numerous challenges in proactively assessing the scope and features of future markets, companies still aim to do this in order to justify their existence to investors and other key stakeholders. The following quotes (Table 6.4) from the interviews reflect some of the typical challenges that the companies are facing.

Sources of market knowledge

Now that the reader has an understanding of the types of customers our study firms are dealing with and the competition they face, we can turn to the question about sources of market knowledge. After inquiring of our interviewees about the customers and competitors of their firms, I asked them to think of their markets consisting of customers, potential customers, and competitors, and asked them an open ended question '*What are the most important sources of market knowledge for your firm*?' Table 6.5 summarizes the answers I got.

Table 6.4 Interview quotes on content of market knowledge

Examples of the role of market knowledge within firms, quotes from the interviews: *Content of market knowledge:*
'It takes long to develop a drug; confidential information is not published early. So you may figure out you are working on something someone else is already doing'.
'Market data are always based on present but our products will be in the future, so the challenge is in foreseeing the future . . . In medical markets, marketing is more about education than advertising'.
'We should actually develop our products backwards: We first think about where the drug is most likely to work, only after that you think about the size of the market. You ask yourself what is the market where you can have most impact and thus charge higher prices'.
'It is really hard to predict what will happen in the markets. Most breakthroughs arise from a back up plan of a small firm turning out to be more valuable than anticipated, not from primary project being easier than anticipated'.

Table 6.5 Sources of market knowledge for study firms ($n = 64$)

Source of market knowledge:	*Number of managers that mentioned this source (n = 64):*
Industry databases	26
Communication with customers/potential customers	22
Academic publications	19
Own in-house market research	18
Academic conferences	16
Commercial fairs and conferences	16
Informal contacts, friends	15
Commercially available market reports	13
Talking to opinion leaders	9
Partner companies	7
Venture capitalists and investors	3
Focus groups	2

Industry databases

The most often mentioned source of market data is industry databases. These databases contain information on competitors, their product development, market sizes worldwide by indications, incidence and prevalence data, etc. However, the use of these data is not always straightforward. Many firms target their products at indications on which scarce information exists. For example:

> We got numbers from UNOS [United Network for Organ Sharing] but we had to find out about clinical practices ourselves by calling transplantation centers and asking how much these tests cost.

Communication with customers/potential customers

Many of the managers indicated that individuals from their firm interact directly with customers or potential customers to find out about their future needs. This happens especially in firms that operate in business-to-business markets:

> We have direct communication with customer companies. We work together with customer companies' R&D and listen to their wishes, customer satisfaction and so on.

However, when assessing the feasibility of products that are disruptive innovations by nature, there are difficulties in interpreting customers' opinions and responding to them:

> Surgeons cannot really communicate what they want. We have to find ways to get into their heads and understand what they want.

> We are a small company early in the process. We cannot be responsive to customers, we are responsive to technology. The only customer information we are responsive to is the clinical trial data. We have started to go down a path [multiple sclerosis] and we cannot change many things anymore.

Academic publications

Maybe surprisingly, many interviewees indicated that academic publications are an important source of market knowledge for them. This either reflects the fact that for early stage firms markets are so intertwined with science that no clear-cut distinction between the two – i.e. markets and science – exists, or it may be a reflection of the scientific background of the interviewees themselves. Managers with backgrounds in science and technology are used to reading academic texts and maybe they are able to derive hints for commercial applications from that literature.

Own in-house market research

Despite their small size and early development stage, many of the firms studied mentioned their own, in-house market research as a source of market data. For many firms this means ad-hoc searches online for incidence and prevalence data of diseases, for example. However, some firms had been engaged in more resource-intensive and time-consuming market research activities, for example:

> We did ourselves an e-mail survey to dentists around the world. We sent our 20,000 questionnaires to dentists through e-mail and got 500 responses.

Academic conferences and commercial fairs and conferences

Both academic conferences as well as commercial fairs and conferences were mentioned as sources of market knowledge. These are the venues where industry friends get together and exchange information. Also, competing firms are often present, providing possibilities for benchmarking.

Informal contacts, friends

Especially for the youngest firms with scarce resources the most important sources of market data are often managers' informal contacts and industry friends. Some interviewees mentioned that they have access to expensive market reports they could not afford to buy themselves through their friends in larger firms. Even though discussions with industry friends provide firms with market insights, the reliability and relevance of this information is sometimes questionable. However, in an extreme case:

> We ask people for favors. It is all about informal contacts, personal networks, student friends, and free information.

Commercially available market reports

There are multiple global providers of market reports on various sides of medical markets, and some of the managers I interviewed indicated that their firm subscribes to such reports. However, most managers felt that these reports were overpriced for small firms. Furthermore, as mentioned earlier, small firms often aim at small market niches with their initial products, and the market reports available tend to cover major markets that are mostly of interest for larger pharmaceutical companies.

Talking to opinion leaders

In the case of medical care, the physician has the ultimate responsibility for choosing which therapy to use or which drug to prescribe, whereas the patient is the end-user and in some cases also the payer of the chosen product. Even though a physician is not the customer in the sense of actually buying the product, nor is he the end user of the prescribed drug, he still dominates the end user's decision-making process to a varying degree. Some interviewees indicated that they consult opinion leaders, i.e. typically academics with clinical experience, when they want to learn about their markets. These opinion leaders are knowledgeable of treatment practices and development in the field, but there are also issues that need to be taken into consideration when consulting opinion leaders:

> Doctors are integrated in our R&D. Their skills and needs vary; top opinion leaders do not represent the mainstream market.

Partner companies

In most cases, a small firm focusing on technology research and development does not have the resources to commercialize innovations to global end user markets. For distribution, commercialization and often also development of the innovation, these firms partner with larger companies. Often, the deals at this stage take the form of licensing deals. Finding a committed licensor that benefits the small firm's internal development as well is a challenge. For some small technology firms, larger partner companies are sources of market knowledge, which follows naturally from their downstream position in the industry supply chain.

Venture capitalists and investors

Some interviewees mentioned their investors as a source of market knowledge. However, further questions on the topic revealed that rather than providing market data to firms as such, some investors facilitate communication between their portfolio companies and in that way contribute to dissemination of knowledge between portfolio firms. In some occasions, venture capitalists also provide their portfolio firms access to market databases and reports that these firms would not otherwise purchase.

Focus groups

Finally, some managers mentioned patient or physician focus groups as a source of market data. However, this method – although often used by larger firms – is not commonly employed by the smaller firms covered in this study.

I did not ask the interviewees to specifically address the issue of geographical proximity related to sources of market knowledge. However, some inferences about the relative unimportance of geographical proximity may be derived from the fact that the issue never came up in the interviews. The majority of the most often mentioned market data sources mentioned above, like industry databases, market reports, and academic publications, contain global information. Furthermore, the nature of academic as well as commercial conferences in the field of biotechnology is very international; companies do scan competitors and potential markets globally. The only sources of market knowledge mentioned by our interviewees that have a somewhat local nature are informal contacts and industry friends as well as investors. For these sources, previous studies regarding the ease of knowledge dissemination within geographical clusters (Feldman, 1999) are relevant. However, contrary to the findings of Jaffe *et al.* (1993), Almeida and Kogut (1999), Audretsch and Stephan (1996), and Zucker and Darby (1996) regarding *technological* and *scientific* knowledge dissemination in biotechnology, I would propose that physical proximity is *not* an important factor for biotechnology firms' sourcing of *market* knowledge. This proposition is based on insights from the empirical study reported here and the fact that the most important sources of market knowledge reported by the firms are not physically bounded.

Conclusions and implications

This research has addressed the 'why' and 'how' questions of market knowledge in biotechnology. Let us now first get back to the 'why' question. Initially, considering the science-driven nature of biotechnology business, one is tempted to assume that market knowledge has a very limited role in small biotechnology firms. However, even though some researchers have even suggested that customer knowledge impedes innovation, a growing body of literature on new product development suggests that innovation is achieved by combining technological knowledge with understanding of markets. Even the early stages of pharmaceutical product discovery and development are influenced by market considerations, typically channelled to firms through professional networks.

Knowledge comes in a variety of shapes and forms, ranging from the activities of innovation and R&D to the more elusive know-how and ways of doing things that somehow add value to a firm. A consensus has arisen around the value of the tacit–explicit knowledge distinction first drawn by Michael Polanyi (1958, 1966). This paper has focused on market knowledge in biotechnology, more specifically, in the context of small, research-intensive biotechnology firms. This knowledge – and the way it was operationalized in the empirical study – is codified, i.e. explicit. Thus, to find out about the 'how' question of market knowledge, specific questions can be presented to managers to tap the origins of market knowledge that flows into firms. The current study has shown that small biotechnology firms source market knowledge from a variety of stakeholders. In addition to the more traditional sources like industry databases and consultants' market reports, these firms rely on their informal networks, opinion leaders, and partner companies in sourcing market knowledge. Furthermore, the fact that many of the interviewed managers saw academic publications and conferences as a source of market knowledge points to the non-specific nature of this knowledge. When dealing with markets of the future, market knowledge is often intertwined with more general knowledge of the field, even scientific and technological knowledge.

Ottosson (2003) concludes that it is of the outmost importance to distinguish between customers and users, even though they sometimes are the same person. Of importance for the direct customers of medical technology products, i.e. for medical doctors, hospitals, and third party payers, are issues such as price, quality, and ease of delivery. On the other hand, relevant issues for the end users, patients, are reliability of the products, their potential side effects, as well as the overall cost for using the products. Based on the sources of market knowledge identified in the empirical study it looks like biotechnology SMEs listen to both their (future) end users as well as other parties involved in the distribution chain, like physicians and hospitals.

The unit and level of analysis of the current research is a firm. Thus, only limited conclusions can be drawn on a regional level. However, the interviews have been conducted in three biotechnology cluster areas with very different kinds of development paths. Initially, one could expect that firms in these various geographic areas relate to their markets and stakeholders in somewhat different ways. However, based on the qualitative interviews reported here, it looks like the geography-based differences in sourcing of market knowledge are almost non-existent. Rather than regional differences, industry sector within biotechnology seems to cause some variation in market knowledge, especially its content. For example, medical device firms source market knowledge on and from somewhat different kinds of stakeholders than drug development firms. Regional variation comes into play in a sense that some of the stakeholders that firms use as sources of market knowledge are area-specific (local venture capitalists, regional biotechnology associations). Also, if the geographical scope of the research was expanded beyond the US, it is possible that regional differences between firms would become more prominent.

Based on the empirical study, a proposition for future research addresses the geography of market knowledge: taking the codified nature of market knowledge, physical proximity to sources of market knowledge is expected to be less important for knowledge dissemination than in the case of more tacit technological knowledge. In the case of technological knowledge, the importance of proximity to knowledge sources has been studied, e.g. by using patent data and citations as a proxy for knowledge. Similar kinds of proxies for somewhat objective measurement of market knowledge dissemination between organizations are scarce. It is likely that also future research has to rely on self-reported measures when assessing market knowledge. However, a more quantitative approach than the one employed in this research could shed light on the geographical aspects of market knowledge.

Notes

1 When talking about young firms here we refer to firms of 20 years of age or less. Firm size and age typically correlate. The notion 'small and medium-sized enterprise' (SME) refers to firms employing 250 people or less. Consequently, throughout the text the attributes 'young', 'small', and 'small and medium-sized' are used interchangeably when talking about the biotechnology firms in focus.

2 Types of firms, i.e. fields of business: (1) drug discovery and development, (2) diagnostics, (3) medical devices, (4) technology platforms.

References

Abrams, S.L. (2004) How to Build A Biotech Center, *Investment Dealers' Digest*, 70, 28, 24–26.

Adams, M.E., Day, G.S. and Dougherty, D. (1998) Enhancing new product development performance: an organizational learning perspective, *Journal of Product Innovation Management*, 15, 5, 403–22.

Almeida, P. and Kogut, B. (1999) Localization of knowledge and the mobility of engineers in regional networks, *Management Science*, 45, 7, 905–17.

Almeida, P., Dokko G. and Rosenkopf, L. (2003) Startup size and the mechanisms of external learning: Increasing opportunity and decreasing ability? *Research Policy*, 32, 2, 301–15.

Arora, A., Fosfuri, A. and Gambardella, A. (2001) *Markets for Technology. The economics of innovation and corporate strategy*, The MIT Press, Cambridge, Mass.

Athuene-Gima, K. (1995) An exploratory analysis of the impact of market orientation on new product performance, *Journal of Product Innovation Management*, 12, 4, 275–93.

Athuene-Gima, K. (1996) Market orientation and innovation, *Journal of Business Research*, 25, 2, 93–103.

Audretsch, D. and Stephan P. (1996) Company-scientist locational links: The case of biotechnology, *American Economical Review*, 86, 3, 641–52.

Baker, W. and Sinkula, J.M. (1999) The synergistic effect of market orientation and learning orientation on organizational performance, *Journal of the Academy of Marketing Science*, 27, 4, 411–27.

Barringer, B. and Bluedorn, A. (1999) The relationship between corporate entrepreneurship and strategic management, *Strategic Management Journal*, 20, 5, 421–44.

Becherer, R.C. and Maurer, J.G. (1997) The moderating effect of environmental variables on the entrepreneurial and marketing orientation of entrepreneur-led firms, *Entrepreneurship Theory and Practice*, 22, 1, 47–58.

Berry, M.M.J. (1996) Technical entrepreneurship, strategic awareness and corporate transformation in small high-tech firms, *Technovation*, 16, 9, 487–98.

Berry M.M.J. and Taggart J.H. (1998) Combining technology and corporate strategy in small high tech firms, *Research Policy*, 26, 7–8, 883–95.

Brown, J.S. and Duguid, P. (1991) Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation, *Organization Science*, 2, 1, 40–57.

Christensen, M.C. (1997) *The Innovator's Dilemma*, Harvard Business School Press, Boston.

Coffey, A. and Atkinson, P. (1996) *Making Sense of Qualitative Data*, Sage Publications, Thousand Oaks.

Cooper, R.G. (1988) Predevelopment activities determine new product success, *Industrial Marketing Management*, 17, 3, 237–47.

Day, G. and Nedungadi, P. (1994) Managerial representations of competitive advantage, *Journal of Marketing*, 58, April, 31–44.

Deeds, D. and Hill, C.W.G. (1996) Strategic alliances and the rate of new product development: an empirical study of entrepreneurial biotechnology firms, *Journal of Business Venturing*, 11, 1, 41–55.

Dey, I. (1993) *Qualitative Data Analysis: A User-friendly Guide for Social Scientists*, Routledge, London.

DiMaggio, P. and Powell, W. (1983) The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields, *American Sociological Review*, 48, April, 147–60.

Enterprise Florida (2004) EFlorida market brief. Florida's Life Science Cluster. http://www.eflorida.com/pressroom/presskit/biopresskit/MarketBrief.pdf. Visited 9/9/2004.

Feldman, M.P. (1999) The new economics of innovation, spillovers and agglomeration: A review of empirical studies, *Economics of Innovation and New Technology*, 8, 5–25.

Frambach, R.T., Prabhu, J. and Verhallen, T.M.M. (2003) The influence of business strategy on new product activity: The role of market orientation, *International Journal of Research in Marketing*, 20, 4, 377–97.

Gatignon, H. and Xuereb, J-M. (1995) Strategic orientation of the firm and new product performance, *INSEAD Working Paper Series*, 95/60/MKT, June, Fontainebleau, France.

Gatignon, H. and Xuereb, J-M. (1997) Strategic orientation of the firm and new product performance, *Journal of Marketing Research*, 36, 1, 77–90.

Greis, N.P., Dibner, M.D. and Bean, A.S. (1995) External partnering as a response to innovation barriers and global competition in biotechnology, *Research Policy*, 24, 4, 609–30.

Hall, L. and Bagchi-Sen, S. (2002) A study of R&D, innovation, and business performance in the Canadian biotechnology industry, *Technovation*, 22, 4, 231–244.

Hamel, G. and Prahalad, C.K. (1991) Corporate imagination and expeditionary marketing, *Harvard Business Review*, 69, 4, 81–92.

Hamel, G. and Prahalad, C.K. (1994) *Competing for the Future*, Harvard Business Press, Boston.

Hammond, K. and Summers, D. (1972) Cognitive Control, *Psychological Review*, 79 (January), 58–67.

Harris, L.C. (1999) Barriers to developing market orientation, *Journal of Applied Management Studies*, 8, 1, 85–101.

Howells, J. (2000) Knowledge, innovation, and location, In: *Knowledge, Space, Economy*, edited by John R. Bryson, Peter W. Daniels, Nick Henry and Jane Pollard, Routledge, London, 50–62.

Hunt, S.D. and Morgan, R.M. (1995) The comparative advantage theory of competition, *Journal of Marketing*, 59 (April), 1–15.

Hurley, R.F. and Hult, G.T.M. (1998) Innovation, market orientation, and organizational learning: An integration and empirical examination, *Journal of Marketing*, 62, 3, 42–54.

Jaffe, A., Trajtenberg, M. and Henderson, R. (1993) Geographic localization of knowledge spillovers as evidenced by patent citations, *Quarterly Journal of Economics*, 108, 3, 577–98.

Kahneman, D., Slovic, P., and Tversky, A. (1982) *Judgment under Uncertainty: Heuristics and Biases*, Cambridge University Press, New York.

Knight, R.M. (1986) Product innovation by smaller, high-technology firms in Canada, *Journal of Product Innovation Management*, 3, 3, 195–203.

Kohli, A. and Jaworski, B. (1990) Market orientation: The construct, research propositions, and managerial implications, *Journal of Marketing*, 54, 2, 1–18.

Krugman, P. (1991) *Geography and Trade*, The MIT Press, Cambridge, MA.

Leonard-Barton, D. (1995) *Wellsprings of knowledge: Building and Sustaining the Sources of Innovation*, HBS Press, Boston.

Leonard, D. and Rayport, J. (1997) Spark innovation through empathic design, *Harvard Business Review*, 75 (November), 102–13.

Levinthal, D.A. and March, J.G. (1993) The Myopia of Learning, *Strategic Management Journal*, 14, Winter, 95–112.

Levitt, T. (1960) Marketing myopia, *Harvard Business Review*, 38, 4, 45–56.

Llobrera, J.T., Meyer, D.R. and Nammacher, G. (2000) Trajectories of industrial districts: Impact of strategic intervention in medical districts, *Economic Geography*, 76, 1, 68–98.

March, J.G. (1991) Exploration and exploitation in organizational learning, *Organization Science*, 2, 1, 71–87.

Marinova, D. (2004) Actualizing innovation effort: the impact of market knowledge diffusion in a dynamic system of competition, *Journal of Marketing*, 68, 3, 1–20.

Matsuno, K., Mentzer, J. and Özsomer, A. (2002) The effects of entrepreneurial proclivity and market orientation on business performance, *Journal of Marketing*, 66, 3, 18–32.

Narver, J.C. and Slater, S.F. (1990) The effect of market orientation on business profitability, *Journal of Marketing*, 54, 4, 20–35.

Nelson, R.R. and Winter, S.G. (1982) *An Evolutionary Theory of Economic Change*, Harvard University Press, Cambridge, MA.

Nemeth, C. (1997) Managing innovation: When less is more, *California Management Review*, 40, 1, 59–74.

Nonaka, I. (1991) The knowledge-creating company, *Harvard Business Review*, 69, November, 96–104.

Nonaka, I. and Takenchi, H. (1995) *Theory of Organizational Knowledge Creation*, Oxford University Press, Oxford.

Oakey, R.P. (1991) High technology small firms: their potential for rapid industrial growth, *International Small Business Journal*, 9, 4, 30–42.

O'Connor, G.C. (1998) Market learning and radical innovation: A cross case comparison of eight radical innovation projects, *Journal of Product Innovation Management*, 15, 2, 151–66.

Ottosson, S. (2003) Participation action research – A key to improved knowledge of management, *Technovation*, 23, 2, 87–94.

Ottum, B. and Moore, W. (1997) The role of market information in new product success/failure, *Journal of Product Innovation Management*, 14, 4, 258–73.

Owen-Smith, J. and Powell, W.W. (2004) Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community, *Organization Science*, 15, 1, 5–21.

Peteraf, M.A. and Bergen, M.E. (2003) Scanning dynamic competitive landscapes: A market-based and resource-based framework, *Strategic Management Journal*, 24, 10, 1027–41.

Pisano, G., Shan, W. and Teece, D.J. (1988) Joint ventures and collaboration in the biotechnology industry, in D. Mowery (Ed.), *International Collaborative Ventures in U.S. Manufacturing*, Ballinger Publishing Co., Cambridge, MA.

Polanyi, M. (1958) *Personal Knowledge: Towards a Post-Critical Philosophy*, Routledge and Kegan Paul, London.

Polanyi, M. (1966) The logic of tacit inference, *Philosophy*, 41, 1–18.

Porac, J.F. and Thomas, H. (1990) Taxonomic mental models in competitor definition, *Academy of Management Review*, 15, 2, 224–40.

Powell, W.W., Koput, K.W. and Smith-Doerr, L. (1996) Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology, *Administrative Science Quarterly*, 41, 116–45.

Powell, W.W., White, D.R., Koput, K.W. and Owen-Smith, J. (2002) Network dynamics and field evolution: The growth of interorganizational collaboration in the life sciences, Forthcoming, *American Journal of Sociology*. Available as Santa Fe Institute Working Paper at http://www.santafe.edu/research/publications/workingpapers/03-02-004.pdf

Prahalad, C. and Hamel, G. (1990) The core competence of the corporation, *Harvard Business Review*, 68, May, 79–91.

Prevezer, M. (1997) The dynamics of industrial clustering in biotechnology, *Small Business Economics*, 9, 3, 255–71.

Rothaermel, F.T. and Deeds, D.L. (2004) Exploration and exploitation alliances in biotechnology: a system of new product development, *Strategic Management Journal*, 25, 3, 201–21.

Rothwell, R. (1992) Successful industrial innovation: critical factors for the 1990s, *R&D Management*, 22, 3, 221–39.

Santomero, A.M. (2002) Forces shaping Philadelphia's Future, *Business Review – Federal Reserve Bank of Philadelphia*, Fourth Quarter 2002.

Saxenian, A. (1994) *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Harvard University Press, Cambridge, MA.

Shan, W. and Song, J. (1997) Foreign direct investment and the sourcing of technological advantage: evidence from the biotechnology industry, *Journal of International Business Studies*, 28, 2, 267–84.

Shan, W., Walker, G. and Kogut, B. (1994) Research notes and communications. Interfirm cooperation and startup innovation in the biotechnology industry, *Strategic Management Journal*, 15, 5, 387–94.

Slater, S. and Narver, J. (1995) Market orientation and the learning organization, *Journal of Marketing*, 59, 3, 63–74.

Slaughter, S. (1993) Innovation and learning during implementation: a comparison of user and manufacturer innovations, *Research Policy*, 22, 1, 81–95.

Stevens, G., Burley, J. and Divine, R. (1999) Creativity + business discipline = Higher profits faster from new product development, *Journal of Product Innovation Management*, 16, 5, 455–68.

Stewart, A.M., Mullarkey, G.W. and Craig, J.L. (2003) Innovation or multiple copies of the same lottery ticket: The effect of widely shared knowledge on organizational adaptability, *Journal of Marketing Theory and Practice*, 11, 3, 25–46.

Takayama, M. and Watanabe, C. (2002) Myth of market needs and technology seeds as a source of product innovation – an analysis of pharmaceutical new product development in an anti-hypertensive product innovation, *Technovation*, 22, 6, 353–62.

Takayama, M., Watanabe, C. and Griffy-Brown, C. (2002) Remaining innovative without sacrificing stability: an analysis of strategies in the Japanese pharmaceutical industry that enable firms to overcome inertia resulting from successful market penetration of new product development, *Technovation*, 22, 12, 747–59.

Teece, D.J. (1982) Towards an economic theory of the multiproduct firm, *Journal of Economic Behaviour and Organization*, 3, 39–63.

Tidd, J., Bessant, J. and Pavitt, K. (2001) *Managing Innovation*, Wiley, Chichester.

Tyler, B.B. and Gnyawali, D.R. (2002) Mapping managers' market orientations regarding new product success, *Journal of Product Innovation Management*, 19, 4, 259–76.

Von Hippel, E. and Katz, R. (2002) Shifting innovation to users via toolkits, *Management Science*, 48, 7, 821–33.

Williamson, O. (1975) *Markets and Hierarchies: Analysis and Antitrust Implications*, Free Press, New York.

Zajac, E.J. and Bazerman, M.H. (1991) Blind spots in industry and competitor analysis: implications of interfirm (mis)perception to strategic decisions, *Academy of Management Review*, 16, 1, 37–46.

Zucker, L.G. and Darby, M. (1996) Star scientists and institutional transformation: Patterns of invention and innovation in the formation of the biotechnology industry, *Proceedings of the National Academy of Science*, 93, November, 12709–716.

Zucker, L., Darby, M. and Brewer, M. (1994) Intellectual capital and the birth of US biotechnology enterprises, *National Bureau of Economic Research Working Paper* No. 4653.

7 Knowledge access at distance

Strategies and practices of new biotechnology firms in emerging locations

Margarida Fontes

Introduction

This chapter addresses the strategies adopted by new biotechnology firms (NBFs), located outside major concentrations of biotechnology knowledge and business, to access scientific and technological knowledge, and raises some questions concerning the potential role of these firms – which are found to be extensively internationalised – in strengthening the emerging knowledge concentrations from which they originated.

Evidence on the US and Europe shows that biotechnology firms appear to benefit from locating in strong regional clusters and simultaneously from being positioned in trans-regional networks that enable them to be connected with a greater variety of organisations and to access a wider range of competences and resources (Owen-Smith *et al.*, 2002; Allansdottir *et al.*, 2002; Cooke, 2001). In fact, biotechnology shows a strong tendency towards clustering, which is associated with three types of factors: the quality, variety and level of integration of the science base; the absorptive capacity of the industrial base and the presence of supporting institutions, namely financial and labour markets. But there is also a parallel tendency of existing clusters to open up and establish a variety of external connections, due to the diversified and fast-changing nature of the science base needed to innovate and to the global nature of biotechnology markets (Allansdottir *et al.*, 2002).

Given the increasingly dominant position of a number of major biotechnology clusters in the world economy, most on-going debates tend to focus on the conditions for development of such agglomerations and on the implications of their presence or absence in a given context (Orsenigo, 2001; Cooke, 2001). While acknowledging that location is not indifferent in biotechnology and that positioning in a cluster confers advantages in this industry, the objective of this chapter is, rather, to understand what is happening outside these major biotechnology agglomerations, in regions that have nevertheless developed a science base, with some autonomous capacity for production of new knowledge and trained human resources. Namely, whether and how entrepreneurs and firms from these regions may benefit from the transnational nature of biotechnology networks (Owen-Smith and Powell, 2004), to establish connections with key actors in biotechnology clusters and integrate the relevant networks, that enable them to overcome some of the disadvantages of their original location.

At a theoretical level, the recent debates on the relative importance of proximity in the access to knowledge, on the importance of extra-regional relations for regions, on transnational networks and communities and on the implications of increased mobility, are particularly relevant for this purpose. However, while these debates have provided useful theoretical approaches, empirical research on them is still very scarce (Oinas, 2000). At an empirical level, research on the behaviour of high-technology firms located in peripheral regions has provided some evidence on the importance of distant relationships, through which firms look for resources and competencies they cannot find nearby (Echeverri-Carroll and Brennan, 1999). But there has been little attempt to understand how firms implement these strategies and what are the implications of pursuing them. Additionally there is no specific evidence of their viability in the particular case of biotechnology.

In order to contribute to filling these gaps, in-depth empirical research has been conducted on the strategies and practices adopted by a group of Portuguese new biotechnology firms (NBFs), to access scientific and technological knowledge. The research addressed two main issues: (1) whether and in which conditions can biotechnology firms emerge and develop in those environments; (2) what is the regional impact of these firms, namely whether they act as connectors to more developed regions contributing to local learning, or whether they simply integrate international networks and disconnect from their regional environment.

In previous papers we have produced evidence towards the possibility of creating and operating an NBF, while relying extensively on 'distant networking' strategies, as well as on the conditions that favour this type of behaviour (Fontes, 2005a, b). In this chapter we start from this evidence and discuss in greater detail the mechanisms used by these firms to access knowledge and establish/manage distant technology-oriented relationships and the associated difficulties. We will subsequently address the dynamics of firms' knowledge acquisition strategies, discussing the relative importance of close/distant relationships through time. The objective is to attempt a first assessment of the degree of firms' connection to/disconnection from the regional (or even national) environment and therefore of their influence as connectors between wider networks and their region.

Understanding the conditions for operating 'out-cluster' in biotechnology

The network structure of biotechnology and the position of new firms

The industrial organisation in biotechnology can be typified as a network structure of interorganisational relationships that act as a coordination device between a variety of actors – new biotechnology firms, large established firms, universities and other non-firm organisations – with diverse competences and assets (Barbanti *et al.*, 1999; Powell *et al.*, 1996).

The position of new biotechnology firms in the 'division of labour' characteristic of the biotechnology industry (Arora and Gambardella, 1994) makes them particularly dependent on the efficient operation of the industry's networking structure (Orsenigo *et al.*, 2001). In fact, to perform their main role – conduct a transformation process that enables the mobilisation and productive use of knowledge generated in research organisations (Fontes, 2001) – NBFs will need: (1) to gain access to and identify application opportunities for new knowledge and generally to consolidate and renew their knowledge base, which requires good connections with research organisations (Orsenigo, 1989); (2) to complement their sometimes very specialised knowledge base, which may require close interaction with large firms, with greater integrative capacities (McKelvey and Orsenigo, 2001); (3) to gain access to markets for technology and/or downstream competences related with regulation, production and commercialisation, which they often lack and which lie with large established firms (Arora *et al.*, 2001).

Thus, NBFs operate in the centre of a network and their success depends on their ability to establish relationships with a variety of actors (Baum *et al.*, 2000; Orsenigo *et al.*, 2001). Given their size and limited resources, they are likely to benefit from being located in a 'biotechnology cluster', where such relationships are easier to establish and manage (Stuart and Sorenson, 2003). However, the relative importance of the cluster will not be the same in all cases. It will depend on the nature of firms' activity and the innovativeness of its products (Mangematin *et al.*, 2002; Zeller, 2001), on the origin of entrepreneurs (Zucker *et al.*, 1998) and their degree of seniority (Mangematin *et al.*, 2002), on the stage of firms' development (Lemarié *et al.*, 2001), on the type of partners (McKelvey *et al.*, 2003) and on the type of knowledge assets firms wish to obtain (Audretsch and Stephan, 1996).

How are the requirements associated with NBFs' positioning and roles addressed by firms located in a peripheral position relative to main concentrations of knowledge?

The behaviour of technology-intensive companies in peripheral areas

Research on the behaviour of high-technology firms located in regions where knowledge accumulation is lower can provide some insights regarding the dilemmas faced by these NBFs. It shows that successful firms will reach out for knowledge and resources they cannot find in the region and therefore will tend to rely more frequently on distant relationships (Cooke, 2001; Felsenstein, 2001; Rees, 2001; Saxenian and Hsu, 2001; Vaessen and Keeble, 1995). Echeverri-Carroll and Brennan (1999) conclude that the importance of proximity is relative, depending on the local accumulation of knowledge and that, when such accumulation is lower, firms will look for knowledge elsewhere, where it is available. Additionally Davenport (2003) argues that firms that are forced to reach out from early stages and experience rapid internationalisation engage in an externally oriented trajectory, which will lead them to have little impact on their home base.

Although presenting evidence towards firms' capacity to source knowledge where it is available, these authors do not explain how firms effectively pursue this endeavour and the additional difficulties they may confront. The objective of this research was exactly to contribute to an understanding of under which conditions firms establish such distant relationships and of what are the implications of strategies that rely extensively on geographical distance to access scientific and technological knowledge. Our argument is that some features of knowledge production in science-based fields such as biotechnology can facilitate this type of behaviour. We will therefore start by addressing the features that may favour those strategies.

Access to and transmission of knowledge at distance

Co-location vs. temporary or virtual proximity in knowledge access

One major argument concerning the importance of locating in a region where knowledge accumulation is higher regards the transmission of tacit knowledge, that would be favoured by geographical proximity (Feldman, 1999), as opposed to codified knowledge, that could be transmitted at greater distances. Biotechnology relies extensively on scientific knowledge which is, in principle, more abstract and codified and thus more easily transmitted at distance (Arora and Gambardella, 1994), especially when access to information at a distance has become easier and affordable (Amin and Cohendet, 2003). However, tacit knowledge still plays a very important role in biotechnology, especially in the early stages of technology development. This is because new discoveries in this field can be characterised by high degrees of 'natural excludability' (Zucker *et al.*, 1998), which means that only those who were involved in the development of the technology, or have direct access to the research team who did it, will possess the know-how necessary to replicate the knowledge, at least until the discovery diffuses sufficiently. People who had such a common experience may have developed shared meanings, a shared language and communication codes – i.e. epistemic proximity (Steinmueller, 2000). This creates conditions for the knowledge produced to be at least partly articulated and transmitted at a distance between members of the same 'epistemic community' (Breschi and Lissoni, 2001).

As a result, geographic proximity – i.e. co-location – is not strictly necessary for transmission of this type of knowledge, although it is necessary for co-development and creation of epistemic proximity. Indeed, the concept of 'proximity' has been subject to much debate in recent years, with several authors attempting to conceptually discriminate between simple geographic co-location and the proximity enabled by the sharing of rules and routines of behaviour, a system of representations, a set of beliefs, which has been described as 'organisational', 'relational' or 'cognitive' proximity (Amin and Cohendet, 2003; Coe and Bunnell, 2003; Depret and Hamdouch, 2004; Torre and Rallet, 2002, 2005).

Thus, according to this approach, proximity will not necessarily imply co-location of *firms* and can be achieved by firms that are geographically distant through a variety of formal coordination mechanisms, as well as new forms of informal networking (both greatly facilitated by the extensive development of virtual communication means), complemented by instances of temporary co-location for activities that require face to face interaction (which make mobility a key element). Gallaud and Torre (2001) have found that the type of proximity required in the process of knowledge transmission depends on the phase of the innovation process: exploration activities (e.g. co-production of new knowledge) require a more permanent co-location, while exploitation activities (e.g. absorption and re-contextualisation of the knowledge produced) only require temporary co-location.

It should nevertheless be pointed out that it may be costly for small firms to periodically move researchers or teams to other locations, and therefore they may find it more effective to locate in the vicinity of their knowledge partners (Gallaud and Torre, 2001). This is particularly evident in the case of scientific entrepreneurs who tend to locate their firms in the neighbourhood of the 'parent' organisation (Audretsch and Stephan, 1996; Fontes, 2001; Lemarié *et al.*, 2001). While the main explanation possibly lies on the advantages of co-location for the transfer of knowledge in whose co-development they were (and sometimes remain) involved, other factors such as risk reduction or wider personal networking strategies are also advanced (Breschi and Lissoni, 2001; Johannisson, 1998). It should also be remarked that there are effective advantages of locating in environments where research is world class, since embeddedness in local social networks facilitates access to information on 'who knows what' and 'who does what', which can trigger the early contacts (Breschi and Lissoni, 2001), being particularly important when the new knowledge being searched is not publicly available (Arundel and Geuna, 2004). Additionally, it has been argued that the proximity achieved by belonging (at distance) to a 'community' may be only a partial substitute to geographical proximity, because virtual communications, while enabling the transfer of knowledge, do not 'offer the same scope for reciprocity, serendipity and trust that is afforded by sustained face to face contact' (Morgan, 2001: 15; Roberts, 2000).

It is also possible to move beyond the case of individual firms and address the opportunities afforded by temporary co-location from the standpoint of regions. Research on the impact of the increased mobility of knowledgeable people and namely on the behaviour of returning expatriates or 'transnational entrepreneurs' (Saxenian and Hsu, 2001; Coe and Bunnell, 2003; Williams *et al.*, 2004) have shown that less advanced regions can benefit from exposure to more advanced contexts, through various forms of temporary co-location: e.g. post-graduate studies, periodical stays in a research centre in direct contact with a research team, work in technologically advanced companies. This creates the conditions for common experiences leading to epistemic proximity, which facilitate further knowledge exchange and in some cases enable would-be entrepreneurs to become part of 'transnational technological communities' (Saxenian and Hsu, 2001).

Reaching out and the nature of distant search

Several authors, while highlighting the advantages of networking within dense clusters, have recognised that closed clusters run the risk of excessive in-breeding and that the development of new knowledge will require reaching out of the cluster for new information and knowledge (Malecki and Oinas, 1999). Therefore, in recent years, the role of extra-regional networks and their impact on local learning activities have started to be addressed in conceptual terms (Coe and Bunnell, 2003; Bathelt *et al.*, 2004; Oinas and Malecki, 2002). However, little empirical evidence has so far been produced regarding the relative importance of distant relationships as compared with proximate ones, or their incidence on different activities, firms or industries (Oinas, 2000).

Given the importance of scientific advances in biotechnology and the international nature of knowledge production in this field, search for knowledge outside the regional environment will inevitably be a requirement, even for firms located in major biotechnology clusters (Owen-Smith and Powell, 2004). However, it can be argued that, while the latter will more frequently look for non-redundant knowledge that enables them to renovate or reconfigure their knowledge base and to avoid in-breeding (Bathelt *et al.*, 2004; Rosenkopf and Almeida, 2003), firms located outside main knowledge concentrations will, first of all, look for knowledge that enables them to develop and exploit their existing knowledge base and only later will eventually start looking for the other type of inputs. For this reason, at least in early stages, 'out-cluster' firms are likely to search for knowledge that is not too far from their current knowledge base. Given the path-dependent nature of innovation, it will be relatively easier for firms to rely on their existing knowledge base to conduct these searches (Sapienza *et al.*, 2004) and also to understand and absorb knowledge that is closer to it (Cohen and Levinthal, 1990). Their search will therefore rely on technological proximity at geographical distance. Later, firms may reach a point when they also need to look for substantially new knowledge, thus facing both technological and geographical distance (Rosenkopf and Almeida, 2003). At this stage, their previous experience in managing geographically distant relationships can be an asset.

Finally, search for knowledge and relationships at a distance present some particular features. It is more purposive and focused, because it does not occur occasionally or without costs, rather it is the result of a conscious effort to identify and gain access to a particular type of partner; trust may not exist at the outset and has to be built; it can be a slow process, with firms tending to apply staged procedures, where levels of risk and commitment from the partners increase through time (Bathelt *et al.*, 2004; Lorenz, 1999). Because these relationships take more time and effort to establish and maintain, there are also tighter limits upon the number of linkages firms are able to manage (Dahlander and McKelvey, 2003).

Connection to external networks and integration of disperse competencies

We will now consider the role of externally oriented firms as *connectors* between their home environment and those to which they are linked through their transregional (or transnational) networks. When these 'extroverted' firms (Malecki and Oinas, 1999) reach out and connect to more advanced regions, in order to acquire resources and competences, they may end up disconnecting from their regional environment (Oinas and Malecki, 2002; Davenport, 2003). But it may also happen that their activities have a positive regional impact. When firms bring-in and absorb the external knowledge and resources, turn them into competencies and eventually disseminate them throughout regional partners and clients, these activities can contribute, in a greater or lesser extent, to local learning, promoting the qualification of the region where they are located. According to Tappi (2002), because extroverted firms are involved in both local and non-local networks and therefore participate in local and non-local social learning processes, they may develop an ability to coordinate between the local and the wider networks. However, the ability of a region to effectively integrate the new knowledge depends on the absorptive capacity of the other actors, as well as on the policies towards the development of their knowledge and skills (Tappi, 2002; Cooke, 2002; Benneworth and Charles, 2004).

The capacity of NBFs from peripheral regions to establish extensive linkages to major biotechnology clusters may have some further policy implications. A recent document on European strategy for biotechnology (EC, 2002) stresses the need for a greater integration of a still very fragmented field, through inter-regional networking. Although the focus is on major 'biotechnology regions', it can be argued that extended inter-regional networks can further act as integrators of dispersed scientific and technological expertise, by including and contributing to enhance small concentrations of scientific expertise and business ideas, which are dispersed throughout Europe, outside major biotechnology concentrations. So, one critical question for firms located in these environments regards their place in these expanding European networks.

Summing up: the viability of knowledge access at a distance

As was pointed out above, there has been limited research on the behaviour of technology-advanced companies located in regions where knowledge accumulation is lower. There is also scarce empirical evidence on the operation of extra-regional networks for knowledge acquisition (with the exception of TNC activities) in different industrial and environmental settings and on the implications for firms of establishing and managing distant relationships.

The above discussion enabled us to put forward, in theoretical terms, some features of knowledge access in science-based fields such as biotechnology, which may favour the development of strategies that do not rely strongly on the advantages of geographical proximity. While access to technological knowledge is critical and the transmission of knowledge (particularly tacit or 'excludable' knowledge) at distance can be complex, these difficulties can be circumvented or lessened in some conditions. For instance new knowledge can be more easily transmitted at distance between actors that were involved in processes of co-production, which enabled epistemic proximity. While the latter may require direct interaction, it does not necessarily need co-location of firms and, therefore, entrepreneurs and their firms may profit from alternative forms of co-location. Also, not all required knowledge will necessarily be frontier knowledge (and thus 'excludability' will not always apply) and therefore a search for relevant knowledge may be conducted through various sources, providing that it is not too far from the firms' existing knowledge base. But the discussion also suggested that firms located 'out-cluster' and relying extensively on distant relationships – particularly in an industry where location can be a factor of competitiveness – will need to comply with different requirements and will experience specific managerial challenges, leading them to display behaviours that can be distinct from those of NBFs in more knowledge-intensive environments.

Empirical research on the case of NBFs in a region that is peripheral in relation to the main biotechnology clusters will allow us to address these issues in a real world setting.

Empirical research on Portuguese biotechnology firms

The above discussion suggests a number of questions concerning the viability of knowledge acquisition strategies that rely extensively on distant relationships. The first question regards whether empirical evidence confirm that these strategies are being used in the biotechnology field (since most research has focused in other fields), as well as the conditions in which they are likely to emerge. The second question concerns the actual processes through which entrepreneurs/firms establish and manage distant relationships. The third question regards the impact of firms' strategies on the region where they are located. Research was conducted to address these issues using the case of Portuguese biotechnology NBFs as the empirical setting.

The first question has been discussed in previous papers (Fontes, 2005a, b). In this chapter we will focus on the mechanisms used by firms to establish distant technological relationships and will provide a first contribution to a discussion on firms' impact on the regional environment.

Research objectives and methodology

Portuguese NBFs provided a good setting to discuss these issues. Given its location in the periphery of Europe, Portugal is geographically distant from regions that have been identified as the main biotechnology clusters (Allansdottir *et al.*, 2002). It cannot either be described as having major concentrations of biotechnological knowledge, although a significant investment in the development of scientific capabilities, throughout the last decade, enabled the creation of a reasonable science base and a pool of highly skilled human resources

(Fontes and Padua, 2002). However, these efforts have not been matched by a parallel development of biotechnology-oriented activities at the industrial level. In the particular case of NBF creation, recent research has shown that the Portuguese environment is not particularly favourable to entrepreneurial initiatives in this field (Fontes, 2001). As a result, there are very few biotechnology firms, most of them very recent: of the 33 companies currently in activity, only 12 were created before 2000.

But despite these conditions, there are a few older firms that achieved some success and have reached a stage where it is possible to look back at their development process. These were the firms chosen for this analysis: the four older surviving firms (created between 1990 and 1996), to which were added two relatively younger firms (created in 1998 and 1999) already with some 'history', to give the counterpoint of firms going through early stages in a more recent period. Table 7.1 gives an overview of this group of firms, showing date of creation, origin of entrepreneurs, firm location and generic information about the business: target market, type of activity and current market situation (regarding the main business).

The analysis combined previous accumulated knowledge about these companies – all of which have been the object, through time, of periodical follow-ups of their activities, providing a quasi-longitudinal view of their evolution – with data collection on their linkages and with in-depth interviews conducted with the purpose of obtaining more detailed information about firms/entrepreneurs relationships (formal or informal): establishment, management, motivations, difficulties, underlying strategies.

In this chapter we focus on relationships that are concerned with the access to scientific and technological knowledge and look in detail into two issues; (1) the actual process of establishment of distant relationships; (2) the evolution of the balance between regional/national and international linkages and namely the motives for and the implications of the growing importance of distant relationships, through time. In addressing these issues we will discuss the potential repercussions for firms of operating at distance from relevant knowledge centres. But before proceeding with this analysis, we will outline the early conclusions regarding the knowledge sourcing strategies devised by these firms, in order to provide the reader with a framework for understanding some aspects of the firms' behaviour.

The choice of focus on the balance between *regional/national* and *international* linkages requires some explanation, being related to the specific location and organisation of biotechnology-related activities in Portugal. In global terms, the 'Lisboa and Vale do Tejo (LVT)' region (and, within it, particularly the area around the capital, 'Greater Lisboa') is responsible for more than 50% of R&D expenditures and personnel, followed by the 'North' region with about 20% and the 'Centre' region with about 15% (OCES, 2003). In practice, the core of biotechnology research activities and technological development are located in a 'littoral strip' between Greater Lisboa and Braga in the North region, being mostly conducted in or around the 5 major towns encompassed by it: Lisboa,

Table 7.1 General characteristics of firms in case studies

	A	*B*	*C*	*D*	*E*	*F*
Year of creation	1990	1992	1994 (1999)*	1996	1998	1999
Founder's origin	Senior Researcher & Industry	Recent graduates & young research fellows	Recent graduates & PhDs	Recent PhD & young research fellow	Recent graduates & PhDs	Recent PhDs & young research fellows
Target market	Agro-food	Agro-food	Agro-food, Health	Health	Environment	Health
Location	Greater Porto	Porto (also Faro)	Greater Lisbon	Greater Lisbon	Porto	Greater Lisbon
No. employees (2003)	20	14	12	25	6	5
Type activity	Product Services	Product Contract R&D	Technology Services	Technology Contract R&D [Product]	Services [Product]	Contract R&D
Market situation	In market with product	Entering market with product	Entering market with technology	In market with technology Develop product	Developing product	In market with services

Note
*Firm was created in 1994, but biotechnology activity only started formally in 1999.

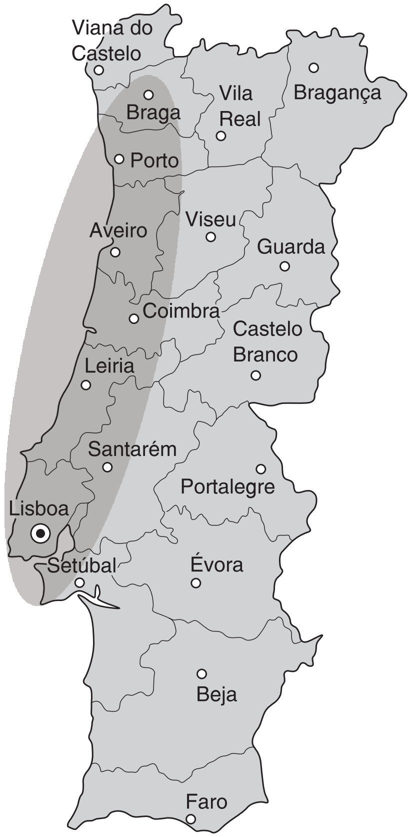

Figure 7.1 Location of biotechnology activity: the littoral 'biotechnology strip'.

Porto, Coimbra, Braga and Aveiro (Figure 7.1). While there is some physical and cultural distance between Greater Lisboa and the North region, these distances are indeed very relative: Portugal is a small country (whose main transportation lines run along the littoral) and its borders configure an essentially homogeneous space regarding institutional and cultural frameworks. Therefore, while co-location facilitates social networking and informal circulation of knowledge, there are strong relationships between biotechnology-related organisations located in the three regions, which are facilitated by relatively short distances and fuelled by the need to achieve critical mass or greater diversity of knowledge bases.

The NBFs are also basically located along this littoral strip, being more concentrated on and around the towns of Lisboa (LVT region) and Porto (North region), although there is a growing number of firms being created around the town of Coimbra (Centre region). With respect to knowledge sourcing, some (although not all) firms were found to rely more strongly on a nearby 'parent' organisation at start-up, which is understandable considering that they are often spin-offs commercialising technology originating from that organisation, where they were also likely to have closer personal relations (which equally favoured the continuity of the links over time). But not only was this not the case with all firms – there were cases where the research organisation that played a 'parent' role was not nearby – but it was also a fact that most firms had, either from inception or at a relatively early stage, started to search for knowledge and linking to organisations in other Portuguese regions or even, as we will see below, outside the country borders. The type of knowledge being sourced and the attitude of a particular research organisation towards its access were key elements that often prevailed upon co-location. Obviously firms located in areas with a greater variety of research organisations (e.g. Lisboa or Porto) might have less need than firms located in smaller centres to search elsewhere in the country (although not necessarily less need to search *outside* the country). But, in general, it can be argued that the strong interaction between research organisations located along the 'strip' was indeed reproduced by their spin-offs, that were often involved in a variety of formal and informal contacts throughout it. Also, it was not unusual that one firm started up on the basis of research produced by a collaborative project, keeping links with the different source organisations. It would even happen (although rarely) that the same team included people linked to research organisations located in different regions. On the other hand, as we will discuss below, some firms would rely more strongly on foreign sources of knowledge that on those located in their region or in another Portuguese region.

Thus, also for firms, while geographical proximity, associated with technological proximity, is regarded as more favourable, mobility and search along the 'biotechnology strip' is frequent and not regarded as particularly problematic. This behaviour is also apparent in the younger firms that were not the object of this research. For this reason and because searching for and establishing relationships outside the relatively homogeneous space configured by the national borders is a more complex endeavour (Malecki and Oinas, 1999), we put the emphasis on the discussion of the relative importance of national vs. foreign sources of knowledge. Similarly, when discussing the impact of firms' activities on the regional environment, the emphasis is put on the levels of connection or disconnection to the regional *and* national environment, assuming that a firm that is willing to feed-back to the home country – as opposed to one that enters a fully foreign-oriented trajectory – not only influences the specific region where it is located, but has an impact upon the whole 'biotechnology system', given the intense circulation of information and knowledge along the 'biotechnology strip'.

Generic evidence on the 'distant networking strategies' of Portuguese NBFs

Empirical research on the structure and composition of firms relationships and on the motives underlying their establishment (Fontes, 2005a) has shown that, for the firms studied, distant relationships were a critical source of competencies and resources since start-up, with the relevance of connections to (and sometimes integration into) transnational networks increasing through time. More specifically, the research enabled a first depiction of what was described as 'distant networking strategies'. Basically it was concluded that:

- Firm formation decisions are usually associated with the co-location to sources of scientific knowledge, with which more or less close relationships are established.
- But firms will also develop, from inception (or even previous to it), a set of international linkages, which assume a key role in their development process and which, in a number of cases, are the determinant factor for the creation process.
- To access scientific and technological knowledge, firms draw, at least in early stages, upon a (diverse) combination of close and distant sources of knowledge, but they tend to search at distance for markets and market-related relationships.
- International connections expand and become increasingly important along the firms' life cycle, as they progress towards commercialisation stages and/or need to broaden or renew their knowledge base.

Thus, concerning knowledge acquisition, it was possible to identify two simultaneous influences at firms' early stages: the relevance of co-location to specific research organisation(s), which provided a variety of assets and the need to possess good international connections to sources of scientific and technological knowledge, which could be based on entrepreneurs personal networks or obtained through 'parent' research organisations.

More detailed research on the technological relationships of this group of NBFs (Fontes, 2005a, b) has enabled us to uncover the relative importance of regional/national vs. foreign linkages as sources of knowledge behind the creation of the firm and supporting its early development and therefore to assess, for every firm, the degree of regional embeddedness and the role of external sources. Two basic patterns were identified: (1) entrepreneurs who decided to create a firm based on the presence, at country level, of high quality, consolidated research, conducted in one or a set of highly internationalised research organisations, which acted as 'parent' and became a fundamental source of early knowledge, even if limitations in terms of research scope and variety required firms to resort also to foreign sources (often through the 'parent' international networks), in order to access additional competences; (2) entrepreneurs who based their initiative in the willingness to explore knowledge that was less developed at country level and thus was largely obtained through their exposure to other contexts, although they were supported, at regional or national level, by research organisations who provided facilities, connections and institutional credibility, but had limitations as sources of knowledge.

These initial conditions had implications for the firms' degree of dependence on distant sources of knowledge, as well as for the conditions under which access to them took place. Differences were evident between those firms that benefited from a more developed indigenous science base and from mediation into international networks, and those firms that had to resort more extensively to foreign sources and rely on their own efforts, usually supported by personal networks, to access them. However, the process of searching for distant sources of knowledge and establishing and managing distant relationships was not necessarily straightforward, even for better supported firms. It was also a dynamic process. Unsupported firms could develop a wider range of relationships through time and build some reputation that assisted them in subsequent searches. Firms that initially benefited from support and mediation in some areas might find themselves faced with the need to conduct unassisted searches when entering new areas, where competences were less developed at country level. Thus, it will be important to understand in greater detail how firms effectively established and maintained distant relationships, which remains an under-explored field.

Strategies and mechanisms for establishing distant relationships

In this section we address the strategies and mechanisms used by firms to identify and access distant technological partners and to manage these relationships. Table 7.2 summarises the various types of approach used by firms to identify and establish contacts with distant partners, in early (*e*) and later stages (*l*).

The process of establishing distant relationships

In many cases the establishment of distant technological relationships was based on previous contacts, or at least mediated through them. Processes of direct mediation involved effective access to and integration into existing scientific

Table 7.2 Approaches to the establishment of distant technological relationships by firm

Firms	*A*		*B*		*C*		*D*		*E*	*F*
	e	*l*	*e*	*l*	*e*	*l*	*e*	*l*		
Direct mediation										
Research organisations' scientific networks					✓	✓				✓
Partners to previous co-development processes				✓				✓	✓	✓
Indirect mediation										
Foreign personal networks	✓	✓	✓	✓		✓	✓	✓		✓
Contacts/institutional credibility through research org.			✓						✓	
Professional networks	✓			✓						
Contacts derived from market relationships	✓							✓		
Brokerage mechanisms (national; E.U.)				✓		✓			✓	
Unsupported own search										
Without previous experience of distant search	✓		✓				✓			
With previous experience of distant search						✓				

Note:
Firms E and F are too young to be possible to consider a 'later stage'.

teams or even wider international scientific communities. They could result from close association with well connected 'parent' research organisations, that afforded their scientists opportunities to participate in co-production of knowledge, as part of international teams and/or afforded their spin-offs access to international scientific networks. Or they could result from entrepreneurs' previous involvement in the co-production of knowledge in foreign organisations (e.g. as graduate students or researchers), which enabled them to draw on these contacts to renew the collaboration, giving continuity to previous projects, or building on them to explore new opportunities. In both cases mediation eased admission into research communities whose access might have been difficult for newcomers, enabling participation in common research projects as well as less formal knowledge exchanges.

It was also possible to identify processes of *indirect mediation*, where some assistance was provided in the identification and access to relevant partners, but where the core effort was based on firms' own search activities. These processes relied above all on entrepreneurs' personal networks. Most firms had at least one entrepreneur and sometimes also employees with previous international experience, who provided a range of contacts – e.g. ex-supervisors, professors or colleagues from graduate studies abroad, or ex-partners from previous projects – who were instrumental in search efforts. They would be mostly *facilitators*, offering critical information on relevant research or potential partners, providing access to their own scientific networks and/or acting as credibility enhancers. Indirect mediation was equally afforded by less well connected research organisations, that still provided some contacts and institutional credibility and also by membership of professional societies or by market partners. Finally, national or European brokerage organisations were also a source of contacts to willing partners with matching requirements.

However, some firms still considered that at least part of their search efforts had gone largely unsupported, suggesting that in some circumstances no mediators could be mobilised to gain access to relevant partners. This was particularly the case in early stages, since, with time, firms became more extensively connected, making at least indirect mediation more likely and also gained a reputation that made them more visible to potential partners.

The case of 'own search' strategies

One important observation was that, while direct mediation was available for some NBFs with the relevant connections, affording them obvious advantages in terms of knowledge access, situations of both indirect mediation and unsupported search were frequent, even among firms that benefited from direct mediation in some areas. Because indirect mediators acted mostly as facilitators and credibility enhancers, their efficacy in influencing the processes that led to the establishment of a connection varied and, in any case, firms still had to prove their worth to the potential partner. The same happened in processes of unsupported search, where firms would neither benefit from previous credibilisation. Given their higher complexity, these processes deserve some further attention.

Indirectly mediated or unsupported search for knowledge was usually conducted towards research organisations, the target being individual scientists or teams. Identification and first contacts were generally easy. But, unless entrepreneurs had a high-class scientific record in the field or some competence that partners regarded as immediately interesting, attainment of status and development of trust could be a slow processes. It could entail prolonged informal exchanges that enabled mutual awareness of skills and interests, leading to an eventual identification of joint interests.

Such links could remain informal and relatively unfocused for some periods, being part of entrepreneurs' personal networks until a mutually interesting opportunity was identified. But they could also be used to support learning processes, in fields where the firm effectively needed to develop additional competence. At least three of the cases analysed fell within this mode, which combines a staged approach to partnering with in-house skills building. Relationships with organisations that are now key technological partners started with formal research contracting by the NBF and progressed along growing levels of co-involvement as firm's competences developed, until conditions for effective collaboration were attained. This process entailed extensive exchange of people (namely stays in the partner facility) and the development of personal relationships, which were associated with increasing mutual trust.

Although further research will be needed for a better understanding of these processes, our current understanding is that situations like the above, where firms used foreign relationships for competence building, were facilitated by the fact that the knowledge being developed, although in new fields, was not necessarily frontier knowledge and therefore the concept of natural excludability might not apply. On the other hand, firms were operating in fields that were not very distant from the entrepreneurs own knowledge base and therefore, both their capacity to demonstrate some previous competence and their absorptive capacity were higher. Thus, as suggested above, we could speak of 'technological proximity at geographic distance'. True new discoveries were more likely to take place in the context of the international networks, where firms entered mediated by reputed scientists, already part of the 'epistemic communities'. But even for these firms, the ability to profit form the resources in principle available to them and to influence the directions of development, depended on the continued development of in-house competences and on their capacity to create their own space within the parent network. With respect to the (rare) situations where, according to the entrepreneurs, in-house knowledge was limited and mediation did not exist, further research will be necessary to understand how the process effectively took place.

Mechanisms used in search and management of distant relationships

The mechanisms used by firms to identify and establish contacts with potential partners can be classified in three main groups: ICT means; direct personal contacts; occasional co-location in international events.

In highly internationalised fields such as biotechnology there are a number of key events – scientific or commercial, global or field-specific – that join the main actors in a given area and where the conditions for intense circulation of information and for frequent personal meetings are enacted for a short period. Presence in these events was regarded as an important source of information about opportunities and the most fruitful means of making new contacts. Sometimes these contacts were mediated by members of personal networks. Mediation by the right individuals could be vital, not only because the mediator could match the right partners, but also because it added credibility.

ICT-based communications were used to identify potential partners, to make preliminary contacts when the target was not personally known, to follow-up from informal contacts, or to manage on-going relationships. Firms also used the Internet extensively to 'advertise' their activities and main exploits. ICT (particularly Web tools), were widely accepted in the field as a means of communication and were equally used by scientists and by firms. But ICT did not substitute for face-to-face contacts in the early processes of establishing a relationship, even if the contact had been mediated and/or the firm already had some reputation in the field. Additionally, when the firm was establishing its status and/or building new competences, direct personal contacts were indispensable and temporary co-location through exchange of people was a requirement.

Once the relationship was formalised and the partnership was on-going, it was possible to manage it at a distance through ICT means, with face-to-face contacts taking place only sporadically. But periodic personal contacts remained important moments for coordination, for discussing more undefined problems, for transmitting less codifiable knowledge and for strengthening the personal elements of the relationship. Exchange of people, for shorter or longer periods, remained an important knowledge sharing factor. It was also used by firms to provide training to their younger staff and to expose them to a wide variety of contexts.

Additionally, firms stressed that, both with their main partners and with the members of their personal networks, there was the attempt 'to pass by and meet' informally, whenever the occasion presented itself. Indeed, given the importance of personal networks to identify opportunities, achieve contacts and enhance credibility, firms took particular care in nurturing them. To be in touch from time to time, to be aware of main occurrences and acknowledge them, to reciprocate in providing information, to invite them for events where their expertise was valued, to meet when in the respective town, were part of this nurturing conduct, that attempted to emulate, at a distance, the informal exchange allowed by geographical proximity.

It is possible to conclude that while ICT-based communications were extremely valuable for managing distant relationships, mobility remained a key requirement. Firms usually appointed one of the entrepreneurs to assume a 'nomadic broker' role and had employees to move frequently to the partners' locations for learning and co-development purposes. This mobility requirement, that results in high financial and personal costs and may demand particularly good relational skills, was perceived by firms as a critical problem of distance.

The above description confirms that the search, establishment and management of distant technological relationships has particular requirements. These processes may be facilitated if firms have, from inception, admission into the relevant 'epistemic communities', or at least, some access to the key international networks. But an extensive reliance on this type of relationship will always entail great personal and financial efforts – that may be higher than those required by similar firms located in clusters – and will demand persistence and superior skills. These difficulties were confirmed by the firms themselves, who assumed the inevitability of their strategic option but were aware of the additional problems and of their potential impact upon competitiveness. But they also considered that some difficulties eased off as the firm become better known and/or more integrated in key networks and that, with time, they tended to become more adept at managing distant networking processes.

Evolution of scientific and technological relationships

A further question raised concerned the impact of firms' knowledge acquisition strategies on their regional environment, namely whether they contributed, in some way, to the qualification of their region.

Levels of (dis)connection to the regional environment

As pointed out above, foreign relationships tended to increase in importance through time, although firms maintained different levels of connection to the regional/national environment. Thus, a pertinent question regards the role still assumed, in later stages, by that environment. Table 7.3 presents a schematic overview of the evolution in relative importance of regional/national and foreign relationships, both early and new. If we consider only the four older firms we realise that with respect to regional/national relationships, there is one case where the early linkages are regarded as increasingly important (↑) and two cases where new relationships are also regarded as very important (↑). In the other cases, the early linkages are diminishing in importance (←), or remain important

Table 7.3 Evolution of relative importance of regional/national and foreign relationships

	A	*B*	*C*	*D*	*E*	*F*
Early regional/national relationships	←	↔	↑	←	↔	↔
New regional/national relationships	↑	↔	↑			
Early foreign relationships	↑	↑	↑	↑	↔	↑
New foreign relationships	↔	↑	↑	↑	↑	↑
More important network (currently)	**N/F**	**F**	**N/F**	**F**	**N/F**	**F**
Perceived trends	**C**	**D**	**C**	**D**	**?**	**?**

but less than the foreign ones (↔). On the contrary, with respect to foreign relationships, not only are all early links are perceived as gaining in importance, but in all but one case new links are also considered very important. This latter perception is also evident in the case of younger firms (E and F).[1]

These results uncover three types of situations:

- Where regional/national research organisations maintain an important role as sources of new knowledge, both in existing and in new areas. This happens with firms whose development was based on a strong indigenous science base, but also happens with one firm which so far has based a substantial part of its development upon foreign linkages, but whose exploratory search for new knowledge involves a nearby research organisation. Interestingly, the same organisation whose expertise already originated and supported other NBFs.
- Where regional/national research organisations had a supportive role at early stages and maintained it, although the main locus of new knowledge was increasingly foreign networks. In some cases these research organisations have engaged in processes of co-development of competences with the firm, triggered by joint involvement in projects with foreign organisations, and thus can continue providing some contribution, albeit only partial.
- Where regional/national research organisations role as sources of knowledge was and remained largely marginal. This situation led firms to resort definitively to foreign organisations in order to obtain the most substantial part of their scientific and technological knowledge requirements.

The growing importance of foreign relationships (existing or new) for all firms, even for those that still rely strongly on research conducted at regional/national national level for their activities, reflects a number of interesting issues. First of all, it reflects the continued internationalisation of the best scientific groups, which is consistent with the global nature of biotechnology research. Firms share this feature of the 'parent' research organisation and, with time, not only incorporate its network, but also build on it to create their own networks (that increasingly differ from the original one). Second, it reflects the limitations in scope and variety of the national scientific and technological infrastructure, which frequently forces firms willing to expand their knowledge base to search elsewhere. In particular, the fact that firms interested in NBFs activities are almost completely absent at a country level prevents them from accessing a whole range of competences that they only find in foreign partnerships. Third, it exposes an effective technological disconnection of some firms, that consistently did not find the required knowledge in the regional/national environment and did not pursue the type of linkages that would enable some co-development processes with their early supporting research organisations.

If we attempt to turn the results of this analysis into trends, regarding the levels of connection/disconnection from the regional/national environment, it is possible to arrive at the tentative results presented in the two last rows of Table 7.3.

In general the firms analysed tend to become more integrated into transnational networks and unless they find, in the national environment, the type of complementary knowledge that give them good reason for keeping a connection (C) to it, they will continue to progressively disconnect (D) in scientific and technological terms. In this process, the capacity of the early supportive research organisations to continue sharing the destinies of their spin-offs – simultaneously contributing to their technological development and gaining new competences through further integration in shared networks – depends on their continued scientific investment in the relevant fields and on their continued interest in exploiting application oriented results.

NBFs as connectors to external networks

The above discussion also enables us to make some preliminary comments about the role of NBFs as connectors to external networks. As was pointed out, the process of reaching out may have some impact in the regional environment, through the feedback activities of NBFs that remain connected to it. Particularly, NBFs that keep a stable link to sources of expertise not available in the region can have a role as conduits to world class knowledge. This may improve the indigenous science base, facilitate the mobility of human resources and also potentiate the integration of other regional actors in these networks.

An effective evaluation of the regional impact of NBFs that remain more or less connected to their home base goes much beyond the scope of this paper. But at this stage it is possible to suggest that, particularly those firms that pioneered the development of activities in fields not addressed at country level, played an important role. More specifically, the contributions of those firms that involved their supporting research organisations in joint processes, triggering the development of new lines of research and enabling the more extensive integration of regional research teams in international networks, should be stressed.

Additionally, it is also relevant to call attention to the potential impacts of the extensive exchange of people enacted by these firms. Due to scarcity of resources, most NBFs resort extensively to offering research training opportunities to young people, either as part of their university graduate/post-graduate training or in the context of government-funded scholarships and mobility schemes. Such young people are frequently involved in the firms' international exchange processes. Some of them remain in the firm, but others obtain temporary posts at research organisations, move to other firms or even decide to create their own firms. Thus these processes can create a momentum where new knowledge obtained in biotechnology centres of excellence circulates and is used by a variety of organisations.

Conclusions

This chapter addressed the problem of knowledge access at a distance, looking at the strategies adopted by entrepreneurs and firms located outside major concentrations of biotechnological knowledge. The discussion drew from theoretical debates on the relative importance of geographical proximity for knowledge access and on the role of transnational networks and communities in knowledge circulation in advanced fields. These theoretical contributions enabled us to put together a number of conditions that make possible the development of strategies relying extensively on distant networking, at least in science-based fields such as biotechnology. Empirical research on the case of Portuguese NBFs was conducted to evaluate the viability of these strategies, as well as to understand how they are implemented and their potential implications for the regions where the firms are located. Although the small number of firms addressed in the empirical analysis may call for some care in the generalisation of results, we believe that the case studies provided in-depth knowledge about the strategies adopted by a set of companies, that are somewhat 'archetypal' of the Portuguese NBF of the 1990s. Further research should now address the process of creation and early evolution of firms starting-up in the last few years – which may have faced relatively smoother conditions – in order to assess whether there are some differences in their behaviour.

Our results confirm the view that co-location of organisations is not strictly indispensable to access knowledge, providing that entrepreneurs and firms benefit from or create what can be described as 'alternative forms of proximity': temporary geographical proximity; epistemic proximity in new scientific fields; technological proximity in fields that are not at the knowledge frontier. The creation of these forms of proximity can result from purposeful strategies devised by firms, but it is also strongly influenced by the activities and policies of other actors that favour the mobility of scientists: for instance, in the cases analysed, the extensive internationalisation achieved by the best research teams, or the high investment in advanced training in foreign centres of excellence (Fontes, 2005b). The significance of such factors for the success of 'distant networking strategies', confirms the growing importance assumed by transnational networks and communities for knowledge production and dissemination. These effects emerge as particularly important for entrepreneurs and firms in peripheral locations: by facilitating the (re)establishment of links with key actors and the integration of the relevant international networks, they enable them to overcome some limitations of their own environment.

The ability revealed by NBFs to reach out and connect to major knowledge concentrations also creates a sort of conduit to world class knowledge, which can contribute to improving the indigenous science base, creates technological competences in new fields and produces new business opportunities, as well as favours the integration of other regional actors in wider networks. However, this potential can only be fulfilled if the firms simultaneously remain connected to their region of origin. The evidence obtained, although limited, suggests that, in a context where firms' markets are essentially located abroad and integration in transnational knowledge networks becomes increasingly important through time, the extent of firms' regional connection depends on the relationships they have developed with the regional scientific and technological infrastructure.

And this is valid, whether these assume the form of a close association with a parent research organisation, that still meets a substantial part of their knowledge requirements; or they assume the form of longstanding processes of co-development of competences with research organisations that, while not being the main source of knowledge, are involved in some knowledge sharing with the firm, namely through the mobility of young people. But, our results also show that when such effects are not at work or are too weak, firms will indeed tend to disconnect, thus substantiating the argument that this type of strategy may end up generating a largely externally oriented trajectory.

Nevertheless, there is a less bright side of the picture. The empirical results also confirm that location is not indifferent in biotechnology and that while these strategies are viable, they may bring additional difficulties for the firms forced to adopt them. Location outside the main biotechnology centres not only prevents firms from benefiting from the general advantages of 'regional embeddedness', but also introduces a number of requirements associated to knowledge access at a distance. Perhaps not surprisingly, it was also concluded that networking at a distance does not eliminate the need for direct personal contacts – either face-to-face contacts for the effective establishment of relationships and for periodical coordination and/or nurturing of on-going collaboration, or temporary co-location for joint knowledge production and development of epistemic proximity – causing 'itinerancy' to become a normal mode of operation in these firms. This specific set of requirements influences NBFs behaviour, has high costs and may impact upon their competitiveness. Thus the implementation of these strategies may entail much greater efforts and superior skills than those required by similar firms located in more munificent environments, which may mean that only the best companies survive these more stringent circumstances.

Finally, it should be remarked that this research revealed a group of highly internationalised firms, some of them involved in extensive networks, which often originate from or include the main centres of excellence in European biotechnology. Compared to many NBFs in more central locations (Allansdottir *et al.*, 2002), these firms have an extensive experience of inter-regional networking, are highly motivated to it and have learned to manage some of the difficulties associated with 'distant networking'. Thus, the case of these firms leads us to suggest that a European strategy for biotechnology should also consider the integration of dispersed specialisations embodied in successful 'out-cluster' firms and regional networks. These can then play a role in the process of expanding and reinforcing Europe's indigenous biotechnology network.

Note

1 Notice that incumbent firms were virtually absent from this process, while foreign firms (both large firms and other NBFs) were often part of the foreign networks.

References

Allansdottir, A., A. Bonaccorsi, A. Gambardella, M. Mariani, L. Orsenigo, F. Pammolli and M. Riccaboni (2002) *Innovation and Competitiveness in the European Biotechnology Industry*, Enterprise Papers n° 7, Enterprise Directorate General, European Commission.

Amin, A. and P. Cohendet (2003) *Geographies of Knowledge Formation in Firms*, DRUID Summer Conference 2003 on Creating, Sharing and Transferring Knowledge, Copenhagen, 12–14 June.

Arora, A. and A. Gambardella (1994) 'Evaluating Technological Information and Utilizing It. Scientific Knowledge; Technological capability and External Linkages in Biotechnology', *Journal of Economic Behaviour and Organisation*, 24(1): 91–114.

Arora, A., A. Fosfuri and A. Gambardella (2001) 'Markets for Technology and Their Implications for Corporate Strategy', *Industrial and Corporate Change*, 10(2): 419–51.

Arundel, A. and A. Geuna (2004) 'Proximity and the use of public science by innovative European firms', *Economics of Innovation and New Technology*, 13(6): 559–80.

Audretsch, D.B. and P.E. Stephan (1996) 'Company–Scientist Locational Links: The Case of Biotechnology', *American Economic Review*, 86(3): 641–52.

Barbanti, P., A. Gambardella and L. Orsenigo (1999) 'The Evolution of Collaborative Relationships Among Firms in Biotechnology', *International Journal of Biotechnology*, 1(1): 10–29.

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.

Baum, I.E., T. Calabrese and B.S. Silverman (2000) 'Don't Go It Alone: Alliance Network Composition and Start-ups' Performance in Canadian Biotechnology', *Strategic Management Journal*, 2(3): 267–94.

Benneworth, P. and D. Charles (2004) *University spin-off companies and the territorial innovation pool: building regional innovation competences*, DRUID Summer Conference 2004, Elsinore, 14–16 June.

Breschi, S and F. Lissoni (2001) 'Knowledge Spillovers and Local Innovation Systems: A Critical Survey', *Industrial and Corporate Change*, 10(4): 975–1005.

Coe, N.M. and T.G. Bunnell (2003) 'Spatialising Knowledge Communities: Towards a Conceptualisation of Transnational Innovation Networks', *Global Networks*, 3(4): 437–56.

Cohen, W.M. and D.A. Levinthal (1990) 'Absorptive Capacity: A New Perspective on Learning and Innovation', *Administrative Science Quarterly*, 35(1): 128–52.

Cooke, P. (2002) 'Regional Innovation Systems: General Findings and Some New Evidence from Biotechnology Clusters', *Journal of Technology Transfer*, 27: 133–45.

Cooke, P. (2001) 'Biotechnology Clusters in the UK: Lessons from Localisation in the Commercialisation of Science', *Small Business Economics*, 17(1/2): 43–59.

Dahlander, L. and M. McKelvey (2003) *Revisiting Frequency and Spatial Distribution: Innovation Collaboration for Biotech Firms*, DRUID Summer Conference 2003, Copenhagen, 12–14 June.

Davenport, S. (2003) 'SME Access to Technological Knowledge: Perhaps Proximity Doesn't Matter?', ASEAT Conference 2003 – *Knowledge and Economic and Social Change: New Challenges to Innovation Studies*. Manchester, 7–9 April 2003.

Depret, M.H. and A. Hamdouch (2004) 'Proximité Spatiale, Organisationelle et Cognitive, Réseaux d'Innovation et Dynamique Concurrentielle dans l'Industrie Pharmaceutique', *Quatrièmes Journées de la Proximité*, 17–18 Juin 2004, Marseille, France.

Echeverri-Carroll, E. and W. Brennan (1999) 'Are Innovation Networks Bounded by Local Proximity?' in M.M. Fischer, L. Suarez-Villa, and M. Steiner (Eds.) *Innovation, Networks and Localities*, Berlin: Springer Verlag, pp. 28–47.

EC (2002) 'Life Sciences and Biotechnology: A Strategy for Europe', COM 27, Luxembourg: European Commission.

Feldman, M. (1999) 'The New Economics of Innovation, Spillovers and Agglomeration: A Review of Empirical Studies', *Economics of Innovation and New Technology*, 8(1/2): 5–25.

Felsenstein, D. (2001) 'New Spatial Agglomerations of Technological Activity – Anchors or Enclaves? Some evidence from Tel Aviv', *Annual Residential Conference of IGU Commission on the Dynamics of Economic Spaces*, Turin, Italy, 10–15 June 2001.

Fontes, M. (2005a) 'Distant Networking? The 'Out-cluster' Strategies of New Biotechnology Firms', in K. Green, M. Miozzo and P. Dewick (Eds.) *Technology, Knowledge and the Firm: Implications for Strategy and Industrial Change*, London: Edward Elgar, pp. 152–78.

Fontes, M. (2005b) 'Distant Networking: The Knowledge Acquisition Strategies of 'Out-Cluster' Biotechnology Firms', *European Planning Studies*, 13(6): 899–920.

Fontes, M. (2001) 'Biotechnology Entrepreneurs and Technology Transfer in an Intermediate Economy', *Technological Forecasting and Social Change*, 62(1): 59–74.

Fontes, M. and M. Pádua (2002) 'The Impact of Biotechnology Pervasiveness and User Heterogeneity on the Organisation of Public Sector Research', *Technology Analysis and Strategic Management*, 14(4): 419–41.

Gallaud, D. and A. Torre (2001) 'Les Réseaux d'Innovation sont-ils Localisés ? Proximité et Diffusion des Connaissances (Le Cas des PME de l'Agbiotec)'. *Third Congress on Proximity – New Growth and Territories*, Paris 13–14 December.

Johannisson, B. (1998) 'Personal Networks in Emerging Knowledge-based Firms: Spatial and Functional Patterns', *Entrepreneurship and Regional Development*, 10(4): 297–312.

Lemarié, S., V. Mangematin and A. Torre (2001) 'Is the Creation and Development of Biotech SMEs Localised? Conclusions Drawn from the French Case', *Small Business Economics*, 17(1/2): 61–76.

Lorenz, E. (1999) 'Trust, Contract and Economic Cooperation', *Cambridge Journal of Economics*, 23(3): 301–15.

Malecki, E. and P. Oinas (1999) *Making Connections. Technological Learning and Regional Economic Change*, Aldershot: Ashgate.

Mangematin, V., S. Lemarié, J.P. Boissin, D. Catherine, F. Corolleur, R. Coronini and M. Trommetter (2002) 'Development of SMEs and Heterogeneity of Trajectories: The Case of Biotechnology in France', *Research Policy*, 32(4): 621–38.

McKelvey, M., H. Alm and M. Riccaboni (2003) 'Does Co-location Matter for Formal Knowledge Collaboration in the Swedish Biotechnology–Pharmaceutical Sector', *Research Policy*, 32(3): 483–501.

McKelvey, M. and L. Orsenigo (2001) European Pharmaceuticals as a Sectoral Innovation System: Performance and National Selection Environments, *Second EMAEE – European Meeting of Applied Evolutionary Economics*, 13–15 September.

Morgan, K. (2001) 'The Exaggerated Death of Geography: Localised learning, Innovation and Uneven Development', Conference *The Future of Innovation Studies*, ECIS, 20–23 September.

OCES (2003) Inquérito ao Potencial Cientifico e Tecnologico 2001, Sumários Estatísticos do Sector Institucional, Lisboa: Observatorio da Ciencia e do Ensino Superior.

Oinas, P. (2000) 'Activity-specificity in Organizational Learning: Implications for Analysing the Role of Proximity', *GeoJournal* 49(4): 363–72.

Oinas, P. and E.J. Malecki (2002) 'The Evolution of Technologies in Time and Space: from National and Regional to Spatial Systems of Innovation', *International Regional Science Review*, 25(1): 102–31.

Orsenigo, L. (2001) 'The (Failed) Development of a Biotechnology Cluster: The Case of Lombardy', *Small Business Economics*, 17(1/2): 77–92.

Orsenigo, L. (1989) *The Emergence of Biotechnology. Institutions and Markets in Industrial Innovation*, London: Pinter Publishers.

Orsenigo, L., F. Pammolli and M. Riccaboni (2001) 'Technological Change and Network Dynamics. Lessons from the Pharmaceutical Industry', *Research Policy*, 30(3): 485–508.

Owen Smith, J. and W. Powell (2004) 'Knowledge Networks as Channels and Conduits: The effects of Formal Structure in the Boston Biotechnology Community', *Organization Science*, 15(1): 5–21.

Owen Smith, J., M. Riccaboni, F. Pammolli and W. Powell (2002) 'A Comparison of US and European University-Industry Relations in the Life Sciences', *Management Science*, 48(1): 23–43.

Powell, 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): 116–45.

Rallet, A. and A. Torre (2000) 'Is Geographical Proximity Necessary in the Innovation Networks in the Era of Global Economy?', *GeoJournal*, 49(4): 373–80.

Rees, K. (2001) *Collaboration, Innovation and Regional Networks: Evidence from the Medical Biotechnology Industry of Greater Vancouver*, Working Paper, Department of Geography, University of Wales, Swansea.

Roberts, J. (2000) 'From Know-how to Show-how? Questioning the Role of Information and Communication Technologies in Knowledge Transfer', *Technology Analysis & Strategic Management*, 12(4): 429–43.

Rosenkopf, L. and P. Almeida (2003), 'Overcoming Local Search Through Alliances and Mobility', *Management Science*, 49(6), 751–66.

Sapienza, H.J., A. Parhankangas and E. Autio (2004) 'Knowledge Relatedness and Post-spin-off Growth', *Journal of Business Venturing,* 19(6): 809–29.

Saxenian, A. and J-Y. Hsu (2001) 'The Silicon Valley–Hsinchu Connection: Technical Communities and Industrial Upgrading', *Industrial and Corporate Change*, 10(4): 893–920.

Steinmueller, E. (2000) 'Will New Information and Communication Technologies Improve the 'Codification' of Knowledge?', *Industrial and Corporate Change*, 9(2): 361–76.

Stuart, T. and O. Sorenson (2003) 'The Geography of Opportunity: Spatial Heterogeneity in Founding Rates and the Performance ob Biotechnology Firms', *Research Policy*, 32(2): 229–53.

Tappi, D. (2002) *Changing Structure – Keeping Location. Global Change and Local Stickiness in Local Industrial Clusters*, DRUID Summer Conference 2002, Copenhagen, 6–8 June 2002.

Torre, A. and Rallet, A. (2005) 'Proximity and localisation', *Regional Studies*, 39(1): 47–60.

Vaessen, P. and D. Keeble (1995) 'Growth-oriented SMEs in Unfavourable Regional Environments', *Regional Studies*, 29(6): 489–505.

Williams, A.M., V. Baláz and C. Wallace (2004) 'International Labour Mobility and Uneven regional Development. Human Capital, Knowledge and Entrepreneurship', *European Urban and Regional Studies*, 11(1): 27–46.

Zeller, C. (2001) 'Clustering Biotech: A Recipe for Success? Spatial Patterns of Growth of Biotechnology in Munich, Rhineland and Hamburg', *Small Business Economics*, 17(1/2): 123–44.

Zucker, L., M. Darby and M. Brewer (1998) 'Intellectual Human Capital and The Birth of US Biotechnology Enterprises', *American Economic Revue*, 88(1): 290–306.

8 Linking less-favoured Finnish regions to the knowledge economy through university filial centres

Kati-Jasmin Kosonen

Introduction

In the era of the knowledge-based economy,[1] many localities are trying to compete with larger, growing cities over knowledge and intellectual capital resources. The regional or local *knowledge environment* and the *innovation environment* for specific business areas have become more important. Furthermore, new institutions are taking part in local innovation networks shaping the technological change and industrial transformation in the region. National, regional and local authorities and development organizations, including universities, are trying to support innovation processes through different knowledge networks and a new type of collaboration. It has often been argued that now the positions of both organizations and regions are determined more than earlier by their competencies and skills to learn and develop themselves in a continuous process, as stated in the 'learning economy' concept (Lundvall, 1996 and 2002).

A learning economy is a system which is pressured by rapid change and a need for new skills and knowledge creation in the form of networks. Technological developments, globalization and political processes of increasing global competition and co-operation (e.g. WTO) drive the acceleration of technical and economic change (Lundvall, 2002: 4). Firms and other actors in regions may form collective learning processes, operating through skilled labour mobility, customer–supplier interchange in technical and organizational matters, imitation processes and especially through informal 'cafeteria effects', local 'noise' or 'buzz'. These local contacts occur in the form of local activity in a shared space and place milieu (see Camagni, 1991: 130; Storper, 1995; Storper and Venables, 2002; Bathelt *et al.*, 2004), where local contacts are mainly formed through tacit and informal routes within face-to-face contacts, rumours, co-operation and co-working.

If a region does not have enough formal and informal research, sufficient development institutions and network interaction between them, actors find it more difficult to transform information (resources) into new knowledge and related innovations. Such regions tend to be called 'less-favoured regions' (LFRs) or 'disadvantaged' regions. They may be building their institutional base by forming collaborative university–industry knowledge transfer institutions and models through networking, but the success rate is not necessarily very high.

The problem worsens if the 'innovation culture' (innovative milieu) is not competitive with other regions, towns and cities. If this institutional base is 'thin', firms in the emerging sectors do not get the appropriate assistance in their growth and internationalization processes. This leads to the question of what possibilities actors in the LFRs have to enhance their innovation environment and knowledge capabilities. Accordingly, this chapter has the following research objectives:

- To present a new organizational mode for universities and less-favoured regions to enhance their knowledge infrastructure – 'university filial centres'.
- To describe the steps taken simultaneously at three different organizational levels (government, regions and universities) and in six different regions engaged in forming university filial centres.
- To test the adequacy of the concept of 'institutional capacity' in actual practices in the respective regions aiming to build up the network of university filial centres.

This chapter is about creating and intensifying linkages with the universities through regionally new types of knowledge networks in six Finnish LFRs. The way to create and strengthen the innovation environment in emerging industries in these LFRs was to *bring knowledge into* the town region. An additional aim was to sharpen the core competencies (resources) of development agencies to make networking easier, to identify the missing elements of the innovation system and to fill in the gaps either by new agencies (institutions) or networks (Sotarauta and Kosonen, 2003, 2004). The empirical material is based on example written material, statistics and reports gathered from regions, and on thematic interviews made in the LIS-project.[2]

Matching the challenges of less-favoured regions to the global knowledge economy – a challenging task

The technological infrastructure and the *institutional and organizational structure* of the locality have been of importance when a specific region has been capable to learn new ways of collecting, producing and using knowledge. This is explained by the local needs of knowledge *resources* and the *partnerships* (coalitions and networks) made by individual actors (e.g. entrepreneurs, development agencies, university units, municipalities, technology centres). The development of global markets is based on comparative and competitive advantage, and hence, quite largely on specialization. Therefore, the significance of place-specific advantage is argued to be increasing, and the aim in many places is to create place-specific advantages on the basis of innovation and pools of skilled labour, different institutional environments and by offering often quite subtle distinctions in the operating environment (Maskell and Malmberg, 1999).

Generally LFRs suffer from a 'thin' infrastructure of higher education and research, brain drain characteristics and cutbacks in educational and research resources. Public knowledge-oriented organizations tend to form *co-operation spaces*, forums and arenas to link R&D organizations and business life to each other (Morgan, 1997: 493; Lundvall, 1996, 2002; Landabaso *et al.*, 1999; Oinas and Malecki, 1999; Kautonen and Sotarauta, 1999). However, the institutions and organizations are frequently inadequate and, what is even worse, they may cause or worsen lock-in situations in the less-favoured regions. In these cases, actors in the regions cannot change their actions towards new ways of producing or networking. To put it simply, they fail to learn. Still, both the innovation processes and policy networks aiming to promote innovation are nowadays seen as processes of *interactive learning* in which a wide array of institutional mechanisms can play a role even in regions defined as less-favoured.

In the 1990s, a new awareness of the demands of the enhanced knowledge society increased among the policy-makers as well, and the need for a new kind of development strategy was widely discussed in various regional programming and strategy processes involving the public sector, higher education and research institutes as well as local firms. In the 1990s, the dominant moods in two Finnish LFRs, Pori and Seinäjoki town regions can be described as frustration and fear that the region had been left out of the innovation- and technology-oriented development. This was thought to imply a serious danger that these regions would end up being some kind of 'peripheral pocket' in an otherwise well-developing national knowledge-, innovation- and technology-oriented economy. Therefore, most of the regional, sub-regional and local development programmes and strategy documents were directed towards solving this issue, particularly in South Ostrobothnia. (For more about South Ostrobothnia, see Sotarauta and Kosonen, 2003, 2004.)

Building institutional capacity in less-favoured regions

Currently, it is commonly perceived that development processes are shaped by a variety of institutional routines and social conventions. The innovation processes and policy networks aiming to promote innovation are seen as processes of *interactive learning* in which a wide array of institutional mechanisms can play a role. Economic actors or players from wide range of organizational backgrounds have to be part of the *knowledge networks which the most essential knowledge is built and formulated formed by professionals*, and those organizational and non-organizational institutions they are involved in (Morgan, 1997: 493; Lundvall, 1996, 2002; Landabaso *et al.*, 1999, Oinas and Malecki, 1999; Kautonen and Sotarauta, 1999; Sotarauta and Kosonen, 2003).

The literature has increasingly turned the attention of researchers and policy-makers away from purely 'economic' reasons for the growth of new industrial agglomerations towards social and institutional factors (see e.g. Cooke and Morgan, 1998; Sotarauta *et al.*, 2002). An environment that supports learning and accumulation of knowledge is based on local *institutional settings* as well as on the *relationships* and *partnerships in and among* different *institutions*. In addition, as Moulaert and Sekia (2003) in their turn show, in 'territorial innovation models' institutions are frequently raised as important factors in regional development, and the policy-making and planning literature focuses on institutional capacity in terms of direction, policies, procedures, organization and other explicit guidance (see e.g. Healey *et al.*, 1999; Henry and Pinch, 2001; Sotarauta and Kosonen, 2003).

However, the notion of *institutional capacity building* is not a new concept. It has been used to highlight the need to build up individual capabilities (e.g. labour force skills or entrepreneurial capacity) and those of public development agencies. The new thinking about *institutional capacity*, as Healey *et al.* (1999) state, focuses on the webs of relations involved in regional development policies, which interlink public development agencies, firms as well as educational and research institutes in collective action (Healey *et al.*, 1999).

In the knowledge economy, a highly skilled labour force, universities and other institutions creating new knowledge, and expertise in general, are usually seen as the most important resources. In the beginning of the process of building institutional capacity as part of the innovation environment, there is a need for *technology and innovation structures* and an *institutional base* strong enough to create critical mass or critical capabilities and valuable *resources*, often called *competencies*. There is also a need for *relationships*, which often take the forms of *networks and partnerships*, between organizational and non-organizational, formal and informal institutions. Summarizing the idea, the key elements of institutional capacity are: *institutions* (technological infrastructure), *knowledge resources*, *networks*, and finally, the existence or creation of '*public spaces as shared arenas*' as presented in Table 8.1.

Once networks or coalitions are created and formed, actors in networks should further be able to create new spaces and common arenas to interact and manage the resources of institutional capacity. (Healey *et al.*, 1999). This is stressed partly in the work of Storper and Venables (2002; Grabher, 2002, see also Bathelt *et al.*, 2004; Sotarauta, Linnamaa and Suvinen, 2003) about the importance of a set of activities called the 'noise' or 'local buzz'.[3] 'Buzz' is used to refer to the information and communication ecology created by face-to-face contacts, co-presence and co-location of people and firms within the same institutional orchestra and place of region (Storper and Venables 2002; see also Bathelt *et al.*, 2004). The idea of noise, buzz or perhaps the 'cafeteria effects' lies basically on

Table 8.1 The key elements of institutional capacity

	Institutions	*Resources*	*Networks*	*Shared arenas*
Elements of institutional capacity in less-favoured regions	Technological infrastructure	Visible, exchangeable resource base	Local and non-local innovation networks	Public forums, places to interact
	R&D&E organizations (HEIs)	Knowledge-related resources	Nodes and key individuals	Knowledge communities and tribes
	Non-org. institutions	Competencies	Interaction	Local buzz

the simple notion that a certain milieu or agglomeration with closely working actors and individuals can be vibrant and culturally lively with social contacts and interaction in the sense that there are a lot of useful, informal and unplanned contacts going on simultaneously and continuously, which makes it easier to share information, interpretations, inspiration and motivation among the networks of communication (e.g. knowledge networks) and information linkages internal and external to that milieu (Maillat, 1998; Bathelt *et al.*, 2004; Lambooy 2004).

Therefore, the existence or creation of '*public spaces as shared arenas*' (arenas in the form of 'local buzz'), and finally, the continuity of development *processes* are the crucial element of the economic development of LFRs (see Healey *et al.*, 1999; Bathelt *et al.*, 2004; Sotarauta *et al.*, 2003; Amin and Thrift, 1995; Henry and Pinch, 2001). It can be concluded that, in less-favoured regions, university branches ('university filial centres') and research communities are common knowledge arenas and the forums for local buzz as understood in the work of Storper and Venables (2002; see also Bathelt *et al.*, 2004; Sotarauta *et al.*, 2003).

The regional element of the Finnish higher education and research system

National, regional and local authorities and development organizations, including universities, are trying to support innovation processes through different knowledge networks and a new type of collaboration. The large share of the Finnish national R&D investment of GDP is made mainly by the private sector, and to be more specific, the telecom industry (Mainly Nokia and its subcontractors). The total annual investments in R&D are around €5 milliard, with the share of GDP around 3.5% (in 2005 the total expenditure was around €5.4 milliard). Direct budget funding for universities covers therefore only 0.82% from GDP at market prices (Universities 2004, ICT Cluster Finland Review 2005).

Of the scientific research carried out in Finland, 20 universities are responsible for approximately 80% and from basic (radical) research approximately 90%. In 2004, public research accounted for 30% of all R&D funding. The percentage of public sector funding for research is therefore around 1% of GDP, while EU country average is 0.75%. The number of research personnel in relation to the labour force in Finland was about 2% (Universities, 2004). However, the research volumes are very small at the international level; Finland produces approximately 1% of the world's (public) scientific knowledge. Most of the scientific knowledge used in Finland is produced somewhere else and therefore transferred to and applied in Finland through networking, publications, conferences, licences, patents, products, for example (Rantanen, 2004). In Finland (5.3 million inhabitants) there are a total of 21 campus universities in 11 cities, six university filial centres in six other cities and 50–60 other university branch units mainly in peripheral areas, with a total student body of around 175,000 students (Rantanen, 2004; Universities, 2004). The largest university cities are also cities or towns with at least decades- or even centuries-long (e.g. Turku in 1640) history of hosting academies, although the current university system was formed almost entirely during the Finnish sovereignity in the twentieth century.

The recent discourse related to the innovation systems and regional innovation environments has focused on the regions where the university naturally has a central role as a source of knowledge and innovations. However, according to various discussants (Virtanen, 2002; Virkkala, 2003; Tura and Uotila, 2005) promoting the innovative capability of the non-university regions presents a remarkable challenge to the development in the Finnish context as well as on the European level. Although perhaps the most active enhances of innovation capabilities to be seen in the contemporary world are in the fast developing economies like China and in many of the politically stable Asian and Latin American economies. The question that follows then is: how are those regions (LFRs) in Finland that do not have their 'own' academic institutions able to link themselves to knowledge economy and global academic networks?

In the report on the regional roles of the universities by the Working Group of the Finnish Ministry of Education (2001), the Finnish regions were divided into three categories according to the effects of the national HEI system: (1) growing and innovative, (2) neutral and (3) lagging behind. In the regions of the last two types, polytechnics play an essential role, particularly in the regions that do not have independent universities (Ahmaniemi and Setälä, 2003; Korkeakoulutieto, 2002; Ministry of Education, 2001). More specifically, the Working Group recommended to the neutral regions and their central towns like Lahti and Pori that they intensify collaboration with the academic institutions involved in these towns and create 'umbrella' organizations for academic activities and institutions and further develop for these cities a new institutional concept of university filial centres. Therefore, it is this Working Group, called the Linna Group in Finland, that first announced the idea of university filial centres.

In recent decades, the Finnish higher education system has diversified. In about the last two decades the system of the higher education in Finland has expanded remarkably to those regions outside the primary university network by establishing non-independent regional university units, namely the branch units and lately consortiums of these branch units, called university filial centres.[4] Figure 8.1 shows the locations of Finnish 'headquarters' of universities and polytechnics.

This highlights the challenges for and developments of the role of the branch offices under their main institutions performing the third task, mainly because of their locations in the regions where the field of knowledge infrastructure is constructed very differently from the university regions. In such regions, the polytechnics are one of the key players in building the innovation environment, while nationally polytechnics are the second pillar of the Finnish system of higher education and universities the first pillar. In addition, this dual model is under continuous development and science and innovation policy discussion.

The third strand tasks made it possible for the universities to 'review' and start to expand their institutional structures not only *internally*, but also spatially, namely with other regional and local partners in the surrounding or neighbouring

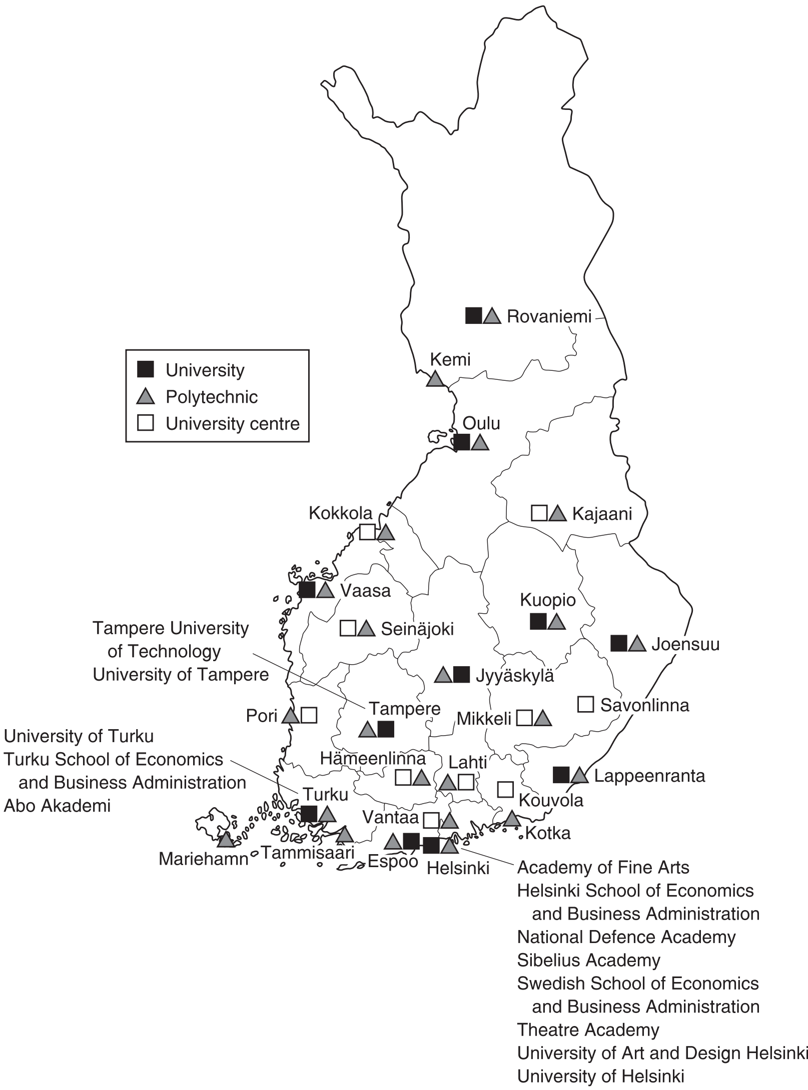

Figure 8.1 Finnish regions and universities.

communities. To highlight the development path of the expansion of the national university system both spatially and contextually, the main phases of development can be divided as follows (see e.g. Goddard, 1999; Goddard *et al.*, 2003; Ministry of Education, 2001; Virtanen, 2002): (a) serving the needs of Swedish Monarchy, or later, the Emperor of the Russia; (b) building a new independent nation at the beginning of the twentieth century; (c) expanding the university system to the 'regions' in the late 1950s and the early 1960s; (d) building a welfare state at the end of the 1960s; (e) construction of strong research in the universities in the 1970s–80s; (f) the rise of knowledge economy framework from the 1990s; and, finally, (g) serving the needs of undeveloped communities from the early 2000s.

According to Tura and Uotila (2005), three central phases of change can be distinguished in the formation of the Finnish university system. They can be called *the first, the second and the third decentralization* of the university system, also reflecting the change of the relationships between the universities and the regions surrounding them. The first decentralization, contributing to the establishment of the first new universities and the 'professional' higher education institutions, took place at the beginning of the twentieth century. The second decentralization started at the turn of the 1950s and 1960s, when so-called provincial universities were formed and the system was expanded to its present form. This period highlighted, on the one hand, the strong role of the universities as supporters of the cultural life and equal opportunities of education and, on the other hand, the expanded needs of civil servants to fulfil the employment needs of the strengthening welfare state (see also Virtanen, 2002; Goddard *et al.*, 2003). The phenomenon Tura and Uotila (2005) present as *the third decentralization of the university system* took place mainly in the 1980s and 1990s, when approximately 50 non-independent regional university units were established. The background of the establishment of the branch units lies in the aims of the non-university regions – and especially the larger cities without a university – to access the benefits brought by the universities. The outcome is a relatively large share of the population aged 15–64 with educational qualification,[5] namely 61.9%.

From the national point of view, serving the needs of undeveloped communities was the turning point in strengthening the knowledge infrastructure in the less-favoured regions from the early 2000s. Under that period, many universities launched university filial consortia with less-favoured main towns in their regions or sub-regions such as Kajaani, Kokkola, Lahti, Mikkeli, Pori and Seinäjoki. Soon after these umbrella organizations were called 'university filial centres'.[6] *University filial centres* were established, first in Lahti in 2001, then in Pori in 2002, and last in Mikkeli and Seinäjoki in 2004.

University filial towns and cities cannot count on permanent university-level education and many other benefits universities offer to 'their regions', although the university filial centres form from volume perspectives even bigger academic institutions to LFRs than many small universities in their respective regions. Totally there are approximately 1,000 employees, mainly researchers and project workers, almost 3,200 degree students and 25,000 students (short courses included). The annual budget from all six filial centres is nearly €70 million.[7] Compared to the smallest Finnish campus universities, these figures are quite substantial (Table 8.2).

The national science and technology policy initiatives and the EU membership in 1995 made this structure more favourable also for the campus universities. Public funding for Finnish Universities constitutes approximately one quarter of

Table 8.2 Basic facts from the smallest universities in Finland

Universities in 2003	*Under-graduates*	*Graduate school students*	*Teaching personnel (persons)*	*Other personnel (persons)*	*Research personnel (persons)*	*Total budget (€ million)*	*External funding (€ million)*
Helsinki School of Business Administration	3,898	425	152	209	75	22.0	11.4
University of Lapland	3,864	349	192	306	73	25.7	10.5
Svenska Handel-högsskolan	2,462	196	100	82	14	10.6	4.6
Turku School of Economics and Business Administration	1,960	259	100	120	61	12.9	5.7
University of Art and Design (Helsinki)	1,562	169	147	221	21	25.2	5.5
Sibelius Music Academy	1,347	128	239	134	2	21.6	2.0
Theatre University	383	35	55	93	3	10.0	0.9
University of Fine Arts	229	11	25	25	–	4.0	0.1
Total in Finland (all universities)	147,375	22,960	7,933	13,961	5,933	1,185.2	639.1

Source: Ministry of Education, 2004, KOTA database, 'Universities 2003'.

the national (state budget) share for R&D investments; in the year 2004, the share was 26%. Additionally universities apply funding through competitive funding tools from the Academy of Finland and the National Technology Agency of Finland (Tekes).[8] In 1993, about 1,900 researchers worked in universities with external funding; in 2003 the number was 4,900. External funding reaches 10–70% of universities total budgets, while the estimated maximum should be 50%.

From the financial point of view, the actual share of funding for universities per graduated student and academic course has decreased.[9] In the peripheral regions, these universities offer for local students several Master's Programmes funded by local authorities (e.g. regional councils, district governments, the municipalities, health care districts). The recent evaluation of the Master's Programmes (Finnish Higher Education Evaluation Council FINHEEC: Spring 2004) still continued to encourage universities and local actors to collaborate and form new programmes.

Building institutional capacity in action – grassroots activity in regions?

University filial centres are models that are formed to function as development tools for less-favoured regions to boost their economic development processes and that are built in the era of multilevel development work and partnerships (global, national, local). The development strategies and models that gradually emerged were presented in many development programmes and strategies summarized as follows: (a) s*trengthening the innovation culture* – the strategic aim is to arouse firms' and policy-makers' interest to innovate and raise their awareness of the demand raised by the global economy and especially promote innovation as a source of competitive advantage; (b) *to improve innovation capabilities both in firms and public organizations, and to intensify their collaboration* – the strategic aim is to support the abilities and skills of the firms to search, absorb and utilize fresh information and technology in their own activities; and (c) *to build and strengthen the regional innovation system and to link it tightly to the national system of innovation* – the strategic aim is to create a flexible and well enough resourced basic innovation infrastructure to support innovation in firms (see Sotarauta and Kosonen, 2003, 2004).

Leaders and managers (e.g. companies, polytechnics, university units, regional development agencies, chambers of commerce) realized the challenging situation in these LFRs in the 1990s and started to strengthen the local innovation environment: 'Something has to be done . . .'. What actions were taken in the Finnish LFRs to create and strengthen the innovation environment in emerging industries? The strengthening actions were taken mainly through local efforts with EU funding. The main strategy was to bring knowledge into the region. This was done by (a) inducing universities (and polytechnics) to found new units and creating university filial centres (institutions) and (b) creating shared arenas (public spaces and networks). Examples of the latter are the EPANET network in Seinäjoki and different research consortiums in the other university filial centres.

In the following, the actual steps of strengthening the innovation environment are presented in more detail.

Strengthening the local knowledge pools – inducing universities to found new university filial centres

In the mid-1990s in the LFRs the new awareness of the demands of the network society increased step-by-step among the regional policy-makers as well, and the need for a new kind of development strategy was widely discussed in various regional programming and strategy processes involving the public sector, higher education and research institutes and to some extent also firms. The university filial centre network began to take shape in the period 2001–2004. The first university filial centre was officially nominated in the town of Lahti in 2001. The other towns where the sub-campuses were organized in the form of filial centres are Kajaani, Kokkola, Mikkeli, Pori and Seinäjoki. Of these, Mikkeli and Seinäjoki are the latest selects. The network is 'frozen' to the level of these six towns and their filial centres for the foreseeable future in order to see the impact of these centres on the respective regions, universities and the national higher education system. In every filial centre, one of the universities that has established a branch unit in a specific location co-ordinates activities and collaboration in that filial centre.

The common features for all these small and medium-sized host cities for university branch units are that (a) they are the central cities or towns of their larger regions (NUTS 3 areas) and (b) they still are not equal to growth centres and regions in Finland. The two largest towns (by population), Lahti and Pori equal the middle-sized Finnish cities, while the others (e.g. Seinäjoki) are among the smallest cities. Lahti, Mikkeli and Pori are larger than some of 'university' cities in coastal regions, Lapland and the Eastern part of the country.

The idea of university filial centres has formed gradually and almost simultaneously at the national level and the regional level. From the **national point of view**, the Government of Finland asserts the network as one their regional development focuses (see Ministry of the Interior 16/2004). In line with this statement are actions taken by the Ministry of Education. The ministry has actively presented or invited new incentives from the regions. The official view is that the basic funding of academic education in these six university filial centres will be covered by the ministry (state budget) from the year 2006. The basis for

Figure 8.2 The university filial centre locations.

the views formulated by the ministry was laid at the beginning of the 2000s as the Finnish Higher Education Evaluation Council (FINHEEC) evaluated or carried out several reports on the higher educational situation in these regions (1999–2003). FINHEEC evaluated the situation of academic institutions operating in Lahti in the year 2002 and observed the need for coordination among separate university branches. This evaluation presented for the very first time the idea of establishing an *academic community* in Lahti.

From the **regional point of view**, the realization of the local economic crisis or the position in losing regional competitiveness in the era of the knowledge economy after the deep recession spilt over the country in the beginning of 1990s made the local actors put emphasis on academic education (both the polytechnic and university levels), creating and intensifying academic networks and strengthening the local innovation environment and knowledge infrastructure as 'the way out of the periphery'. From the recovering and stagnating processes in the Finnish economy after the recession in the 1990s the Finnish regional economy has been very diversified; the four–five main cities are growing and performing well in almost every economic and knowledge sector, while the other regions and cities have performed worse. In the growth cities there are several academic institutions and campus universities, science parks, technology centres and diverse high-tech-dominated industrial bases. The realization of these factors made local actors in many other regions place a policy on similar courses of action.

The **academic institution point of view** varies. In all of these regions there has been adult academic education from the 1960s and at least from the late 1980s. The institutions located longest in these regions have offered varied academic services, from extension studies to applied research, mainly in the form of contract research and from the mid-1990s onwards, in the form of R&D projects. National science and technology policy initiatives and the EU membership in 1995 also made this structure more favourable for the campus universities. Tura and Uotila emphasize in their study on third task units (2005) the notion that although the universities increasingly underline that the active involvement in societal and regional development belongs to the whole university, not just to its individual parts, in practice they have founded several units specialized to carry out this function. Typical examples of these are the centres of continuing education, the institutes for applied research and different technology transfer and innovation support actors, science parks and technology centres. The second type of enlargement of the regional task is to establish regionally embedded institutes and branch units to neighbouring localities. Therefore, it can be concluded that the movement of establishing branch units to the regions did not take place only because there were growing markets for academic education and an opportunity for the universities to expand their recruitment area, but also because there was a possibility to find new sources of funding from the EU and Finnish Structural Funds. In one perspective this target hit its goal in 2003, when first the Ministry of Education allocated funding for the coordination purposes of university filial centres and the Parliament of Finland allocated ear-marked additional funding (€3 million) for the years 2004 and 2005.

The university filial centres as local knowledge hubs

The first campus universities to establish educational units in LFRs acted in the mid-1980s. In Kajaani, it went the other way around: the existing college was introduced as a part of the University. The next active period was at the end of the 1990s and at the beginning of the new century, when neighbouring universities especially activated to outreach to academically peripheral regions. At that time, the 'third role' of the universities became a formal task of the universities because their financial possibilities for such outreach activities increased, especially compared with the funding that only remains in the university's 'own' region. Therefore, in the LFRs the universities are offering local students several Master's Programmes funded by regional actors (e.g. regional councils, district governments, the municipalities and health care districts).

The very basic feature of filial centres is that they consist of several academic institutions, from three (Kokkola) to six (Seinäjoki). The main functions of this university branch unit consortium are (a) to expand the *student recruitment area* for the main university and (b) to expand the collaboration *network with 'customers'*, public institutions or firms located in these regions, and therefore to be able to increase the amount of research funding. Most of these branch units were founded to execute continuing education at the universities, the Open University education and the various regional research and development projects. The idea is to work as a single actor in the region and for the region.

The regional branch units' background in general lies deeply in executing universities' regional development function and in answering to the needs of a region. The disturbing factor for both regions and university filial centres is the insecure situation of branch units in general and university filial centres in particular; their funding is based on mainly temporary funding and the institutional role among the parent universities tends to be weak. In addition, these campus universities differ in their attitudes towards regional service activities, because every university has its own kind of strategy or portfolio of regional effectiveness; technical universities typically have more expanded and diversified view than multi-educational, 'classical' humanistic universities. Due to this sometimes challenging navigation in the deep waters of the Finnish higher education system, the branch units have to build their effect mechanisms and their functions by some other means. Table 8.3 shows the main characters or functions separating single university filial centres from neighbouring ones.

As seen in Table 8.3, many university filial centres have grounded their effectiveness and main task from the regional emphasis directly, supporting different; locally important schemes. Their activities are typically strongly affected by regional emphases and expectations, in which a local development network may play a substantial role in their guidance and decision-making. The expectations are mainly extremely high, casting University Filial Centres as the main engines of the economic growth of the region but also unlocking the existing knowledge structures. As an outcome of this, all centres have been able to introduce organizational innovations, even though the focus on other types of innovation varies.

Table 8.3 Differences and similarities between university filial centres[10]

	Kajaani	*Kokkola*	*Lahti*	*Mikkeli*	*Pori*	*Seinäjoki*
'Geographically closest' universities involved	X	X	X			
Local polytechnic clearly involved	X			X		X
PhD programmes	X	X	X		X	X
Focus on research			X	X		X
Focus on education	X	X	X		X	
Focus on regional development	X	X		X		X
Educational innovations		X	X	X	X	
Radical (research) innovations			X			X
Organizational innovations	X	X	X	X	X	X

Also the emphasis on regional development varies. The university filial centres in Kajaani and Mikkeli are the most active ones in that category.

In the following section, I will briefly describe the basic structure of university filial centres (Lahti, Kokkola, Mikkeli and Kajaani, Pori and Seinäjoki), as examples of the varied structures and implications the university filial centres have in Finland.

Lahti features

The Lahti University Filial Centre Consortium is a network university that was established by *four Finnish universities* in the year 2001. From these, the University of Helsinki has organized activities in the Lahti region for as long as 25 years. The Lahti University Filial Centre employed approximately 200 people in the spring term 2005 and had a student body of more than 5,000 students. The units of the Lahti University Consortium offer university-level education both in the form of under- and post-graduate studies, in addition to which it offers development training programmes and Open University studies of different durations (Palmenia). The main task of the Lahti University Consortium is to raise the level of education and know-how and to serve trade and industry in the Lahti region as well as the region itself through university research, development and education. The mission of the Lahti University Consortium is to develop and implement partnership practices that again generate multidisciplinary and distinct research of international standards and thus to act as an internationally orientated and regionally embedded testing base for flexible, regional collaboration under the Finnish Innovation System.

Kajaani features

The Kajaani University Filial Centre (Kajaani University Consortium, KajUC) is a centre of *four universities*, which all have branch departments in the town of Kajaani, and was established at the beginning of the year 2004. The KajUC is seeking synergy and enhancing collaboration with local economic sectors and university activities involved in the region. Generally the activities in the KajUC include continuous education, adult education, vocational studies and Master's Degree Programmes, PhD education (around 100 students), Open University courses, a certain type of innovation promotion such as applied R&D services, mainly in the form of projects, a certain set of biotechnology operations, and education services (short and customized courses for local purposes). The total number of staff of the University Filial Unit is approximately 220. The oldest and biggest branch unit is the Kajaani Department of Teacher Education; its roots go back as far as to the year 1900, when it was a college for teachers. Because education has been a primary task for the Kajaani branch units, their educational line is still stronger than the research line in the filial centre's operations.

Kokkola features

In the town of Kokkola, the university filial centre is called the 'Chydenius Institute – University Consortium of Kokkola'. The Institute is a collaborative branch unit of *three universities* but administratively clearly organized around the Chydenius Institute, which in turn is a separate institute of the University of Jyväskylä. Generally its activities include continuous education, adult education, vocational studies and Master's degree education, teacher training, PhD education, Open University courses, Master's degree 'hatchery', and education services (short and customized courses for local purposes). The educational line is stronger than the research line in the Filial Centre's operations. However, the centre is trying to turn its weakness into a new strength, for the current development efforts of the centre concentrate on reforming the Chydenius Institute and the university filial centre as a national laboratory (or testing point) for a virtual learning environment for adult education. The other activities are targeted at serving this vision with extensive collaboration among institutions, local partners and polytechnics, and with the usage of new (educational) technology and recent research results in the fields of pedagogic, medical sciences, regional sciences, social sciences and teleinformatics. Therefore, it can be concluded that the Kokkola University Filial Centre seeks its role as national hot-spot or testing base for most recent 'edutech' applications.

Mikkeli features

The Mikkeli University Filial Centre (MUC) was established at the beginning of the year 2001 as a networked academic community. Its initial task is to provide scientific research and university-level teaching and interaction with surrounding society – its 'own' region. There are *four Finnish universities* involved in the Consortium which enable it to fulfil the regional needs. In Mikkeli, the regional polytechnic (Mikkeli Polytechnic) and other non-university laboratories have significant roles in the local knowledge environment and, therefore, the University Filial itself is organized more in the form of a consortium than in Lahti, Pori and Seinäjoki, for example. The MUC conducts research and development in co-operation with the business sector, other universities, the Mikkeli Polytechnic and other research institutes. The special factor in the MUC is that one of the partner universities, the Lappeenranta University of Technology, is involved in collaboration mainly through the polytechnic, not directly with other university units. Even if the consortium is dispersedly located and have somewhat separate interests, it can be said that the systemic view of regional economic development has been achieved in MUC. The MUC focuses on regional involvement more deeply than other university filial centres.

Pori features

The Pori University Filial Centre is a centre of *five Finnish universities* with branch departments in Pori. The centre co-ordinates an academic environment with about 1,240 degree students and 190 staff members. It is specialized in certain sectors of the growth sectors in society and has therefore close linkages to large businesses. The centre is also well networked both politically and economically to the local and national level. Tampere University of Technology (TUT) is the co-ordinating university for the filial centre. The Pori University Filial Centre specializes in technology, economics and business management, the humanities, welfare research, arts, short sea studies and visual art. Adult and extension studies in different fields have been offered since 1987, but since the 2000s, the university units in Pori (Pori University Filial Centre) offer full degree education in Pori for upper secondary school graduates. After many years of heavy investment in higher education infrastructures and particularly in the University Centre, the views of the local industry and business life have stressed the need for increased co-operation among the Polytechnic, Pori university units and PrizzTech Ltd (see e.g. Ahmaniemi *et al.*, 2001; Poijärvi-Miikkulainen, 2004; Satakunta Visio, 2010).

Seinäjoki features

The Seinäjoki University Filial Centre is among the latest 'university filial centres', as it was officially founded at the beginning of the year 2004 (Kinnunen *et al.*, 2004) although the first academic institution in the region was already established in 1981. The centre was formed out of *four already existing branch units* in the Seinäjoki region and one university expanding its functions around that time. The Centre is co-ordinated by the oldest partner in the consortium, the University of Tampere. By the end of year 2004, it had 130 staff members, 55 degree students and over 4,150 other students. The aim of the Centre is to co-ordinate the traditional university tasks (research, education and the 'third strand' activities). The EPANET network was expected to fill many gaps in the applied research resources of the region caused by the lack of research traditions and absence of any independent (particularly technical) university. In contrast to Pori, Kokkola, Kajaani and Mikkeli, the leaders in development agencies and municipalities in the Seinäjoki region put major emphasis on applied research. Therefore, EPANET is the main research activity under the University Filial Centre 'umbrella' and the main research 'community' in South Ostrobothnia.[11]

Organizational innovation in Seinäjoki town region – creating a research community

There is in the Seinäjoki region a new effort to create a higher educational and research network. The network, *South Ostrobothnian University Network* (EPANET), is a co-operation network of the above-mentioned six Finnish universities in the Seinäjoki region. The core of the network is a loosely organized group of fixed-term research professors, who in their turn have gathered a group of researchers around themselves, but all have their 'home base'[12] in South Ostrobothnia and most of them in Seinäjoki. By the end of 2005, there were around 15 full-time professors (research chairs), around 40 other researchers and around 50 PhD students and 38 undergraduates in the EPANET network. The EPANET research programmes contribute mostly to applied research work in the fields of research and universities as follows: information technology applications, economics and business administration, food technology, regions and welfare and more industry-specific topics.

The EPANET research network has formed a new kind of creative community working especially on themes found in the local business environment. The network is therefore largely accepted and directly invested among local companies, as the network focuses on applied research. The idea is to get a broad understanding of the characteristics and problems of regionally based industry by combining tacit knowledge with theory and by combining approaches of different disciplines. The EPANET concept aims to create a new kind of research culture in co-operation with universities, research institutes and enterprises. The idea is not to function as a direct problem-solving and research transfer institution for companies, but to merely search and find new research questions arising from traditional industries and local knowledge sharing culture in agriculture, foodstuff, forestry, machinery, furniture, carpets, therefore a functioning source of local buzz. Although the network is strengthening the institutional academic infrastructure in South Ostrobothnia by allocating new knowledge and relational resources and forming a new type of research community. So far, through EPANET and other related processes, (a) faith in the future has been strengthened, (b) an enormous discussion about research and innovation in firms has been raised, (c) positive curiosity towards South Ostrobothnia in Finland has been aroused, and (d) a new type of interdisciplinary and inter-university research community has been born.

Concluding remarks

The aim of this chapter was to raise the understanding of creating and intensifying linkages with the universities through regionally new types of knowledge hubs in six Finnish LFRs. How the innovation environment in these LFRs was created and strengthened was presented in this chapter as a development path which *brings knowledge into* the town region. This was done by (a) inducing universities to found new units and creating university filial centres (institutions) and by (b) creating shared arenas (public spaces and networks).

The idea of university filial centres has formed gradually and almost simultaneously at the national level and the regional level. In spite of the differences between the academic institutions in their interests in different regional strengths, their timing in starting the outreach activities was quite similar. The connections to national higher education have been (perhaps surprisingly) close during the 35-year history of university education in Lahti, Pori and Seinäjoki. All actions taken in these regions were rapidly reflected and sometimes rejected at the national level. National science and technology policy initiatives and the EU membership in 1995 made the somewhat dispersed structure favourable also for the campus universities. On the one hand, the movement of establishing branch units in regions which had growing markets for academic education, and on the other hand, the capability to reach new sources of funding from the EU and Finnish Structural Funds became a new possibility for campus universities. This phenomenon underlined with societal, political, economic and cultural changes combined with increased challenges of globalization formed the local institutional processes and the evolutionary processes, in the course of which essential knowledge was achieved, created and cumulated. The timelines of these activities in the University Filial Centres are presented in Figure 8.3.

The outcomes and orientations among university filial centres varied. For example in Mikkeli, *the idea of regional development* has been strongly supported by the Filial Centre. Setting up of a loose university consortium started already in the year 2000 under a specific 'Regional Centre Development Programme' process. Under that regionally oriented programme (and because the 'spirit of time' guided so) the representatives of branch units, local authorities, polytechnic representatives and local business leaders realized the importance and the opportunities of strengthening the internal collaboration between several interest institutions

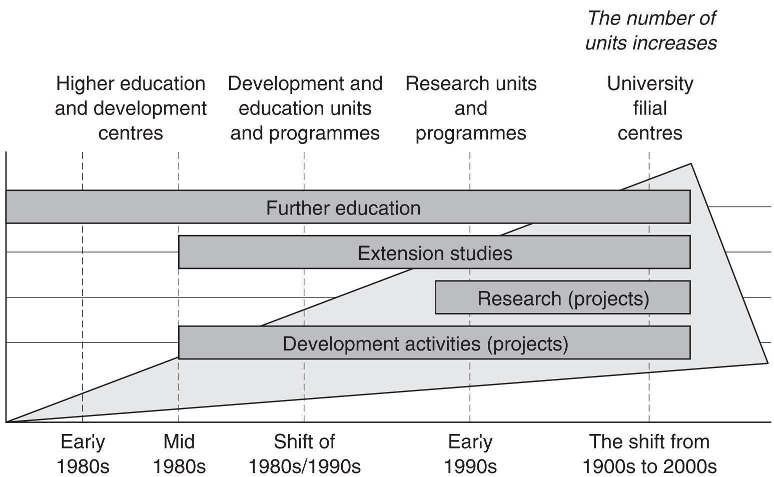

Figure 8.3 The timeline of academic activities in university branch units in Pori and Seinäjoki town regions.

and units at the local and regional levels. Despite separate interests, the common goal of the region was accepted as a part of the involved universities as well. Some of them, mainly the University of Helsinki and the Lappeenranta University of Technology experiment on such educational practices, fields of applied research, collaboration practices and partnerships in Mikkeli, which experiments are very slow to actuate in the universities' home bases in Helsinki and Lappeenranta.

In Pori the leaders put emphasis on *the wider higher education network* – research was seen as a 'logical outcome' of the investments in university units and the Pori University campus. In fact, the R&D capabilities in both pillars of local knowledge creation system vary significantly by field and both work on overlapping themes in the above R&D categories. Basically, however, the Pori University Filial Centre is an educational unit, even though it has been able to introduce organizational innovations with possibilities of joint education and cross studies between separate academic institutions.

In Seinäjoki, however, the focus was different. The academic as well as wider development network put emphasis on the *EPANET research community*. Epanet is an *organizational broker*; through EPANET many difficult borders and barriers between universities, between universities and polytechnic, between business and universities have been overcome. In reality, it was EPANET that was able to induce five universities to be more actively involved in the economy of South Ostrobothnia region. In addition, EPANET has been able to transcend disciplinary borders by creating a research community of researchers from different disciplines and universities. EPANET has also been able to induce important firms in the region to fund research professorships and therefore also to participate in more in-depth discussions on knowledge, innovation, applying new technologies, for example. Thus EPANET professors and their research groups are also expected to connect the 'academic wasteland of Finland' (Seinäjoki) to the main scientific centres of Finland and beyond, and in that way to channel information to and from South Ostrobothnia.

Along with these examples, it can be claimed that, in less-favoured regions, university filial centres and research communities may constitute common knowledge arenas and forums for local buzz as well as a testing base for new organizational innovations, but as such are less likely to be introduced in the main campus cities. In spite of the obvious success in creating and putting together the EPANET concept and network and getting funding for it, further questions remain to be raised: is it realistic to expect that the EPANET and similar kinds of locally embedded research communities generate enough 'local buzz' for unlocking the knowledge environment of a typical Finnish LFR and enable it to link itself to worldwide knowledge networks? Are the EPANET and similar communities capable of functioning as relay links in global networking?

Notes

1 The knowledge-based economy is an economy in which the base of knowledge evolves institutionally, and the biggest portion of the economy may be described as knowledge-intensive. The institutional evolution actualizes itself by linking different kinds of

knowledge-creation institutions to the knowledge-exploitation organizations and sub-systems through new kinds of knowledge-enhancing mechanisms, and mainly from R&D conducted in relation to regional capabilities (Cooke and Leydesdorff, 2006).

2 The 'Local Innovation Systems' Project (LIS, 2002–2005) investigated cases of actual and attempted industrial transformation in about 23 locales in the United States, Finland, Japan, the United Kingdom, and Norway. Additional research has been carried out in Ireland, India, Taiwan and Israel. The study addressed a central issue now confronting industrial practitioners and economic policymakers throughout the world: How can local economic communities survive and prosper in the rapidly changing global economy? Therefore the LIS Project aimed at developing new insights into how regional capabilities can spur innovation and economic growth and how to develop new models of innovation-led industrial development. The research partners of the Project consisted of an interdisciplinary team of faculty, graduate students and research staff at the following research groups and institutions: MIT Industrial Performance Center (USA), Sente, Research Unit for Urban and Regional Development Studies, University of Tampere, (Finland), Helsinki University of Technology, (Finland), Center for Business Research, University of Cambridge, (UK), Rogaland Research Institute, (Norway). The study of Pori and Seinjoki regions are two of the total 23 case studies.

3 'Buzz' is used to refer to the information and communication ecology created by face-to-face contacts, co-presence and co-location of people and firms within the same industry and place of region (Storper and Venables 2002; see also Bathelt *et al.*, 2004).

4 University consortiums in the Finnish context.

5 Upper secondary schools, vocational schools and colleges, polytechnics or universities. Source: ICT Cluster Finland Review 2005.

6 The Finnish way to express the new organizational mode is to call it 'the university consortium'.

7 Source: University Filial Centres and the forthcoming report by Palmenia/Helsinki University. The official statistics do not know the term university filial centre so far. The students, personnel and outputs are listed under the respective campus university statistics.

8 In the year 2001, the Academy of Finland funding covered 14% (€112 million) of the budget; Tekes allocated a total of €381 million to R&D. Most of that funding was channelled to companies, but for the university sector Tekes allocated nearly €80 million (Rantanen, 2004, KOTA database, Ministry of Education).

9 In Finland, higher education is in principle free of charge for the students; the costs are covered by general taxation.

10 Table 8.3 is based on the author's subjective view based on discussions with the representatives of filial centres, written material and statistics of the stressed focuses in the filial centres activities. For example, if there are five universities involved in the Centre and only one institution highlights the importance and influence of the research or regional development, but all institutions highlight the importance of degree education, the general point for the Centre is the 'focus on education'.

11 See Sotarauta *et al.*, 2002; Sotarauta and Kosonen, 2003, 2004.

12 When the nominations of professorships are confirmed, the home base will be mentioned and entered.

References

Amin, A. and Thrift, N. (1995) 'Globalization, Institutional "Thickness" and the Local Economy', in P. Healey, S. Cameron, S. Davoudi, S. Grahm and A. Madani-Pour (eds) *Managing Cities: The New Urban Context*, Chichester: John Wiley & Sons Ltd, pp. 91–108.

Ahmaniemi, R and Setälä, M. (2003) Seinäjoen ammattikorkeakoulu – alueellinen kehittäjä, toimija ja näkijä. Seinäjoen ammattikorkeakoulun raportteja ja selvityksiä B 15. (Seinäjoki Polytechnic – the regional generator, actor and seer.) Seinäjoki Polytechnic, Seinäjoki.

'Ahmaniemi, R., Kautonen, M. and Tulkki, P. (2001) *Tietointensiiviset yritysverkostot Porin alueella*, Working Papers 63/2001, Work Research Centre, Tampere: University of Tampere.

Bathelt, H., Malmberg, A. and Maskell, P. (2004) Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation. *Progress in Human Geography*, Vol 28(1), pp. 31–56.

Camagni, R. (1991) 'Local? Milieu?, uncertainty and innovation networks: towards a new dynamic theory of economic space', in R. Camagni (ed.) *Innovation networks: spatial perspectives*, London: Belhaven Press, pp. 121–43.

Cooke, P. and Morgan, K. (1998) *The Associational Economy: Firms, Regions and Innovation*. Oxford: Oxford University Press.

Cooke, P. and Leydesdorff, L. (2006) Regional Development in the Knowledge-Based Economy: The Construction of Advantage. Introduction, in P. Cooke and L. Leydesdorff (eds) The Knowledge-Based Economy and Regional Development. Special issue of *The Journal of Technology Transfer*, Vol 31(1), pp. 5–15.

Goddard, J. (1999) 'Korkeakoulut ja aluekehitys – yleiskatsaus', in A. Vähäpassi and S. Moitus (eds) *Korkeakoulut alueidensa vetureina. Viisi näkökulmaa vaikuttavuuteen*, Korkeakoulujen arviointineuvoston julkaisuja 2. Helsinki: Edita.

Goddard, J., Asheim, B. T., Cronberg, T. and Virtanen, I. (2003) *Learning Regional Engagement. A Re-evaluation of the Third Role of Eastern Finland Universities*. Publications of the Finnish Higher Education Evaluation Council 11. (Korkeakoulujen arviointineuvoston julkaisuja 11:2003.) Helsinki: Edita.

Grabher, G. (2002) Cool Projects, Boring Institutions: Temporary Collaboration in Social Context. Introduction for a Special Issue. *Regional Studies*, Vol 36, pp. 245–62.

Healey, P., de Magalhaes, C. and Madanipour, A. (1999) 'Institutional Capacity-Building, Urban Planning and Urban Regeneration Projects', in M. Sotarauta (ed.) *Urban Futures. A Loss of Shadows in the Flowing Spaces?* Futura – a Quarterly Magazine of Finnish Society for Futures Studies, Vol 18(3), pp. 117–37.

Henry, N. and Pinch, S. (2001) Neo-Marshallian nodes, institutional thickness, and Britain's "Motor Sport Valley", thick or thin? *Environment and Planning A*, Vol 33(7), pp. 1169–83.

ICT Cluster Finland Review (2005) *A Finnish Information Society Review*, Helsinki: TIEKE Finnish Information Society Development Centre. Available at: www.e.finland.fi and www.tieke.fr.

Kautonen, M. and Sotarauta, M. (1999) *Seinänaapurien innovaatio-ohjelma* (The Innovation Programme of Seinäjoki Sub-region). Seinänaapurit. Seinänaapurien kumppanuusyhteisö. Seinäjoki.

Kinnunen, J. Eskelinen, H., Lehto and Karjalainer–Jurvelin, R. (2004) *Etelä-Pohjanmaan korkeakouluverkost EPANET? enemmär kuir yliopistokeskus. Arviointiryhmäm raportti* (in Finnish). Tampere, Finland: Tampere University Press.

Korkeakoulutieto (2002) *Quarterly Magazine of Finnish Ministry of Education*, Number 1–2002.

Lambooy, J. (2004) The Transmission of Knowledge, Emerging Netwoks, and the role of the Universities: An Evolutionary Approach. *European Planning Studies*, Vol 12(5), pp. 643–57.

Landabaso, M., Oughton, C. and Morgan, K. (1999) Learning regions in Europe: Theory, policy and practice through the RIS experience. Third International Conference on Technology and Innovation Policy: Assessment, commercialization and application of science and technology and management of knowledge, Austin, USA, 30 August–2 September.

Lundvall, B-Å. (1996) *The Social Dimension of The Learning Economy*, DRUID Working Paper No. 96–01. Danish Research Unit for Industrial Dynamics. www.druid.dk.

Lundvall, B-Å. (2002) *The University in the Learning Economy*, DRUID Working Paper No 02–06. Danish Research Unit for Industrial Dynamics. www druid.dk.

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*, Vol 6(2), pp. 117–29.

Maskell, P. and Malmberg, A. (1999) The competitiveness of firms and regions ubiquitification and the importance of localized learning. *European Urban and Regional Studies*, Vol 6(19), pp. 9–25.

Morgan, K. (1997) The Learning Region: Institutions, Innovation and Regional Renewal. *Regional Studies*, Vol 31(5), pp. 491–503.

Ministry of Education 28: 2001. *(Korkeakoulujen alueellisen kehittämisen työryhmän muistio. 2001. Opetusministeriön työryhmien muistioita 28:2001).* Helsinki: Ministry of Education.

Ministry of Education 17: 2004. *(Koulutus, tutkimus ja työllisyys. Valtion tiede-ja teknologianeuvostolle laadittu seurantaraportti).* Helsinki: Ministry of Education.

Moulaert, F. and Sekia, F. (2003) Territorial innovation models: a critical survey. *Regional Studies*, Vol 37(3), pp. 289–302.

Oinas, P. and Malecki, E. (1999) 'Spatial Innovation Systems', in E. Malecki and P. Oinas (eds) *Making Connections. Technological Learning and Regional Economic Change*. Aldershot: Ashgate, pp. 7–33.

Poijärvi-Mükkulainen, J. (2004) Porin Yliopistokeskuksen alueellinen vaikuttavuus (in Finnish). Publications A, number A5/2004. Pori: Turku School of Economics and Business Administration.

Rantanen, J. (2004) Yliopistojen ja Ammattikorkeakoulujen tutkimuksen rakenneselvitys, *Opetusministeriön työryhmämuistioita ja selvityksiä* 2004:36, Helsinki: Opetusministeriö.

Satakunta Vision 2010 (2003) Rauna Chamber of Commerce, Satakunta Chamber of Commerce, and the Regional Council of Satakunta (in Finnish). Swot Consulting, 3 March.

Sotarauta, M., Hukkinen, J., Bruun, H. and Linnamaa, R. (2002) 'Observations and Policy Recommendations. Nordic Regional Development Policy in Search of New Modes of Action', in M. Sotarauta and H. Bruun (eds) *Nordic Perspectives on Process-Based Regional Development Policy*. Nordregio report 2002:3. Stockholm.

Sotarauta, M. and Kosonen, K-J. (2003) *Institutional Capacity and Strategic Adaptation in Less Favored Regions: A South Ostrobothnian University Network as a Case in Point*. MIT IPC Local Innovation Systems, Working Paper 03–003.

Sotarauta, M. and Kosonen, K. (2004) 'Strategic adaptation to the knowledge economy in less favoured regions: A South-Ostrobothnian university network as a case in point', in P. Cooke and A. Piccaluga (eds) *Regional Economies as Knowledge Laboratories*. Cheltenham, UK: Edward Elgar.

Sotarauta, M., Linnamaa, R. and Suvinen, N. (2003) *Tulkitseva kehittäminen ja luovat kaupungit. Arvio Tampereen mahdollistavasta mallista ja osaamiskeskusohjelmasta*. Alueellisen kehittämisen tutkimusyksikkö – Sente ja Tekniikan Akateemisten Liitto TEK ry. Sente-julkaisuja 16/2003. Tampere: Tampereen yliopisto.

Storper, M. (1995) The Resurgence of Regional Economies, Ten Years Later: The region as a nexus of untraded interdependencies. *European Urban and Regional Studies*, Vol 2(3), pp. 101–221.

Storper, M. and Venables, A. (2002) 'BUZZ: The Economic Force of the City', paper presented at DRUID Summer Conference on Industrial Dynamics of the New and old Economy – who is embracing whom?', Copenhagen/Elisnore, 6–8 June. www. druid.dk

Tura, T. and Uotila, T. (2005). 'Rethinking the Roles of Universities and Polytechnics in a Regional Innovation Environment'. Paper presented at the 45th European Congress of the Regional Science Association (ERSA). Amsterdam, the Netherlands.

Universities 2004. Annual Report. Ministry of Education publications 2005:13. Ministry of Education (of Finland). Department for Education and Science Policy. Printed by: Yliopistopaino, Helsinki, 2005.

Virkkala, S. (2003) *Oppiva alue käsitteen tausta ja sovelluksia alue- ja maaseudun kehittämisessä*. ChyNetti nro 31, Chydenius-Instituutin verkkojulkaisuja. Jyväskylän yliopisto, Chydenius – Instituutti. Kokkola: Jyväskylän yliopisto.

Virtanen, I. (2002) Yliopistojen kolmas tehtävä. Polemia-sarja, Nro 44. Kunnallisalan kehittämissätoö. Vammala.

9 Economic growth in emerging knowledge-intensive areas

The high-tech cluster in Pisa[1]

Alberto Di Minin, Michela Lazzeroni and Andrea Piccaluga

Introduction

The aim of this chapter is that of describing and discussing the growth model of a high-tech (HT) cluster in a non-central, emerging area in Central Italy, which is also characterized by the presence of both medium- and low-tech traditional manufacturing sectors, and important higher education and scientific research public structures. Within a consolidated stream of literature regarding local and regional case studies, we argue that some of the characteristics of the model observed in the area of Pisa, such as the type of interactions among companies and between companies and local institutions, the knowledge and technology transfer process, specific localization dynamics and network relations offer some relevant insights. The analysis has been carried out with a quantitative approach which has been integrated with qualitative analyses. Detailed studies are in fact needed to understand strengths and weaknesses, factors of competitiveness and reasons of expansion and decline of a HT cluster. We argue that such contributions are particularly useful in a period in which the debate about the birth and development of HT clusters or technological districts is often based on insufficient theoretical background and incomplete empirical evidence. The case which is here analysed might represent an interesting example of the opportunities and problems which arise in non-central areas with strong endowments in science and technology.

This chapter is divided into three parts. In the first one, the model is presented and described in relation with other models discussed in the literature, in particular those dealing with a local HT-led growth process. Different approaches to the study of local technological transfer dynamics and concentration of knowledge-intensive activities are also introduced and discussed. The second part deals with the analysis and interpretation of the HT sector in Pisa. Specifically, four different types of HT firms are identified and discussed in relation to three distinct stages of development of the local economy. The third part of the paper tries to identify general characters of the Pisa case with regard to both its strengths and weaknesses, and the application of a similar approach for the study of other knowledge-based areas.

High-tech development in emerging regions in Italy

HT-based growth processes have been among the most studied topics by regionalists and economists in the last few decades. The result is an impressive amount of models, methods of analysis and case studies, with the objective of capturing the phenomenon and its crucial components. Political authorities in both developed and emerging economies have clearly identified HT activities as strategic assets to monitor and promote, although it is generally believed that no short-term normative recipes are available to achieve HT-based economic growth. The role and importance of HT for local economies has been vastly discussed. Previous studies, such as Storey and Tether (1998), empirically supported the claim that high-tech sectors in advanced economies are likely to experience faster employment and income growth rates. Also, dynamic small HT-based firms might play an important role by linking different sources of knowledge creation, such as universities and industry, in a way not feasible for large corporations (Autio and Yli-Renko, 1998). In some cases, such as in biotech, this is explained by the nature and intrinsic complexity of the technology and the research (Jones, 1992). In these cases, large companies integrate, in their strategic behaviour, the presence of small companies, in the early phases of commercialization (Arora and Gambardella, 1990). Recent trends regarding an increase in R&D outsourcing towards small firms confirm the relevance of small HT businesses (Cooke, 2005).

Empirical findings, such as Carlino (2001), showed that HT clusters are likely to be present in metropolitan areas, which are likely to attract talents, or in the proximities of leading public and private R&D centres (Bade and Nerlinger, 2000). The present study tries to contribute to that part of the economic literature which has identified similarities and differences between HT concentrations/clusters and industrial districts, as known in the Italian experience, i.e. clusters of firms operating in traditional sectors in a relatively limited and well defined territory. The works of Piore and Sabel (1984) and Sabel (1993), among others, showed to the international research community the particular nature of Italian industrial districts. Regional social capital was also found to be positively correlated with faster technical knowledge growth and competitiveness of HT companies (Yli-Renko *et al.*, 2001). By shifting the focus of the analysis from agglomerations to networks, researchers were able to show that the knowledge/awareness of resources available in the network became itself an important resource, to be coupled with internal capabilities, for HT firms (Lee *et al.*, 2001). A more qualitative approach is therefore necessary to analyse and interpret interactions between firms and their environment. The dynamics of cooperation and relational capabilities of cluster actors are considered as necessary conditions for intense circulation of knowledge. From this point of view, Maskell (2001) emphasizes the fact that clusters represent a development model which is both spontaneous and organized, which contributes to decrease cognitive distances among firms, favours knowledge transfer and use, as well as knowledge production. Examples of these types of approaches focus on the advantages that spring from the agglomeration/clustering of activities in a particular sector, within the borders of a regional economy, such as biotech in Cambridge (Cooke, 2002: 146) or Silicon Valley (Saxenian, 1994).

Nevertheless, in regional economies characterized by the dominance/monoculture of one or a few successful 'traditional' industrial sectors, the transition to new HT-based excellence – which seems very often a sort of an obliged path, given current international competition from emerging countries – is not so obvious. Some of the areas which are planning or experiencing such transition can be considered emerging or newcomers with respect to traditional hubs of science, technology and innovation. Gambardella (2003), in his analysis of new technological districts in emerging countries, emphasizes some 'ignition' factors, such as the supply of labour force in science and technology and investments in education by the public system.

This represents both the incentive to consider new technologies as a gateway for a new centrality and growth, but also an obstacle that policy makers in less favoured places need to consider in order to secure the efficacy of their efforts.[2]

Italy is traditionally included among the most important players in the world economy, despite being a country which traditionally lags behind in R&D investments, mainly because of the large numbers of small and very small firms, and the small number of large R&D-based companies. Also, the Italian public research system has a good scientific reputation and performance in terms of number and quality of publications and in the education of qualified human resources. Italy's main weaknesses consist of the relatively low number of researchers, the limited number of large science-based corporations and the fact that the technology transfer processes from university to industry is not as intense as experienced elsewhere in both Northern Europe and the US.

In her contributions Markusen (Markusen, 1996; Markusen *et al.*, 1999) shows that mid-sized cities are characterized by different possible configurations of industrial districts and HT clusters. We here attempt to position Pisa with respect to other examples of areas which are experiencing HT-led growth in Italy.[3] In an attempt to contribute to the already vast literature on this topic (for example, Lawton Smith, 2000) we propose four categories for HT-based development in non central, emerging regions in Italy.

1 *Non metropolitan areas, often medium-sized university cities, where the public sector has heavily invested in scientific research.* In these contexts HT firms are likely to be set up, in many cases as spin-off initiatives from public research centres; also, established firms may be attracted in the area by the abundance of qualified human resources, often in the same sectors of specialization of public laboratories. The case of **Pisa** falls into this first category.
2 *Areas where a significant private investment, usually by one or a few large technology-intensive companies, has promoted effective interactions with and exploitation of existing areas of excellence in local public scientific research.* The most typical case in Italy is **Catania**, where investments by STMicroeletcronics (Stm) exploited and

further strengthened significant positive competencies in the local public research system in the field of physics (Schillaci *et al.*, 2000; Torrisi, 2002).

3 *Areas which are not historically characterized by relevant entrepreneurial or industrial traditions, and where previous public investments in research have determined more recent private investment and the development of an HT cluster.* The relative importance of private and public investments in these cases is debatable, as for example is the development of the **Cagliari** ICT cluster. In the Cagliari case, public investments in the CRS4 project seems to have had a positive influence on the setting up of Video on Line and well known Tiscali (Ferrucci and Porcheddu, 2002 and 2004).

4 *Areas where the concentration of firms in a new specific technology-based industrial sector has reached a critical mass without relevant contributions from public research and thanks to the action of a sort of Schumpeterian innovator and the involvement of larger firms from external areas and from abroad.* In these cases, high or mid-tech activities were established in areas which were relatively poor in terms of scientific and technological know-how, but with a strong and established entrepreneurial culture. Examples are the bio-tech clusters in **Mirandola** (Lipparini and Lomi, 1999) and the packaging district around **Bologna**. In the first case, the entrepreneurial initiative of Mauro Veronesi in the 1960s started a process which has later led to the creation of about 100 firms. In the second case, a crucial element has been the leadership role of the firm Acma.

These typologies and cases show that knowledge-based development can be pursued in different ways in non-central, emerging areas. For example, some non-central locations offer advantages (or overcome disadvantages) that more traditional centres are not able to offer. Also, a small or medium-sized city willing to encourage knowledge-based development processes might enjoy the advantage of being able to concentrate its (human and financial) resources on specific sectors. At the same time, the dimensions of the local market, the business community and the scarcity of some production factors (such as qualified labour or capital) might represent bottlenecks for the development of an HT economy.

Today, Italy is in a particular international competitive position. On the one hand, the country faces competition from advanced economies which are investing heavily in R&D and are able to impose their technological leadership in international markets. On the other hand, emerging economies are becoming good quality manufacturers themselves (beyond being much less expensive) and also represent alternative locations for qualified private investments, due to the presence of a skilled and cheap labour force and political environments which are very open towards foreign direct investment (and technologies). Betting on the HT development of Italian emerging areas might indeed seem an interesting albeit risky alternative. Policies launched by the public sector could be aimed at overcoming some of the disadvantages which characterize non central locations, which might represent an obstacle for private investors.

As a matter of fact, the case of Pisa shows problems and opportunities that an economy based on small firms in mature sectors faces in the transition towards an HT-based model, and the creation of new linkages between research and territorial development.

The city of Pisa: in search of an HT identity

The evolution of the local economic system and the rise of the HT sector in Pisa

According to census data, in 2001 the province of Pisa had 384,555 inhabitants (89,694 of which within the city limits), 32,871 firms employing 144,291 workers (of these, 8,364 firms employing 42,080 workers were located within the city limits).

Since the 1960s, the manufacturing sector has been predominant in the area. In 1971 almost half of the population was working in the secondary sector. Since then, the province has experienced a gradual decline of its manufacturing specialization, and a progressive movement towards a post-industrial society. During the 1980s the tertiary sector became the predominant one. New activities, more or less integrated with the old ones, changed the types of production, and became the new drivers of a changed local economy.

The traditional manufacturing specializations for the province of Pisa are the leather and shoe industry (in Santa Croce and surrounding towns), the light motorcycle industry (around the Piaggio company in Pontedera) and the wood and furniture sector, which have gone through serious crises and deep changes. Another important resource for the local economy is tourism. Among the HT sectors, the pharmaceutical industry has been present in the province for many decades, and ICT is the sector in which more than half of high-tech companies operate.

The most recent change for the local economy is linked to the presence and dynamism of the three local universities (University of Pisa, Scuola Normale Superiore, Scuola Superiore Sant'Anna), several public research centres (CNR, INFN, INFM), and other technology transfer institutions (Consorzio Pisa Ricerche, Consorzio Qualital, Polo Tecnologico di Navacchio, Pont-Tech, etc.). About 50,000 students are enrolled in the University of Pisa, 3,800 people are directly employed by the local university system and about as many work as research collaborators with contract positions. Numerous HT firms started up in or relocated in Pisa because of linkages with the local universities or because they were attracted to the city due to this important scientific and technological endowments. In particular, ICT, electronics, machine tools, and pharma are the sectors that experienced a significant development (Varaldo, 1991). The following three phases describe the development of these industries since the mid-1950s (Bellini *et al.*, 1998).

Birth and innovative growth (1955–1980)

In this phase Pisa was in a very favourable position to exploit the extraordinary investment in IT by the local public research system. Large companies, such as

Olivetti and IBM, decided to invest in Pisa in order to have privileged access to the scientific results of local academics. However, these investments, as well as the setting up of smaller IT companies, remained an important but rather isolated phenomena, not linked to the rest of local manufacturing activities which at that time were far more important for the area in terms of total employment.

Consolidation and stability (1980–1995)

This phase is characterized both by a consolidation of competencies in the IT field and by a diversification of research and private industrial actors in other scientific and technological fields, such as mechatronics and life sciences. Attention towards technology transfer activities greatly increased, despite the fact that various initiatives were launched without a single, widely accepted plan for the area. Tertiary activities were increasingly considered as possible complements to, or even substitutes for more consolidated and declining manufacturing sectors. Spin-off companies, and small HT start-ups replicated the 'dual system' of a few big firms and a large group of small companies which was already present in other traditional sectors in Pisa.

Clustering and restart (1995–2004)

In this phase the area of Pisa is widely recognized as an important high-tech cluster, and the valorization of research results by public research grows. Awareness of the importance of knowledge-based development increases at both regional and local administrative levels. The HT community diversifies and opens up to sectors such as the medical-pharmaceutical, electronics, micro-electronics, and telecommunications. Growth rates show rapid increase in both the number and the turnover of high-tech businesses, despite the general crisis after 1999. The funding of technology parks and incubators in the province of Pisa leads to a spatial diffusion of what used to be a mainly urban phenomenon. The economic and socio-political weight of the HT community further increases, as the mission of a knowledge-based area more widely accepted, but general attention by policy makes is often more attracted by mature rather than HT sectors.

Public research and advanced education in Pisa

Pisa can be described as a typical mid-sized university town, characterized by a vibrant research system, with an outstanding public research base and a well-developed education and training system. The city is the birthplace of IT in Italy since when, in 1955 a team of professors built the first Italian computer, called CEP (Pisa Electronic Calculator). This machine, completely made in Italy, was one of the most advanced computers at that time. After this project, the importance of the IT sector in the city further increased. CNUCE, a university national institute for IT, and the first school of computer science in an Italian university were set up respectively in 1964 and 1968.

At present the university system in Pisa has a remarkable capacity to attract students. The number of students is impressive for a city with less than 100,000 inhabitants (Table 9.1). They are an important source of qualified labour, since many of them wish to remain to work in Pisa, and this potentially represents an important advantage that the city has, when compared to other non-central areas, for the attraction of HT investments. Almost half of the students graduate from scientific or engineering departments, a figure which is far above the national average.

The potentialities shown in the description of the scientific system are confirmed by the analysis of some indicators – including some output indicators – which weight Pisa superior to the rest of Italy (Figure 9.1).

Table 9.1 Composition of the university population in Pisa compared to the two other university cities in Tuscany, to Tuscany and to Italy

	Students (2001)	*Students per 1,000 inhabitants*	*Number of students graduated (2001)*	*Students graduated in scientific-technology studies*	*Students graduated in scientific-technology studies (%)*	*Students graduated in engineering (%)*
Pisa	46,659	122.4	4,600	2,173	47.2	19.2
Florence	58,383	62.9	5,357	1,571	29.3	9.8
Siena	18,943	76.6	2,430	644	26.5	2.9
Tuscany	123,985	35.8	12,387	4,388	35.4	11.9
Italy	1,702,029	30.2	173,710	56,280	32.4	12.2

Source: MIUR, www.miur.it.

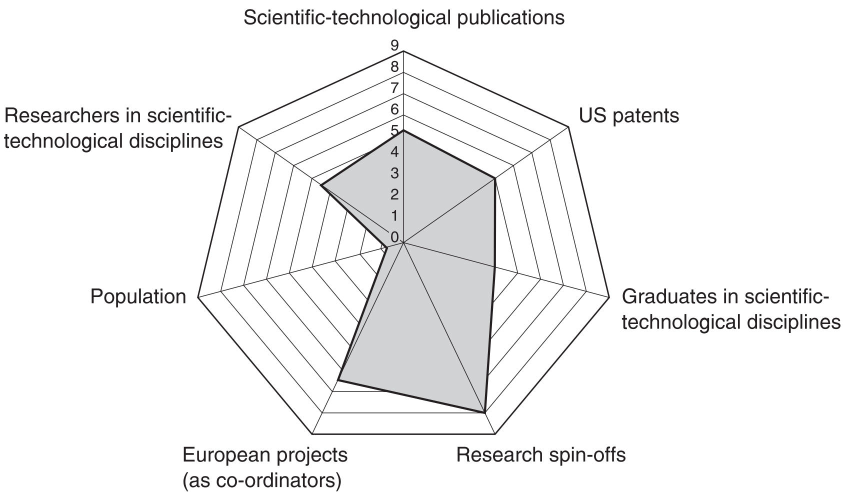

Figure 9.1 The relative weight of the province of Pisa in Italy (in percentage) (Lazzeroni, 2004).

In fact, despite its small population, Pisa has more than 4% of total Italian researchers, more than 5% of total scientific-technological publications, more than 5% of US patents assigned to Italian organizations, approximately 4% of the people with a scientific-technological degree, more than 8% of the total number of research spin-off firms, and more than 6% of EU research projects with an Italian organization as coordinator.

Pisa has also experienced important cases of spin-off activities from public research. In the late 1980s Scuola Sant'Anna began a series of activities which have so far resulted in 16 spin-off firms headed by professors and/or students in robotics, mechatronics and IT. Scuola Sant'Anna, Piaggio and the provincial and city local administrations have also promoted the launch of a new company, Pont-Tech, to encourage technology venture development in the area. A technology incubator, funded by local governments and the EU, in the town of Navacchio has been set up in a former factory. Initiatives such as the Pisa Research Consortium seek to provide support for technology transfer projects to existing firms, or to promote quality management practices, as in the case of Qualital (established in 1988). Nonetheless, despite this presence, according to quantitative research (Counts and Di Minin, 2003) and to academic and political observers, there is agreement on the fact that the quality, volume and consistency in time of the local public research effort is not fully exploited. In other words, the growth of S&T-based businesses as well as the contribution of the HT sectors to local GDP is not the one which could be expected in an area where investments in R&D have been so high for many years.

The characteristics of the HT sector in Pisa

In search of an explanation for the current situation, we will now summarize the recent developments of the Pisa economy, focusing in particular on recent fluctuations in the HT sector, during what we have defined as the *clustering and restart* phase. The present analysis is based on data collected through a survey of high-tech firms located in the province of Pisa.[4] In presenting the data, it is important to keep into account the cyclical fluctuations which have characterized recent years in HT sectors at international level. Such a transitory phase continues and, where possible, we present data from our base years: 1999, 2001 and 2003, thus covering the peak of the expansion and part of the IT crisis.

At present (Table 9.2) half of the HT firms in Pisa operate in the IT sector. The following table shows the composition of the industry.

According to Observatory data, at the end of 2003 the area was characterized by the presence of 229 high-tech companies, with a turnover of €1.4 billion, and an employment of approximately 6,400 – mostly highly qualified – people. The so-called 'IT distribution' and pharmaceutical sectors are the largest in terms of turnover, accounting for respectively 55% and 23% of total revenues.[5] Also, within the HT sector, it is possible to observe a dualism between small firms and big companies. More specifically, 75% of the HT companies in Pisa employ less than 30 people. The IT sector is dominated by firms which employ an average of

Table 9.2 Distribution of HT firms in Pisa

Industry	*Number of firms*		*% of total firms*	
	2001	*2003*	*2001*	*2003*
IT services	62	57	29.7	24.9
IT R&D	46	56	22	24.5
Innovation management	27	25	12.9	10.9
Mechanics and electronics	22	21	10.5	9.2
Energy and environment	9	15	4.3	6.6
Telecommunication services	6	9	2.9	3.9
Microelectronics	9	6	4.3	2.6
Pharmaceutical	7	7	3.4	3.1
Telecommunication R&D	6	7	2.9	3.1
Biomedical	3	6	1.4	2.6
IT distribution	2	1	1	0.4
Other	10	19	4.8	8.3
Total	209	229	100	100

Source: Observatory on HT companies in the province of Pisa, 2005.

12 people per company, while the average in the pharmaceutical sector is 208 employees per firm.

For the IT sector 2001 was the peak of an extraordinary period of expansion. The inflammatory growth of the 'dot-com' boom soon revealed its flipside for the economy of the city. As the tables previously discussed show, the IT sector was particularly hit by a phenomenal downsizing after 2001. In spite of the fact that not many firms went out of business (and actually new firms were created even in the 2002–2003 period), employment declined sharply in IT. Overall, it is still possible to observe a small increase in employment, but the double digit growth rates of the late 1990s are a phenomenon of the past. The last two years, instead, were characterized by significant negative fluctuations, in particular for the IT sector.

With regard to employment (Table 9.3), during the 1998–2001 period the HT sector in Pisa experienced a significant and steady growth, and total employment grew by 62%. However, the crisis which hit IT worldwide has had the effect of reducing to a mere 7.7% total employment growth between 1998 and 2003. In particular, IT-based businesses lost most of their growth, whereas more 'hardware-based' companies managed to face the crisis with less severe employment sacrifices.

This expansion in Pisa was not simply a cyclical phenomenon. Despite the dramatic fluctuations of the last few years, the Italian Central Bureau of Statistics (ISTAT) confirms that while in 1981 the HT sector in Pisa employed 3,859 people, in 1991 this number increased by 35%. In 1996 the HT sector in Pisa was employing 5,707 persons,[6] with an average yearly growth rate of 3% over a 15-year period. In 2001, the HT sector peeked to 1,245 firms employing 7,286 employees.

Beyond quantitative aspects, important financial and governance restructuring also took place within the HT industry in the area of Pisa. Three main changes

Table 9.3 Pisa HT industries' turnover and employment (2003)

Industry	*Average number of employees*		*Average employment growth rate*	
	2001	*2003*	*(1998–2003)*	*(1998–2001)*
IT services	19.9	20.0	−0.1	86.5
IT R&D	17.3	8.5	4.3	79.4
IT distribution	137.5	192.5	n.a.	n.a.
Innovation management	6.2	8.2	13.9	5.6
Mechanics and electronics	18.6	15.1	0.6	40.3
Energy and environment	18.0	16.4	−5.5	73.3
Telecommunication services	5.3	6.7	2.3	0.0
Microelectronics	10.7	21.0	66.3	35.8
Pharmaceutical	190.2	209.0	5.3	n.a.
Telecommunication R&D	40.5	45.0	6.0	n.a.
Biomedical	7.4	9.7	9.3	n.a.
Other	49.7	62.5	6.4%	98.2%
Total	43.4	51.2	7.7%	62.3%

Source: Observatory on HT companies in the province of Pisa, 2005.

Table 9.4 Equity relationships in the HT sector (2003)

Industries	*% of companies which are part of an industrial group*	*Type of group*		
		Local group	*National group*	*Foreign group*
Pharmaceutical	57.0	–	25.0	75.0
Information technology	24.3	50.0	44.5	5.5
Total industries	27.2	34.2	50.1	15.7

Source: Observatory on HT companies in the Province of Pisa, 2005.

are worth mentioning: (1) *merging and acquisition of local companies by international corporations*, (2) *holding relationships with national companies*, and (3) *the rise of local industrial groups*.

From this point of view, the pharmaceutical sector has been by far the most dynamic one. In fact, five out of seven companies based in the province gained access to foreign capital and changed their proprietary base. In 1997 the Gentili Institute, one of the oldest pharma firms in Pisa (set up in 1917), became part of the Merck Sharp & Dohme Group. In the same year, the American company Baxter acquired the Austrian Immuno, and the UK financial group 3i took part in a family buyout operation for Farmigea in 2001; finally, two foreign companies recently invested in Pisa: the Spanish Grifols (1994) and US Abiogen Pharma (1997) (Table 9.4).

Not only the pharmaceutical sector but also other foreign groups invested in Pisa. In aerospace, Alenia Marconi System, the result of a joint venture between British Aerospace and the Italian Finmeccanica, has a research centre. In mechanics and electronics, the Japanese multinational Mitsuba and German Siemens invested in Pisa, while in the IT sector, Engisanità (previously part of the Olivetti group) was set up as a joint venture between the French group GFI Informatique, and the Italian Ingegneria Informatica; in 1997, ISL (a local IT company) was acquired by the French group Altran.

Italian corporations also invested in the area. This happened either by means of buying out local companies (such as the Espresso Group acquiring Ksolutions in IT, or Laboratori Guidotti becoming part of the Menarini Group in pharma), or the establishment of local subsidiaries in the area, such as Netikos, part of Telecom Italia, which absorbed a pre-existing Italian IT company (and was finally acquired by Etnoteam). As a result, 27.2% of the sampled IT companies and 57% of the pharmaceutical ones are now part of larger business groups.

As Table 9.5 shows, R&D investments in the sector are quite relevant, both in terms of percentage of people employed in R&D, and in terms of the share of R&D expenditure over total revenues. On average, 42% of total employees work in R&D. However, these data might overestimate the real importance of R&D in the sector, given the micro-dimensions of most of these firms, where it is quite common for R&D personnel to be also involved in other roles in the organization. Nevertheless, the workforce is generally highly qualified, usually graduated from scientific and technical schools (61.4%).

R&D is normally conducted in house rather than acquired from outside (the make/buy ratio is 70/30), but there are significant differences among sectors.

Table 9.5 Main R&D indicators

Industry	*R&D employees (%)*		*R&D Expenditures (%)*		*R&D make/buy ratio*	*Number of patents*	*Employees graduated in S&T (%)*	*Firms that have introduced technological innovations (%)*
Year	2001	2003	2001	2003	2001	2001	2003	2003
IT services	38.1	30.3	21.9	19.2	69/31	2	52.9	72.3
IT R&D	34.4	31.6	26.2	16.7	61/39	3	76.4	83.3
Mechanics and electronics	36.1	18.7	14.2	22.5	90/10	6	63.7	81.2
Energy and environment	56.7	20.7	18.3	2.5	87/13	4	80.5	100.0
Microelectronics	75	10.0	38.0	20.0	73/27	2	80.0	100.0
Pharmaceutical	12.3	8.6	4.9	6.6	52/48	2	31.2	85.7
Telecommunication R&D	36.2	38.0	16.2	33.0	28/72	0	100.0	100.0
Innovation management	12.5	65.0	10.0	65.6	N/A	1	66.7	66.7
Biomedical	N/A	69.0	N/A	N/A	N/A	2	N/A	100.0
Other	44.4	14.7	22.7	11.1	68/32	2	63.0	100.0
Total	42	33.7	20.0	19.7	70/30	23	61.4	82.0

Source: Observatory on HT companies in the province of Pisa, 2005 (total sample: 73 companies).

Table 9.6 Sources used to develop new technologies (2003)

Ways to introduce new technologies	*Frequencies (%)*			
	Never	*Sometimes*	*Often*	*Always*
In-house R&D	2.7	12.5	34.2	50.3
Collaborations with university	44.1	31.5	18.9	5.6
Collaborations with companies	28.0	50.3	19.6	2.1
R&D acquisition from the public research system	72.7	18.2	7.7	1.4
R&D acquisition from the private research system	71.3	21.7	6.3	0.7
Technology licensing	66.4	20.3	11.2	2.1

Source: Observatory on HT companies in the Province of Pisa, 2005 (total sample: 143 companies).

Outsourcing prevails in the telecommunication sector (with a make/buy ratio of 28/72), and the two vectors have equal importance in the pharmaceutical sector (make/buy ratio of 52/58).

The use of patents is still quite limited. In 2001, only 23% of the interviewed companies owned a patent or had applied for a US, European or Italian patent.

With regard to the interactions that take place within the HT sector, the presence of particularly high public research investments can be expected to strengthen networking between local HT companies and the university system. However, even if the share of HT companies that have interactions with the university is quite high (72.3% in 2003 and 76% in 2001), the frequency and intensity of these relationships are limited.[7]

According to the survey, interactions between the university system and HT firms are not based on systematically organized initiatives (like liaison offices or technology transfer partnership), but tend to be the sporadic result of personal contacts. The interactions between HT companies and universities are often related to partnerships in research projects and internships for students, but these are not the most common activities through which firms introduce new technologies. Generally, companies invest in in-house R&D for the generation of new technologies and they rarely use collaborations with universities or with other HT firms. In 2001–2003 this already small number of collaborations further decreased.

The lamented difficulties to build up strong and long-lasting networking between the university system and HT local companies have to do with the existence of different goals and time frames in the organizations' activities and goals. Also, the different size of the partners and desired scale of the projects generate significant difficulties. In particular, it is hard to set up the right incentives to convince small companies to get involved in joint R&D projects with a university. Usually, in those small companies that now systematically interact with the university, entrepreneurs had strong relationships with the academic environment even before the firm's start-up phase.

Nonetheless, high-tech entrepreneurs in Pisa recognize that the university system plays a crucial role. They expect local universities to be involved in basic research projects, to be internationally competitive, and to attract world class excellence in research. Local entrepreneurs in Pisa note that universities should

Table 9.7 Geographic location of the markets and of companies' main competitors

Geographic area	*Most important market*		*Location of the main competitor*	
Year	*2001 (%)*	*2003 (%)*	*2001 (%)*	*2003 (%)*
Province of Pisa	12.5	12.4	12.5	17.5
Tuscany	22.5	26.9	12.5	17.5
Italy	53.8	48.3	43.8	11.2
Europe	10.0	7.6	15.6	11.3
Rest of the world	1.3	4.8	15.6	12.4

Source: Observatory on HT companies in the Province of Pisa, 2005.

also be able to produce transferable results, and should be more sensitive to specific local needs.

Networking within the community of HT firms could also be more intense. In particular, what seems to be lacking is an agreed strategy to foster the development of the sector. Industrial associations are more or less active, but none of them has firmly taken a strategic leadership role. In fact, it is often argued that the full potential of the high-tech associations already present in Pisa is not fully understood and exploited.

Another important limitation of the HT community is the local dimension of the market to which local companies are selling. Thirty-nine per cent of Pisa HT companies have the province or the region as their primary market, and only 12% are mostly active in an EU or world market (Table 9.7).

The data collected by the Observatory and the large number of in-depth interviews with local entrepreneurs and researchers have allowed identification of four main clusters of HT firms. The identification was mainly based on variables such as R&D intensity, firm size, market/technology orientation, stage of development of the firm. The four clusters are 'established innovators', 'technology integrators', 'technology labs' and 'emerging innovators and research spin-offs'.

1 **Established innovators**. These are medium and large firms which spend a significant amount of resources in R&D. In most cases they have developed effective commercial strategies, and operate on large national and international markets. Collaborations with public R&D and with the national HT industrial community are considered very important and resources are deployed in that direction. Nonetheless, these firms often face difficulties in achieving effective and fruitful interactions with the local entrepreneurial community, as well as with the local public research system.
2 **Technology integrators**. These firms are specialized in the adaptation and integration of technologies which are already available on the market; their clients are local and national organizations. They usually do not invest significantly in human resources or in R&D projects for the production of new knowledge, and do not collaborate intensively with the public research system. For these firms, the interaction with other companies, both suppliers and potential customers, is critical for the definition of their market and for

the organization of the innovative process. Learning by doing and technical consultancy with clients represent strategic activities.

3 **Technology labs**. These are rather consolidated firms which do invest in R&D, but have not fully developed a market strategy able to support their efforts in the production of new technologies, and very often they are not able to identify and address new markets. Most of their clients are local. This is the category of firms that was the main player in the fluctuations of the 1998–2003 period. The significant turnover and employment growth experienced until 2001 was a source of enthusiasm for local policy makers, as these firms were able to absorb a considerable number of graduates from the local universities. The impressive contraction which followed left a slightly positive employment increase over the 1998–2003 period. Their main difficulty, at the moment, is that of extracting economic value from past and current R&D investments.

4 **Emerging innovators** and **research spin-offs**. Differently from the previous category, these are particularly young firms with a strong R&D orientation based on recent academic research. The fact that they are still closely linked with the scientific institutions where their founders come from make these firms perhaps the most promising presence in the area, since they work on technologies which are the direct result of recent academic research. As a matter of fact, however, they show a very high survival rate, but still a rather low growth rate, both because entrepreneurs are rather conservative about making relevant investments and accepting new partners, and because of a lack in VC organizations.

Apart from the first category, the three others fall within the category of so-called 'technological artisans', because of their small size, strong regional/national orientation and one-to-one relationship with customers and clients. The core business for some of these firms is technical consultancy. In the IT sector, in particular, companies assist their clients in the adoption of new technologies or software. For companies of this type, one of the main disadvantages is the lack of adequate marketing skills. In these companies, in fact, technological competence is not always coupled with the capacity to identify the most appropriate markets or clients.

Even if the Pisa HT sector offers examples of impressive innovative and R&D activities, which are successfully exported abroad by internationally oriented companies (such as Baxter, Abiogen Pharma, Netikos, Siemens, IDS), overall the firms' small size, the exclusively local (and not particularly sophisticated) market, and the lack of intense networking represent important limitations.

Another major problem for the technological development of the area is an endemic one among Italian HT communities in non-central, urban areas. Growth is sometimes limited by the lack of specialized capital, in particular venture capital. The survey showed that most HT companies in Pisa have been set up with personal resources. What has been observed is a lack of major VC organizations, but also an insufficient presence of lower scale financial instruments which could facilitate the start-up phase. The lack of such organisations – which are, however, growing in the last few years – specialized in supporting new ventures, has several negative consequences. Among these, the lack of a pre-screening activity on behalf of a specialized financial expertise increases the mortality of firms, and even when personal funds are available, the lack of resources sufficient for an expansion project lead to choices that might be too conservative and not competitive. Firms without the appropriate support of outside capital might never get out of the start-up phase. Also, the active presence of a VC leads to an important networking effect among assisted firms, which can be beneficial for local competitiveness. The already mentioned re-ordering of the ownership structure might offer a way out of this dilemma, but might open up new problems in terms of the relative weight of the local area within foreign corporate strategies.

The relationship between the HT sector and local non-HT industry

Even if the public research system has not been able to consolidate a technology transfer strategy, with a few exceptions, the survey shows the role of the university system as a *factory of entrepreneurs*. The largest majority of HT entrepreneurs graduated from the local universities, but the most striking data is that 66.7% of them were not born in Pisa, and moved to the city during their university studies. Only 25.6% moved from other cities in Tuscany, and 41% moved to Pisa from other Italian regions. The local undergraduate programmes are therefore able to attract and, to some extent, retain HT entrepreneurs.

The significant presence of public research activities leads to a relatively large *local market for qualified labour*. This is one of the most important elements that local entrepreneurs have indicated for locating in Pisa. Potentially, public labs represent important *research partners* for the largest companies. Marconi, Ericsson, Telecom and Austriamicrosystem International in the microelectronics industry, Komo Machine Inc. in mechanics and electronics, and Ital TBS in the biomedical sector have set up research facilities in the city to exploit the proximity with the local university system.

Thus, the data from the Observatory survey confirm that the role of the local university goes beyond education and research (Table 9.8). In fact, besides the place of residence of partners (average score 4.58 in a 1 to 6 scale), the availability of qualified labour (averages score 3.58) and the proximity to local universities and research (average score 3.23) emerge as HT location factors. Most local HT entrepreneurs have studied in local universities and personal reasons that influence the location in Pisa intersect with professional ones. Also the characteristics of the environment, geographical position and transportation infrastructures of the regional play a significant role. Other factors such as proximity to other HT firms, availability of office space, and easy access to markets and suppliers are not extremely relevant, while on the contrary they are traditionally very important for other traditional local industries.

Local HT firms argue that the availability of local qualified labour, local universities and research centres, and the presence of other HT firms are the

Table 9.8 Main factors behind the choice to locate in Pisa (number of firms 130) (1 = scarce relevance; 6 = extremely high relevance)

Factor	*Score*
Proximity to the residence of the entrepreneur	4.58
Availability of qualified labour force	3.58
Proximity to universities and public research centres	3.23
Quality of life in the area	2.58
Transport infrastructures (e.g. airport)	2.52
Geographical position in Italy	2.52
Proximity to other HT firms	2.32
Access to suppliers and customers	2.02
Availability of office and industrial space	1.82
Quality of services	1.74
Public funding	1.68
Support programmes for families	1.29

Source: Observatory on High-Tech companies in the Province of Pisa, 2003.

perceived strengths of the territory. On the contrary, among the perceived difficulties, firms signal the lack of a local market, scarce entrepreneurial culture and lack of innovation in the traditional industries. The presence and interaction with local public research centres is considered to be both an advantage and a disadvantage. More precisely, firms are aware of the possibilities offered by local research centres, yet they are also aware of the difficulties involved in fully exploiting these collaborations from a commercial perspective, in particular because of epistemic barriers and incentives.

When inter-firm relationships are considered, 39% of the local HT firms claim to have some kind of collaboration with public research centres. However, only 22% of these relationships are considered ‘highly intensive’ (and therefore not sporadic). The reasons behind these collaborations are joint research projects. A significant majority of firms (61% among the interviewed ones) claim to have some kind of commercial collaboration or joint research project with other local HT firms. Forty-two per cent of the HT firms claim to have a relationship with other non HT organizations, in particular banks and training centers. Finally, only 31% of HT firms in Pisa interact with non-local organizations. It is possible to conclude that a real local relational cluster of HT firms has not been established so far, and also that significant relationships are not established between firms and other support organizations. The general impression is that HT firms do concentrate in Pisa but do not cluster together to a significant extent. This might not represent a problem in periods of economic growth, but might represent a difficulty when market circumstances make it more important to be present with a larger critical mass.

Conclusion: high-technology in emerging areas

In his theory about the Network Society, Manuel Castells argued that to be ‘on the map’ of global competition, regions need to have both connectivity and content

Table 9.9 Analysis of the main opportunities and obstacles for HT development in Pisa

Actors	*Pros*	*Cons*
University system	– an outstanding public research base and well-developed systems for education and training;	– networking activities within the area appears low and this hinders firms growth and transfer of knowledge from public science;
	– capacity of acting as catalyst to attract and retain students and potential entrepreneurs;	– a main challenge for the area is how to encourage a more positive attitude towards risk-taking and adaptation to new trends in the educational sector.
	– several technology transfer organizations have been established, and some technology poles are active in the area.	
High-tech firms	– fast and significant rise of new firms;	– lack of intense networking activities among firms;
	– emerging new corporate governance;	– weakness of HT-led initiatives by local associations;
	– steady growth trend of the sector: the number of high-tech companies has risen constantly during the 1990s, including foreign multinationals, local companies, start-ups and spin-off companies;	– absence of a formally agreed strategy and lack of a clear leadership in the high-tech community;
	– overall, good innovation capacity.	– low capacity to enter extra-regional markets and low marketing skills of the technical entrepreneurs.
Human resources	– highly qualified;	– low possibility of labour mobility inside the area and risk of losing talents;
	– rather abundant;	– low attitude towards entrepreneurial risk.
	– less expensive than in the North of Italy and the North of Europe.	
The area of Pisa	– good quality of life;	– limited regional market;
	– presence of good transportation infrastructures (port, airport, highways, rail);	– low presence of innovative finance instruments;
	– central geographical position in Italy;	– lack of some knowledge business services;
	– presence of some high-tech incubators infrastructures.	– need for better organization of networking institutions and infrastructures.

endowments (Castells, 2000). Connectivity infrastructures and capabilities are necessary for the flow of goods, people and knowledge, to easily get to and from the region. Once 'online', local unique content is necessary for any region to define its own unique niche on the map. This is true for both central and peripheral regions, but indeed it represents a major challenge for the most peripheral ones, which struggle to exploit worldwide their technological endowment, building sustainable competitive advantage.

This study has tried to show how the case of Pisa might be useful to understand limits and opportunities that an HT-led growth strategy might face in peripheral regions. In the following table, we summarize the opportunities and weaknesses for the development of the Pisa HT industry.

The complexity of the research question called for both a quantitative and an in depth qualitative empirical study of the economic and technological potentials of the area. The steady growth trends up to 2001 of the HT sector led to increasing political attention by local administrators. The development of the HT sector in the area shows an important opportunity not to be missed, highly compatible with local endowments in knowledge production, qualified human resources and entrepreneurship. However, the lack of innovative financial instruments, networking activities and technology transfer initiative represent grey clouds which darken the HT sky over the city. Three main recommendations for policy makers in mid-sized cities and researchers involved in similar studies emerge from this study.

First of all, it is crucial to fully comprehend the extent of local resources available endogenously. In the case of Pisa, a world class university system and research community need to be coupled with adequate links with industry. In terms of both scientific results and the availability of a qualified labour force, Pisa has an important and unexploited endowment.

Secondly, the Pisa case shows the importance of institutionalized partnerships and lobbying groups, which should contribute to the definition of and, if necessary, the redirection of HT policies according to the particular needs of the industrial community. Similarly, the lack of leadership, both in the private sector and within the public research community might cause short-termism in technology policies, and both industrial and market strategies. The local HT community is seeking its own identity, and this is a process that is unlikely to happen spontaneously. Public intervention, focusing of professional training activities, coordinated set of initiatives, and territorial marketing are necessary to promote the focus of the local HT industry.

Finally, a main challenge for the area is to learn from the intense networking which is typical of the Italian industrial districts. Agglomeration of firms in the same sector does not automatically lead to clustering, and clustering in HT does not automatically generate the benefits which are usually attributed to clustering in industrial districts. Nonetheless, local HT firms seem to need to increase communication and exchange among them, and specific incentives for this are required. The facilitation of personal contacts among entrepreneurs, technological partnerships and labour mobility are all pathways to go in this direction and help foster local tacit knowledge transfer.

Notes

1 Most of the empirical data about Pisa have been collected within the Observatory on High-Tech companies in the Province of Pisa (http://osservatorio.sssup.it/), managed by In-Sat Lab in collaboration with the Provincial Government of Pisa and local industrial associations. The Observatory was originally a three-year project and was funded by the Province of Pisa, the Region Tuscany and the European Union; it is now funded by several organizations.

2 The CyberGeorgia project http://www.cherry.gatech.edu/cyberga/is an example of such an effort to promote technological adoption and networking in peripheral and mid-sized cities.

3 The debate about technological districts is at the moment rather intense in Italy. Miur, the Ministry for university and scientific research, has formally approved several technological districts in Italy and in December 2004 has allocated €140 million for 13 projects of technological districts in the South of Italy. This action has led to both positive and negative reactions. From one point of view, it reflects attention to a relevant issue in regional economic development; from another point of view it seems dramatically similar to a previous project for the setting up of science parks in the South of Italy which turned out to be a severe failure.

4 The survey, mentioned at the beginning of the present work, is based upon direct interviews to the more than 200 high-tech companies which are present in the Province of Pisa. Interviews started in 2001, with funding from the provincial government of Pisa, and were carried out with the help of a specifically designed questionnaire. Since then, a questionnaire is sent to firms every year and the survey has been extended to the whole region (Tuscany). Further information and a research report about this project are available at www.osservatorio.sssup.it.

5 With one company in 'IT distribution' clearly accounting for a large share of total turnover.

6 According to estimates of the Observatory, this number is now beyond 6,500. The upcoming results of the official census are expected to confirm this growth trend.

7 We are not arguing that networking has a value *per se*. Also, we acknowledge the fact that different industrial and territorial contexts can be successful and experience different degrees of networking. However, we believe – as demonstrated by many authors – that networking is very useful for small HT firms, and that an intense flow of knowledge and information can be generally considered a positive phenomenon in industrial and technological districts.

References

Arora, A. and A. Gambardella (1990) 'Complementarity and external linkages: the strategies of the large firms in biotechnology'. *The Journal of Industrial Economics* 38 (4): 361–379.

Autio, E. and H. Yli-Renko (1998) 'New, technology-based firms in small open economies – an analysis based on the Finnish experience'. *Research Policy* 26: 973–987.

Bade, F.B. and E.A. Nerlinger (2000) 'The spatial distribution of new technology-based firms: empirical results for West-Germany'. *Papers in Regional Science* 79: 155–176.

Bellini, N., M. Lazzeroni and A. Piccaluga (1998) 'Innovazione e ricerca nell'area pisana', *Conferenza Economica dell'Area Pisana*, Pisa, 28–29 May.

Carlino, G.A. (2001) 'Knowledge spillovers: cities role in the new economy'. *Business Review* Q4.

Castells, M. (2000) *The Rise of the Network Society*. Oxford: Blackwell.

Cooke, P. (2002) *Knowledge Economies. Clusters, learning and cooperative advantage*. London and New York, Routledge.

Cooke, P. (2005) 'Regional asymmetric knowledge capabilities and open innovation: exploring 'Globalisation 2' a new model of industry organization'. *Research Policy*, 34, 1–22.

Counts, P.M. and A. Di Minin (2003) 'Research and innovation in mid-size cities. Local technology-based development experiences in Savannah (GA-USA) and Pisa (Italy)'. Paper presented at *Regional Studies Association Conference*, Pisa, Italy.

Ferrucci, L. and D. Porcheddu (2002) 'Start up and evolution of an ICT district: the Cagliari case'. Paper presented at the workshop *Software in Emerging Regions*, 28 September, Scuola Superiore Sant'Anna, Pisa, Italy.

Ferrucci, L. and D. Porcheddu (2004) *La new economy nel Mezzogiorno Istituzioni e imprese fra progettualità e contingencies in Sardegna*. Bologna: Il Mulino.

Gambardella A. (2003) 'Perche' alcune delle 'nuove' Silicon Valley sono nate in paesi emergenti? I risultati di una ricerca internazionale', in Cesaroni F. e Piccaluga A. (a cura di), *Distretti industriali e distretti tecnologici. Modelli possibili per il Mezzogiorno*. Franco Angeli: Milano, pp. 33–46.

Jones, S. (1992) *The Biotechnologists*. London: The Macmillan Press.

Lawton Smith, H. (2000) 'Innovation Systems and 'Local Difficulties': the Oxfordshire Experience', in Acs, Z.J. (ed.), *Regional Innovation, Knowledge and Global Change*. London and New York: Pinter.

Lazzeroni, M. (2004) Geografia della conoscenza e dell'innovazione tecnologica. Milano: FrancoAngeli.

Lee, C., K. Lee and J.M. Pennings (2001) 'Internal capabilities, external networks, and performance: a study on technology-based ventures'. *Strategic Management Journal* 22: 615–40.

Lipparini A. and A. Lomi (1999) 'Interorganizational Relations in the Modena Biomedical Industry: A Case Study in Local Economic Development', in Grandori, A. (ed.), *Interfirm Networks: Organization and Industrial Competitiveness*. London: Routledge.

Markusen, A. (1996) 'Sticky places in slippery space: a typology of industrial districts'. *Economic Geography* 72 (3): 293–313.

Markusen, A., Y. Sook-Lee, and S. DiGiovanna (eds) (1999) *Second Tier Cities: Rapid Growth Beyond the Metropolis*. Minneapolis US and London, England: University of Minnesota Press.

Maskell P. (2001) 'Knowledge creation and diffusion in geographic cluster'. *International Journal of Innovation Management*, 2: 213–37.

Piore, M., and C. Sabel (1984) *The Second Industrial Divide*. New York: Basic Books.

Sabel, C. (1993) 'Studied Trust: Building New Forms of Cooperation in a Volatile Community', in R. Swedberg (ed.) *Explorations in Economic Sociology*, New York: Russell Sage.

Saxenian, A. (1994) *Regional Advantage*. Cambridge Massachusetts and London, Harvard University Press.

Schillaci, C., C. Di Gesù and Di Guardo (2000) 'Microelettronica e imprenditorialità: verso lo sviluppo di un polo Hi-Tech nell'area catanese'. *Economia e Management* 1: 75–90.

Storey, D.J. and B.S. Tether (1998) 'New technology-based firms in the European Union: an introduction'. *Research Policy* 26: 933–46.

Torrisi, S. (2002) *Imprenditorialità e distretti ad alta tecnologia. Teoria ed evidenza empirica*. Milano: Franco Angeli.

Varaldo, R. (ed.) (1991) *I poli scientifico-tecnologici delle città universitarie. Il caso di Pisa*. Pisa: ETS.

10 An emerging ICT cluster in a marginal region

The Sardinian experience

Luca Ferrucci and Daniele Porcheddu

Introduction[1]

Sardinia, in Italy, is the second largest island of the Mediterranean Sea (Sicily being of greater land area), having slightly more than 1.6 million inhabitants and a very low density of population, equal to 68.5 inh./km^2 (EU15 $\cong$ 120) (see Figure 10.1 for its geographical location).

This island presents numerous characteristics of the marginal region in terms of the *knowledge economy*. In 1998, Sardinia still had a *Knowledge Economy Index* below the European average at 82.8 (EU=100), reaching the 168th place (out of 199) of the performance ranking of European towns and regions (Cooke and De Laurentis, 2002). It is currently characterised by a very low offer of qualified work.[2] Furthermore, in 2002, it was placed last in the classification of Italian regions in terms of expenditure on R&D in relation to the regional GDP (Unioncamere, 2005).[3] This negative figure is confirmed when considering the workers in the field of R&D, who are present at a proportion of 1.6 per 1,000 residents (the sixth smallest value at national level), a figure which is notably lower than the Italian average of 2.9 (Unioncamere, 2005). Furthermore, as regards patents, in 2003 Sardinia was placed fourth from the bottom at national level (Patent Office of Milan Chamber of Commerce, 2004). On the whole, on the *Regional Innovation Scoreboard* (RIS) referring to 2003, Sardinia scored 0.98 (fourth last in Italy and 143rd out of 173 European regions) (CRENOS, 2005).

Despite these connotations of marginality, Sardinia (and in particular the area relating to its principal city, Cagliari) has emerged in recent years as an ICT cluster (it has already been defined a 'Mediterranean Net Valley'). For instance, the most important ICT regional company, Tiscali, in 2004 has approximately 900 employees in the Cagliari area and about 3,100 employees in Europe. One may well wonder how could this happen in a Southern Italian region, far from territorial integration with the rest of the country, with its well-known problems of industrialisation? And how could this happen in a high-tech industry, distant from the historical and economic characteristics of these territories?

This chapter aims to describe the processes that have deeply affected Cagliari-based economic structure in recent years and the differences in terms of development factors in comparison to other Italian and international net economy

Figure 10.1 Geographic location of Sardinia and its principal city, Cagliari.

experiences in marginal regions. In particular, the role played by public institutions and firms in the different phases of the development of the Cagliari ICT cluster will be examined. What follows, is however, the story of a few key figures (regional policy makers, scientists, entrepreneurs, etc.) who contributed, in various ways, to the start up and development of ICT in Sardinia and of the (sometimes casual) meetings of these individuals.[4] As is noted more than once by Sir K.R. Popper, following the line of thought of *Methodological Individualism* (Infantino, 1998), reference to the so-called *collectiva* (as for 'firm', 'cluster', 'state', 'society', 'market', 'economic system', etc.) in the language of the social sciences should not lead us to forget that '(. . .) that which really exists is the individual. That is what really exists' (Popper, 1990: 24–25).[5]

Methodologically, following a micro–historiographic approach, the procedure has been the following: (a) quantitative reconstruction of the number of companies and employees in the ICT industries operating in Sardinia and in the Cagliari area in the last fifteen years; (b) analysis and systematisation of articles that have appeared in both national and regional newspapers and magazines since 1990, referring to the economic events in the Cagliari area or to national institutional issues (for instance, changes of regulations in the telecommunication industry, which have had a notable impact on the development strategies of Cagliari-based high-tech companies); (c) numerous interviews with entrepreneurs, managers, policy makers and researchers involved in the local high tech industry. In this way it has been possible to analyse and evaluate this territorial history, which is particularly emblematic for its different way of conceiving economic development – even in innovative sectors – in Southern Italian regions.

We will conclude our study by pointing out that a 'recipe' for industrial policy capable of replicating the mechanisms and logic of Cagliari's new economy simply does not exist. The unique and specific experience of the Cagliari area highlights the existence of a series of pathways, and the absence of a single recipe for regional economic development. The history of Cagliari's ICT is a complex network of intended and unintended consequences of multiple human actions (only some of which can be attributed to the 'great men' who will be directly referred to in our narration of the events).[6] In relation to this complex plot, composed of efforts of human planning and contingencies, any deterministic approach whatsoever to the problem of the development of regions (whether marginal or not) appears weak. On the other hand, it is undeniable that, in terms of the different empirical experiences of ICT development in the region analysed by the international scientific literature, some 'ingredients' that are common to each can be extracted (as is illustrated in the concluding section). By this we refer to several 'regularities', that, in a dynamic sense, have favoured the start up and development of the *net economy* in some regions. These 'basic ingredients' constitute a condition that is necessary, while not in itself sufficient, in order for a specific trajectory of regional economic development to be followed. As observed by Bronson (1999: 215), with reference to the Silicon Valley case: 'Don't think for a moment that this stew can be re-created by throwing together some engineers, VCs, headhunters and electronics shops, and then by drowning them all in money'.

The ICT companies in the Cagliari area

Until the early 1990s, Cagliari's economy, like that of many economically marginal regions of Southern Italy, bore markedly different features from those in which ICT industries were consistently present. At that period, three different dominant sector activities were evident: tourist–retail industries, building industry and mining-mineral manufacturing activities. This traditional economic structure revealed highly significant problems of competitiveness for a number of reasons. This was, first, reflected in very considerable levels of unemployment, even if compared to the high national average. Putting it differently, the traditional

Sardinian economic structure exhibited instability, while seeking new economic development paths, followed by both companies and policy makers. Second, ICT, which entails the integration of three sectors (software, hardware and telecommunications), exhibited a very marginal incidence on employment overall, both as absolute and relative values (as can be seen from Table 10.1), and was unable to reduce the economic problems of the island.

Table 10.2 illustrates the number of employees in ICT in relation to total employees.[7] As can be noted, Cagliari's economy, though it had in 1971 and 1981 rates similar to those of the rest of Sardinia and the other Southern regions, already displayed far better performance in the general census of industry and services in 1991, higher than those of some industrialised regions in the north of Italy. In the 1991–2001 period, the ICT employment rate of the area of Cagliari increased remarkably (+113%) and was clearly higher than the rate relative to Italian North-eastern regions and similar to that of the Central Italian regions. These data stress particularly the fact that, in the early 1990s, in the Cagliari area, events triggering a new development path in the ICT industries occurred. The following account will attempt to outline the history of this economic development.

Table 10.1 Total manufacturing employment in the province of Cagliari

	1971	*1981*	*1991*	*2001*
Mining	5,338	2,207	3,213	1,792
Food industry	3,136	3,845	4,029	3,966
Building	10,310	13,954	18,672	18,489
Retail	28,165	35,603	38,796	36,058
Hotels and restaurant	3,801	4,816	7,168	8,815
Transport	4,881	6,256	10,139	12,062
Mineral goods	3,683	4,390	2,820	1,976
Metal goods	2,504	9,091	6,065	6,140
Computer science and telecommunications	61	154	1,564	3,501
Total number of employees	76,680	100,360	114,925	120,673

Source: General census of industry and services in different years, ISTAT.

Table 10.2 ICT employment rates in relation to total employment (%)

	1971	*1981*	*1991*	*2001*
Cagliari	0.08	0.15	1.36	2.90
North-western Italian regions	2.35	1.23	3.18	4.77
North-eastern Italian regions	0.08	0.31	1.14	1.98
Central Italian regions	0.76	3.58	2.00	3.12
Southern Italian regions	0.07	0.27	1.03	1.86
Italian islands (Sardinia and Sicily)	0.08	0.19	1.01	1.89

Source: General census of industry and services, in different years, ISTAT.

Cagliari's net economy: institutions and companies, projects and contingencies

The first step: the creation of immaterial scientific competencies

In the area of Cagliari, the beginning of a new technological path was due to radical institutional innovation pursued by some regional policy makers. In November 1990, the Regional Executive Board promoted the initiation of CRS4 (Centre for Advanced Studies, Research and Development in Sardinia), appointing the 1984 Physics Nobel Prize winner Carlo Rubbia as chairman. Carlo Rubbia, at the same time, was the director of the Geneva CERN, where Tim Berners-Lee developed the worldwide web in 1989 (Pelcovits and Cerf, 2003).[8]

The aim of CRS4, approved by Rubbia himself, was the development of applied mathematics and numerical analysis supported by powerful computers and display instruments, focusing, above all, on implementing research and industrial applications, in collaboration or on behalf of important Italian and multinational companies. CRS4 became an important advanced scientific institution, with trans-regional and trans-national research activities. At the beginning, CRS4 was not linked to the Sardinian economy, because of the lack of regional companies able to adopt its know-how and scientific competencies. CRS4 was actually a radical institutional innovation, apparently without possible industrial applications in the following years in the context of the island's economy. Moreover, CRS4 was a stable public investment, since the Regional Executive Board allocated, for its initiation alone, a figure of €5.16 million, increased to €12.39 million in July of the following year. A huge amount of public money was allocated, year on year, to work in these pioneering scientific research fields; dozens of junior researchers were trained in this organisation, linked to other institutions at national and international level.

In this first stage, CRS4 was not spared from significant institutional and political criticism; meanwhile, however, the structure was setting up advanced scientific competencies, acquired by a number of junior researchers.[9] At this stage, the role of the University of Cagliari was marginal until appropriate scientific competencies were acquired; in detail, there were not, between the late 1980s and early 1990s, any graduate programmes with specific orientation to the fields of computer science and telecommunications.[10] During this period, the university did not supply qualified ICT competencies into the regional labour market. It lacked degree programmes in computer or telecommunication science, offering courses only in traditional scientific and technological fields, such as mechanical, electrical or mining engineering. On the whole, shortage of skills in the ICT sector is a common phenomenon in Italy because of the traditionalism of the Italian educational system and the late development in Italy of the Internet industry. Accordingly, the industry has proved unable to give enough feedback to the public research and educational system to respond as far as skills and knowledge requirements are concerned (Corrocher, 2003). As a consequence, one view in the economic literature (Bozeman, 2000; Cohen *et al.*, 1998;

Godin and Gingras, 2000; Mansfield, 1998; Rosenberg and Nelson, 1996; Etzkowitz *et al.*, 2000; Bellini and Piccaluga, 2000) about the strategic potential role of the regional university for the start-up of an ICT industry is not confirmed in this case.

The second step: the arrival of the Schumpeterian entrepreneur

Who was the first to apply these scientific competencies to the world of business? The Cagliari-based publisher Nicola Grauso. He owned newspapers and regional television networks and he wanted to innovate in his own business. What did he do? In 1995 he started up Video On Line, an Internet service company supported by one of the ten most powerful servers in the world at the time.

There are strong links between CRS4 and Video On Line. First of all, Grauso was fascinated by Rubbia's ideas about the feasibility of an international data transmission network; the meeting between the entrepreneur and Nobel Prize winner Rubbia took place in 1994, a short time before Video On Line started up. The initial positive experiments by the CRS4 computer-scientist team aimed at the web publication of the newspaper 'L'Unione Sarda', the first Italian newspaper on the web, strengthening Grauso's plans for the start of a new business through the creation of Video On Line.[11] Moreover, from the very beginning, Video On Line recruited CRS4 junior researchers as well as the services of a Dutch computer engineer, Reiner van Kleij, who was working as system manager at the 'L'Unione Sarda' newspaper.

In the beginning, Video On Line offered new software, distributed freely by national magazines and the like, enabling large numbers of users to access the Internet without any charge. In this way, Video On Line became a content-type ISP (developing, moreover, synergies in its information competencies between the hosts of journalists employed in its original business and innovative web services). An important Video On Line strategy was an agreement with the American carrier Sprint, on the international backbone of which (between USA and Europe) all the Video On Line data transmission traffic was conveyed. Grauso's project enticed also Nicholas Negroponte, director of the famous research centre MediaLab at MIT, who wanted to sign a six-year research agreement between his own laboratory and Video On Line, according to which some American researchers would work in Cagliari on innovative projects, relating to natural language application to computer science and to the development of intelligent agents.

Moreover, Video On Line represented for the territory of Cagliari a basic 'contact moment' between the competencies (above all, programming in the Unix environment) developed at CRS4 by many researchers, employed by Grauso, and many small local entrepreneurs (contracted by Video On Line to supply external services, for instance the database or LAN structuring, rather than the set-up of information technology structures). In certain respects, Video On Line can be defined as a context of technological transfer between CRS4 research frontiers (especially in the web environment) and numerous local computer experts.

During this period, Grauso was an entrepreneur with an innovative project but without a market or a business model.[12] He was closer to an inventor than an innovator, according to the traditional Schumpeterian distinction. He promoted exploration of scientific knowledge for a 'service economy', rather than business exploitation.[13] As Grauso said, 'I was not doing business but exploring. And exploration has different rhythms: you have to search, you have to discover things' (Isiline Magazine, 2000).

The third step: the risk of the loss of web territorial competencies

Within a few months, in mid-1995, Video On Line gathered about 30 thousand subscriptions and a record of 400,000 daily contacts, with 30% of market share in the Italian subscriber segment. On 23 September 1996, *Time Digital* (Time's Technology Supplement) underlined the strategic role of Sardinia in web development: 'An island off the coast of Italy might seem the last place to build an international empire, but that's exactly what Video On Line has done. The Sardinian service (www.vol.it) has Web content from nearly 40 countries – from South Africa to the US – and offers its 50,000 subscribers state-of-the-art Web based chat and E-mail services'.

Telecom Italia, the former telecommunications monopolist company in Italy, was concerned about its second-place position in this new business. In June 1996, Telecom Italia acquired Video On Line, and temporarily cancelled any danger of competition by this dynamic and innovative company operating in a business frontier, which was still unknown to the national monopolist. How could all this happen after little more than one year after Video On Line started up? What changes did this acquisition cause in the local and regional economy?

Dependent on the economic connection structure to the web available at the time,[14] Video On Line became financially indebted to Telecom Italia. It is easy to understand how Video On Line could have accumulated debts for about €10.5 million[15] within a few months. This serious financial situation was also due to the pursuit of an innovative and highly expensive project for the elaboration of a new browser (called Video On Line 1.0) carried out by the Palo Alto, California, Teknema Company.[16] Moreover, the internationalisation process of Video On Line represented another important economic challenge. In 1995, Grauso organised a presentation tour in different international cities (where Video On Line was operative with its own server and a data transmission network) preceded by an intense advertising activity, in order to strengthen penetration among business customers.[17] Finally, Video On Line was not able to check that correct payment of subscriptions was taking place, and, consequently, to pursue the defaulting users. From a certain viewpoint, the fast proliferation of customers had not been supported by an organisational and administrative structure adequate to the resulting needs.[18] It is clear that the organisational structure was severely lacking balance, if technical and computer science competencies are compared to the strictly managerial and accounting skills.[19]

The Italian Antitrust regulator allowed the acquisition of Video On Line by Telecom Italia under several conditions, two of which seem particularly important: (a) Telecom would have to permit the required connections, on equal economic terms, both to its own basic network customers and to the other Internet service providers;[20] (b) the monopolist would have to provide, for transparency reasons, a complete separation of accounting of the new Business Unit in which Video On Line would be merged (AGCM, 1996).

In the sales contract, the entrepreneur Grauso agreed with Telecom Italia that the location of Video On Line should have to remain in Cagliari and that the employment level would have been maintained. From the outset, however, these agreement conditions were not respected especially because of the resignation of many computer experts: by late 1995, Video On Line employed about 300 people, including direct employees and external contractees. With the exception of the Video On Line call centre (consisting of low qualified staff), out of the 100 employees no more than 40 shifted to Telecom Italia, giving way to a high number of resignations in the phase immediately following the acquisition process.

There were different organisational motives for these resignations. On 1 March, the merger between Telecom On Line and Video On Line gave birth to Telecom Italia Network (TIN), the Internet business unit of Telecom Italia. At first, TIN planned to move the Video On Line researchers to its Rome-based legal headquarters. Many computer researchers did not accept the relocation to a monopolistic and bureaucratic structure in Rome, facing the occupational risk of remaining in Sardinia, and in a few cases they resigned from TIN. The latter is another relevant aspect: scientific competencies exhibit peculiar organisational features. Offering salaries and other economic benefits is not enough: researchers prefer a dynamic organisational atmosphere, far from the constraints of the bureaucratisation of decision processes (Fry and Saxberg, 1987). Thus Telecom Italia acquired a company, but not its immaterial and qualified competencies. This is why many of these competencies did not leave their location: the Cagliari area.

The fourth step: entrepreneurial and institutional spin-offs

In the regional labour market, some of these junior researchers began to exploit their professional competencies, stimulating the starting up of regional small business in the ICT industry or helping to strengthen institutions involved in the implementation of the activities relating to the creation of the Scientific and Technological Park of Sardinia[21] and technology transfer in favour of Sardinian small and medium firms. These entrepreneurial spins-offs strengthened the contribution, in terms of competencies, provided by the first wave of small entrepreneurship in computing activities, which up to then had been supplying their services to Video On Line, as noted.

What has been described above is an important step for a series of education and professional trajectories, which can be reconstructed referring to the people who have characterised the fortunes of Cagliari's ICT; in detail, interviewing these people enabled us to single out some 'typical' education and professional paths. Their 'orthodox' professional path is the following:

1. education in a scientific field outside the Sardinian Universities with a degree in computing engineering science, computer science or physics;
2. professional activity at CRS4 (in some cases preceded by the experience at CERN in Geneva);
3. professional collaboration with Video On Line;
4. employment at TIN for a short time;
5. professional activity at Tiscali or at other local companies.

On the whole, the intertwining of individual routes helped to evolve an embryonic high-tech cluster. However, despite the proliferation of initiatives, the history of Cagliari ICT, at that point, became eclipsed with the closing of Video On Line. There was now no strong leader competent to network the regional system into a trans-national system and market.

The fifth step: the Tiscali start-up

The launch of Tiscali was made possible by the insight of an entrepreneur, Renato Soru, and by a certain number of conditions external to Sardinia and favourable to a new business initiative. These included liberalisation and regulation of the telecommunications industry,[22] increasing reduction of rent tariffs on infrastructures and lines required for the creation of a widespread and distributed network,[23] Internet business growth, easier access to the stock market with the starting up of the Italian New Market[24] (also to venture capital), and the availability – in the regional labour market – of a significant number of researchers with advanced competencies in ICT activities. These are the components that, since its foundation in June 1997, have made Tiscali an interesting business case and, at the same time, an economic propeller of the local and regional system.

The connections between this developmental step and the preceding one become evident if one considers that Soru had been in frequent contact with the entrepreneur Grauso since 1995. Nicola Grauso offered Soru the license of Video On Line for the Czech market. The new business (Czech On Line) became the first Internet provider on that national market, and was then sold to an investment fund managed by Deutsche Bank.[25] Another aspect worth emphasising is that the pioneering initiative of Video On Line was, for Soru, a 'golden thread' for the success of his project.[26] In addition, the Tiscali project drew a plurality of researchers and managers who were veterans of the Video On Line and TIN ventures: three people out of eight in the founding team, excluding Soru, had gone through the Video On Line and TIN experience.

Initially, Tiscali started as a national telephone company and offered home-telephony services with an aggressive pricing strategy through considerable discounting (about 50%) of the telephone fees current at the time. The crucial moment for Tiscali's history was in November 1998. First, an important

European investment company, Kiwi, invested in a 10% stock share. Kiwi had been operating through a ten-year closed investment fund exclusively devoted to new computer and telecommunication companies and was established by venture capitalists Elserino Piol (former Olivetti telecommunication manager) and Oliver Novick (former General Telephone & Electronics manager). Secondly, in late November of the same year, the Italian Telecommunications Authority compelled the former monopolist Telecom to upgrade the interconnection fees level to the European Community parameters.[27] Naturally, brought about earlier, these two factors could have made a decisive difference to the unfortunate vicissitudes of Video On Line.

The sixth step: Tiscali becomes an important national and international Internet communication company (ICC)

From the outset, Tiscali operated as a home-telephony company but did not neglect the exploration of Internet business (an industry in which Soru, as indicated, had acquired entrepreneurial competence in the Czech Republic). These strategic moves are confirmed by the results of analysis of the turnover composition for activity classes of the Tiscali Group (Table 10.3).

It can be seen that telephone return shares were losing ground rapidly to the advantage of Internet business. Within a few months, Tiscali became the third Italian ISP, after Telecom and Infostrada, controlling, together with the other two operators, about 80% of the market.

At its start also, Tiscali had technological standards not only for telephony but also for Internet communication. This technology had economies of scope

Table 10.3 Tiscali returns distribution for activity class (in millions of Euro and in percentages)

	1998	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005**
Internet access returns	0.33	11.40	65.618	409.30	517.00	612.93	730.41	177.99
	(25.6)	(34.8)	(37.9)	(64.4)	(69.08)	(68.03)	(67.60)	(74.27)
Telephone returns	0.95	19.98	61.123	54.40	51.8	70.39	88.33	30.29
	(73.6)	(61.1)	(35.3)	(8.6)	(6.92)	(7.81)	(8.17)	(12.64)
Business services returns	–	0.70	25.85	85.30	106.60	161.25	205.95	19.83
	(–)	(2.1)	(14.9)	(13.4)	(14.24)	(17.9)	(19.10)	(8.27)
Other returns	0.01	0.15	13.31	21.80	24.96	9.23	10.09	1.97
	(0.8)	(0.5)	(7.7)	(3.4)	(3.34)	(1.02)	(0.93)	(0.82)
Portals returns	–	0.50	7.28	64.90	48.00	47.22	45.78	9.58
	(–)	(1.5)	(4.2)	(10.2)	(6.42)	(5.24)	(4.2)	(4.00)
Total	1.29	32.73	173.17	635.70	748.36	901.02	1080.56	239.66
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)

Source: Our elaboration on Tiscali balances, different accounting periods.

Note
*first quarter 2005 report.

for these two communication services but it needed more investment than traditional telephone technologies. This technological option, persistently pursued by Tiscali, demonstrates its main business model: Internet communication services. From early February 1999 onwards, Tiscali appeared as an aggressive Internet service provider, launching, after the UK model of FreeServe, a free net access service named 'Tiscali Free Net' (*The Wall Street Journal*, 11 October 1999). In this phase Tiscali had clear ideas about the revenue model expected to support the Internet business, where it was making a headlong entrance; according to Soru's statements, Tiscali's incomes were to be generated by:[28]

1 a share of the telephone call cost paid by the customer for connection to the Telecom Italia network;[29]
2 on-line advertising;
3 fees collected on e-commerce platforms run by the Sardinian company.[30]

Tiscali pursued yet another step in its strategy: the move from being an Internet service provider (ISP) to an Internet communication company (ICC). In the course of time, the increasing value of Tiscali on the stock market has supported business growth through the acquisition of numerous European ISPs to pursue an internationalisation strategy (*Financial Times*, 15 February 2000; *Business Week*, 7 February 2000).[31] In Figure 10.2, we outline Tiscali's quotation value, from entry to the Italian New Market to the summed value of the acquisition operations carried out by Tiscali in the reference quarter.

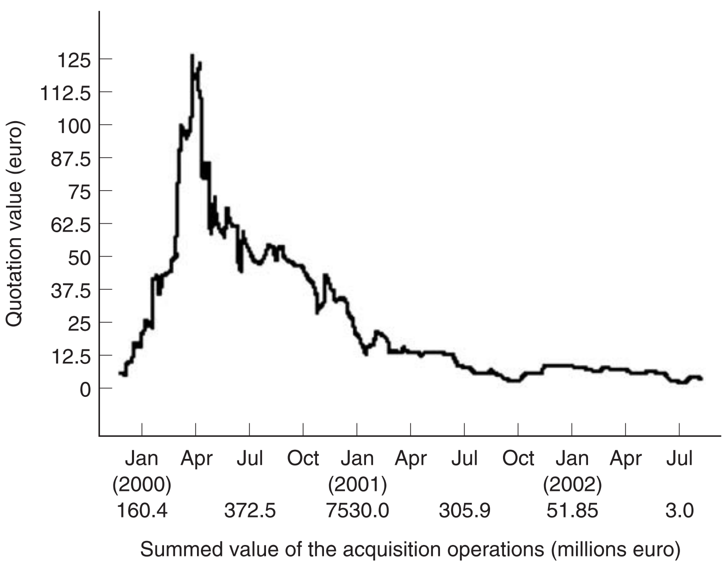

Figure 10.2 Tiscali quotation value and the summed value of the ISP acquisitions. Source: Our elaboration on Tiscali data.

The figure shows that the second and the fourth quarter of Tiscali quotation correspond to implementation of the most dynamic acquisition strategy (€372.5 and €7,530 million of acquired values, respectively), while such figures dropped progressively in the following periods.

In this period, Tiscali made 32 acquisitions,[32] often through stock markets, above all in Germany (five acquisitions), in France (four acquisitions) and in The Netherlands and Belgium (six acquisitions). This is closely related, allowing for a certain time lag, to the value trends of Tiscali shares. In fact, at the time, while Tiscali shares presented a considerably higher value than the initial access price, the utilisation of share change used to carry out the acquisitions represented a relevant tool, which enabled Tiscali, among other things, to avoid getting too heavily into debt.

The time lag between the highest values reached by Tiscali shares and the successive substantial acquisition process can be explained, on one hand, by the urge to explore and evaluate possible acquisition opportunities in the international scenario (a time consuming activity) and, on the other hand, by the streamlining of the share values, proportioned to Tiscali's, experienced also by other Internet companies listed in other stock exchanges, which made acquisition more appealing. This increasing acquisition strategy, however, must be correctly framed within a new Tiscali mission: becoming the prime European Internet communication company (ICC) in Europe. ICC is a business hinged on the implementation of an owner's network, supported by TCP/IP protocols and interconnected at European level. This infrastructure context is instrumental, additionally, to the supply of an array of services (voice, audio and video streaming, besides Internet *stricto sensu*).

Which are, then, the main ICC ingredients, according to Tiscali? First, a 'users' community' (principally, but not exclusively, of consumer type at European level, which Tiscali tried to set up through the acquisition of several ISPs in different European countries). Secondly, Tiscali was trying to create an 'owner's network' at European level, supported by IP protocol, through strategic acquisitions and agreements with important partners. Thirdly, an offer of services extended both to the consumer segment and to that of business, which ranged from communication services of an innovative type (amongst which, for instance, VoIP and netfax and more generally, a unified messaging offer to the growth of B2B services resorting to in-house available goods and resources; in relation to this last ingredient a number of acquisitions proved useful). Fourthly, a wide and comprehensive content offer. In April 2001 Tiscali, with more than 16 million registered users, became the prime European ISP, preceding T-Online, the German ISP controlled by Deutsche Telekom.[33]

The seventh step: the re-focusing strategy of Tiscali and the future of Cagliari's ICT cluster

After two years, initially characterised by a standstill in the process of takeover but later by an orientation to the acquisition of firms with mainly business-oriented customers, 2004 became a year of great changes for Tiscali. From May its founder became president of the Regione Autonoma della Sardegna and was no longer the group's CEO (even if he remained the most important shareholder, with some 27% of shares). Furthermore, during the period from August to September 2004, the Tiscali Group sold a series of Internet-oriented undertakings in Switzerland, Norway, Sweden, South Africa and Austria, showing a clear intention to refocus activities and financial resources on the main European markets where it operates. In fact, in April 2005, the cession to Telecom Italia of Tiscali's activity in France (up to then the main market of the Sardinian ISP) was confirmed. Tiscali's ADSL and Dial up clients are currently concentrated in the following nations: UK (35%), Italy (30%), Germany (16%), Netherlands (11%), Czech Republic (4%) and Spain (4%). These refocusing manoeuvres revealed difficulties linked to the running of a real pan-European strategy by European ISPs (Corrocher, 2003; Ferrucci and Porcheddu, 2004). Rumours about a possible take-over of Tiscali by competitors like T-Online (controlled by Deutsche Telekom) and Telecom Italia (former telecommunications monopolist in Italy) were also frequent. Hence one can legitimately wonder what will happen to the cluster of ICT firms of the area of Cagliari. In the space of only 10 years, this displayed interesting growth dynamics, with 659[34] firms and 2,667 workers in 2001 (our elaborations on ISTAT data, General Census of industry and services, 2001).[35]

Even if there is no lack of further relevant actors (besides Tiscali), such as the multi-utility Energit, Akhela or Abbeynet,[36] we have the distinct impression that the present cluster of Cagliari's ICT firms is still quite fragile in several respects.[37] On the one hand, the outstanding evolutionary dynamics of Tiscali may lead this undertaking to stray from the interests of co-evolution with the regional supply system. Furthermore, Tiscali has already reached a pan-European institutional and strategic structure which might be a sign of reduced integration with Cagliari's territory (also because of possible changes in corporate ownership). On the other hand, small firms in Cagliari's ICT do not properly represent a cluster that is integrated in a functional way within one or more Internet-related businesses. Each firm seems actually to pursue its own activities, often without structured and converging relationships with other small undertakings; hence, there is a serious problem of governance for the cluster, which should be reflected upon in the future (Cooke, 2004; Piccaluga, 2003).[38] The ICT firms of Cagliari, furthermore, sprang up thanks to the local dissemination of competencies by Video On Line, or in the wake of Tiscali's success and of the great expectations created by the worldwide rise of the Internet; nonetheless, they suffer from a link to markets which is very often limited to their regional context, and hardly ever transcends national frontiers (Ferrucci and Porcheddu, 2004; Bresnahan *et al.*, 2001).

Policy issues and lessons from this regional economy history

The history of the ICT 'cluster' of Cagliari shows a series of analogies and specificities,[39] compared to other experiences analysed internationally

(Bresnahan *et al.*, 2001; Oakey and During, 1998; Saxenian, 1994; McKendrick *et al.*, 2000)[40] and in the Italian economic literature (for a review, see Di Minin *et al.*, 2003, 2006). However, it is important to distinguish between factors which determined the birth of this cluster and factors which have characterised its development.

With reference to the start-up phase of the Cagliari cluster, the importance of public regional and industrial policies, that aimed at research in the pioneering fields of science, was fundamental. The foundation of CRS4, in 1990, due to the foresight of some Sardinian politicians, but also to factors that were exogenous with respect to the sphere of influence of private and public regional subjects,[41] represented an investment in scientific research, that was able amongst other things to generate relevant qualified human resources (also considering the training carried out by the CRS4 of dozens of young Sardinian graduates). Nevertheless, investment in science cannot predict economic consequences. Policy makers could not foresee, at the time when CRS4 was created, the development dynamics in the regional economic context, such as that which was subsequently created. Hence there was no intent to create a specific development model of the net economy. In this territorial history, regional public institutions have displayed great intelligence in decision-making and in the allocation of financial resources to support scientific research, without any short term economic results in the regional economy.[42] The policy lesson we may derive, analysing this history as a whole, is the advisability of adopting an approach that is different from the 'top-down' for the future of a regional economy (the top-down approach has, besides, characterised some well-known experiences of failure, as in the case, for example, of the Multimedia Super Corridor in Malaysia; Breschi and Malerba, 2001).[43]

Second, from the experience of Cagliari we can derive implications about a non-univocal role of regional universities in the start-up of ICT clusters; in fact, the supply of qualified labour played an important role in the story we have analysed, but the educational *locus* must be identified not so much with regional universities, as with CRS4 (or institutions outside Sardinia, such as CERN in Geneva, other foreign or Italian universities, etc.). Nevertheless, the presence of a relevant supply of qualified labour becomes an important factor, particularly linked to situations of low-cost opportunity (Bresnahan *et al.*, 2001), and this is substantially true for Sardinia, where, despite regional governance of the Sardinian economic structure, there are still high rates of qualified youth unemployment.

Third, the specific geographic localization of the area where the cluster of ICT firms is to be placed is instructive. The particular geographic position of Sardinia (situated in the centre of the Mediterranean sea, with obvious and still existing problems of transport of goods and passengers to the mainland) played an important and specific role in the start-up of the Cagliari cluster. In order to close the spatial gap with the scientific communities Sardinian researchers were compelled quickly to familiarise themselves with the Internet, besides actively contributing to improvement of its functional characteristics and services (some services worth recall are: the first Italian and the second European web site, created in Sardinia; the development of the Mosaic browser, as well as the first web mail prototype; the first European electronic newspaper, etc.) (Ferrucci and Porcheddu, 2002).[44]

Fourth, this territorial history demonstrates the fundamental value of social, cultural and professional cross-influences for the initiation of innovative development. Several facts confirm the value of this blending, such as the cultural and professional backgrounds possessed by the ICT pioneers and their preceding experiences outside Sardinia (often outside Italy). This background allowed them to acquire new competencies and new beliefs. Moreover, the cultural and professional background of the pioneers is essential to support organisational attraction, recruitment integration in the regional labour market with other non-Sardinian people (sometimes non-Italian). This factor presents evident policy implications, emphasising the importance of forms of tolerance towards *brain drain* phenomena (Bresnahan *et al.*, 2001). Indeed, the historical experience of the area of Cagliari shows that constraints to development are not so much those of financial capital, as qualified human resources specialised in innovative competencies (Cooke, 2001; Maillat and Vasserot, 1988; Nelson, 2001). Professional resources depend on the role of local excellence in scientific research centres, operating in a national and international network. Moreover, financial capital does not have spatial frontiers (Feldman, 2001), while researchers do have spatial and organisational frontiers (they prefer not working in a bureaucratised and monopolistic company), or are linked in a socio-institutional context, which can offer something else in addition to appealing salaries. This means that the start-up of growth originates from the capacity to produce, to attract and retain such qualified human resources.

Fifth, the importance of a strong presence of a *firm building capability*, sometimes even in the absence of specific technical competencies is noteworthy. One of the entrepreneurs we interviewed, very clearly stated: '. . . I didn't know anything about computers . . . I had been working on Internet eight hours a day for my job . . . after six months I thought of creating a firm of my own . . . a group of us started to think about it together'. More exactly, the starting up of the cluster of Cagliari shows the existence of two kinds of entrepreneurs: the first is irrational and utopian, close to science (and its inventions) rather than to business (as in the Video On Line experience). These entrepreneurs – a kind of incomplete innovator – represent a fundamental translation and application of scientific and technological knowledge into entrepreneurial applications, even if still immature and indefinite. Such entrepreneurs suffer from an underserved failure of their own pioneering initiatives,[45] that, however, becomes source of inspiration and imitation for the following entrepreneurial generation. The second kind of entrepreneur is composed of experienced innovators. They capitalise on the local and regional knowledge owned by public research centres and by incomplete innovators within a sustainable business model. Their organisation includes not only technical and scientific human resources but also managerial (accounting, marketing and financial) competencies. In this regional development model, there are complementary roles among scientific institutions, pioneering entrepreneurial explorations (to open windows of technological opportunity in the regional context) and ensuing entrepreneurial exploitation (being able to ride the emerging techno-economic trajectory with a specific business model).

With reference, instead, to the development of the cluster of Cagliari, we can state that several factors were involved. In this context, we cannot neglect the role played, in specific phases, by the flow of financial capital. This attraction of exogenous financial capital demonstrates that the latter has no boundaries, against the emergence of business opportunities (Feldman, 2001). The reference is, for example, to the importance reached by venture capital in the initial phase of Tiscali's growth and by applying to the stock market in the phase of transition towards a national dimension by the operator itself (see 'The fifth step').

In addition, we have to reflect on the role of some *key figures*[46] (of relevant dimensions and, as in the case of Tiscali, real *global players in terms of international leadership*) amongst the factors of development of this cluster (Breschi and Malerba, 2001). Nevertheless, we had better specify the endogenous nature of the various lead figures of the regional system (Video On Line and Tiscali, above all) who brought about a nebula of spin-offs (real 'waves of entrepreneurship' that have characterised the various phases of the story of the Cagliari cluster). Indeed, this territorial history shows an endogenous development, through regionally qualified entrepreneurial supply. For a number of reasons previously described (see 'The seventh step'), the lead role of the big firm seems to have dried up; hence, in the future, regional policy makers will have to face an important challenge, in terms of promotion of forms of associative governance of the local ICT firms cluster (Cooke, 2004).[47] On the other hand, it must be underlined that the absence of a strong associative system in the Cagliari area is perfectly coherent with the particular evolutionary dynamics of the new economy in Sardinia, characterised by a sort of 'big-bang development' around a few and isolated key figures of pioneers.

Moreover, the strengthening of managerial competencies turned out to be relevant for the development of the cluster (Moore and Davis, 2001). Actually, the phase characterised by the foundation of CRS4 and that marked by the unfortunate experience of Video On Line are typical of a clear lack of balance in favour of technical competencies. The phases characterised by the leading presence of Tiscali, on the contrary, show a greater attention to business resulting from the combination of the two types (technical and managerial) of competencies.

Despite their importance in the start-up phase, the role of public policies in influencing the development of the cluster of Cagliari has been all in all marginal, at least if we leave out the support, which has been halved over the years, to the financing of CRS4 activities (Ferrucci and Porcheddu, 2004). In some cases regional policy makers have even been accused of excessive disinterest in the destiny of the Cagliari ICT cluster (the most important example is the non-intervention of the Sardinian Regional Council in the Video On Line case, see 'The third step'); some authors, on the contrary, may see in these choices some desirable forms of '*benign neglect*' (Bresnahan *et al.*, 2001). In fact, immediately after the start-up phase of this regional high-tech development history, initiatives by entrepreneurial personalities and 'mundane' regional policies are seen to be clearly independent: the increasing dissociation between the two in the case of Cagliari raises the question of how to embed entrepreneurial personalities (or spectacular singular projects) in more broader regional programmes.

On the contrary, in Sardinia the importance of local external effects and the resulting agglomeration economies for local economic development, as well emphasised in the economic literature (e.g. Saxenian, 1994; Porter, 1998), are relatively limited nowadays. This arises from the fact that this regional production system remains 'molecular'. Its enterprises are now weakly tied to the leading role that Tiscali was initially able to play and no longer integrated in a global territorial project.

On the whole, the particular combination of the already quoted factors suggests that there are no 'magic recipes' for the founding and development of ICT clusters (this is true not only for clusters born in peripheral regions). In our telling of the story, 'ICT Cluster' is a stenogram with which we indicate a complex network of intended, and far more often unintended, consequences of multiple human actions (that can be attributed to policy makers, scientists, entrepreneurs, managers and common individuals). This history also corroborates the fact that the success of a territory or a company may even also depend on pure chance. Some small historical events and contingent factors (Arthur, 1989), probably unrepeatable and exogenous, have influenced development paths. For example, without specific public regulation in the telecommunications industry or without the realisation of the Italian New Stock Market, the history of Tiscali would not have been the same. This means that territorial history is path dependent but is not a deterministic development model.

Notes

1 We acknowledge useful comments from Philip Cooke and Gernot Grabher.

2 Sardinia possesses a percentage of degree holders, in the 25–64 age group, of 8.2% in comparison to an Italian average of 10.2% and an average in the 25-member European Union of 21%, and in 2002 occupied the 252nd place out of 261 regions of the EU (CRENOS, 2004).

3 In particular, in 2002, the island sustained expenditure in R&D equal to 0.7% of the regional GDP, to be compared to a national average of 1.2%, and an average figure relating to Southern Italian regions of 0.8% (Unioncamere, 2005).

4 These encounters between 'great men', seen from subsequent reconstruction, have assumed an almost consequential nature. The whole story of this high-tech development spot assumes the dynamics of a sort of relay race and, in our opinion, the natural unit of analysis is the actions of single key figures and the events that lead these figures to approach each other.

5 Mises (1966) goes even further, claiming that *collectiva* may be studied in their evolutions only by starting from the actions of individuals.

6 The Cagliari ICT is actually also the unintentional result of the actions of apparently 'minor' individuals. An example may be at the start of the 1990s, a Dutch computer engineer arrived in Sardinia to be with his future wife, a Sardinian woman who had lived in Holland. This engineer played a fundamental role in the initial phases of the

Cagliari ICT cluster (Ferrucci and Porcheddu, 2004: 45). To paraphrase the Argentine writer J. L. Borges (1977), several episodes of the start up and development of the Cagliari ICT cluster underline the fact that History, real History, is more 'modest' than we are generally prepared to admit.

7 The classification adopted for the ICT industries includes: hardware, software and telecommunications.

8 As was recently noted by Murroni (2004: 8): 'The regional administration governing Sardinia in the late 80s chose to invest heavily in the creation of local knowledge through a series of complementary measures, which included direct investment in research structures. The main project entailed setting up a consortium – named Consorzio21 after the law that established it (L.R. 21 of 1985) – charged with promoting, implementing and managing a Science and Technology Park for Sardinia. The consortium became operational in 1989 and it commenced its work by developing: (a) CRS4, a centre for international excellence and innovation in the field of computing and large scale calculations, established in 1990, (b) The Science and Technology Park, Polaris, a network structure for research and other services for businesses, whose headquarters officially opened in 2003'.

9 By September 1991, after about ten months from its launching, CRS4 consisted of 15 researchers; in the first months of 1992, there were 30 research students (about 20 of whom were certainly Sardinian, trained in the University of Cagliari and elsewhere in Italy); by mid-1992 some ten more researchers were added; two years after its establishment CRS4 consisted of about 70 researchers; among the scientists belonging to CRS4 there are prestigious personalities (Clementi, Quarteroni, Rossi, Bruno, Zanella), some of them trained in American universities; some of the junior researchers (namely, Antonio Ticca, Luigi Filippini – future founder of an important Sardinian multiutility company: Energit – Luca Manunza) distinguished themselves very soon as they set up the first Italian Internet site (second in Europe: www.crs4.it) and contributed to the improvement of the first public browser Mosaic, developed in the USA by NCSA (National Center for Supercomputing Applications) at the University of Illinois, as well as inventing one of the first Web-mail systems in the world.

10 The first five students in computer science at the University of Cagliari only graduated in April 2001. More in general, at least initially 'The Sardinian universities do not seem to have adhered with great enthusiasm to the project of a scientific park in Sardinia' (Mongili, 1998: 14).

11 The main results of the experimentations were reported at the meeting, held in San Miniato (Florence) in March 1994, with the title 'World Wide Web and beyond in Physics research and Applications' and published in Ruggiero and Van Kleij (1994).

12 As Sarasvathy (2001a: 1) wrote recently: 'That entrepreneurs create firms is a simple fact. But that entrepreneurs often create firms in the absence of markets is an idea that is recently gaining ground with researchers' and, also, 'before there are products, there is human imagination, and before there is a market, there are human aspirations . . . entrepreneurs have long created firms, industries, and even economies by matching up the offspring of human imagination with human aspirations. They have realised that this matching does not occur spontaneously or ''inevitably''. Rather, the creation of economic artefacts demands imagination, inspiration, and protracted endeavour' (Sarasvathy, 2001b: 261).

13 As Grauso underlined: 'Internet is the adventure of the future, it is boundless intelligence, without constraints, without barriers, without stopping. We are preparing a world in which every family, every housewife, every child, with their own computers, will be able to connect world-wide' (*Il Mondo*, 13 April 1996).

14 At that time, there was no public price regulation in Italy relating to access charges and Telecom Italia offered high prices for this monopolistic service.

15 On the other hand, the revenue model of Video On Line, at the time, was not at all clear to Grauso himself, as he states in different interviews: 'It is an adventure in a world still to be discovered' (*Il Sole 24Ore*, 7 December 1994) and again 'It is too early to speak of break even. I am not prepared to bet on the times. There are too many variables' (*Il Mondo*, 6 November 1995).

16 This browser, the multilingual version of the browser 'Tiber' conceived by the Californian company Teknema, could support a series of 'minor' languages, such as Afrikaans, Amaric, Ewe, Haoussa, Ibo, Kimbundu, Nyanja, Pullar, Suto, Tigrigna, Chokwe, Yoruba, Bassa, Indi, Kikongo, Lingala, Lunda, Mandekan, Fulani, Somali, Wolof, Tswana and Swahili, as well as the most important world languages (English, Arabic, etc.).

17 The first step was in March 1995 at the Cannes great international fair of Computer science. There the Cagliari team was invited to report in Paris, at the publisher's international convention, where they presented their hyper textual daily newspaper. In April 1995, Video On Line was the only European company invited to California, Silicon Valley, precisely at the international data transmission fair. Video On Line could avail of two servers (in New York and San Francisco) for the automatic duplication of all the services offered in Europe. In the same period, the Video On Line presentation tour reached other international cities, such as Athens, Alexandria, Sofia, Istanbul, Tunis, Bucharest, Beirut, Budapest, Casablanca, Saint Petersburg, Berlin, Lisbon, Amman, Moscow, Madrid, Shanghai, Brussels, Barcelona, Singapore, Stockholm, Paris, London, Copenhagen, Jakarta, Geneva, Tel Aviv, Tripoli, Johannesburg, New York; it concluded on 23 June in Tehran.

18 Similar pioneering experiences in the Silicon Valley are pointed out by Bresnahan *et al.* (2001).

19 As Grauso declares, 'the stakes were getting too high for us' (*Business Week*, 26 August 1996).

20 Our feeling is that the Video On Line event was a sort of important precedent that created a new sensibility in Italy towards the problems of competition in ICT. From a certain point of view, Video On Line is a sort of 'sacrificial victim' offered to anticipate much more open competition scenarios, like those of the second half of the 1990s.

21 'While CRS4 was established in relatively little time, setting up the Science and Technology Park Polaris required nearly ten more years: the Park's headquarters were officially opened only in June 2003' (Murroni, 2004: 9).

22 The reference is, above all, to the reverse connection agreement to the telephone network enforced by the 23 April 1998 law on the former monopolist in Italy, Telecom Italia, in order to allow the access of the operators in the sector, an agreement which is monitored by the Italian Telecommunications Authority. On the other hand, the absence of this regulation negatively influenced the fate of Video On Line. The economic literature affirms that the competitive advantage of new entries depends on their characteristics and on the timing of the telecommunications regulations (Clark, 1996; Ono and Aoki, 1998).

23 In addition to the intervention of the Authorities, reference is made to the specific national agreement between the Italian Association of Internet providers and Telecom signed on September 1999.

24 27 October 1999 is the first day of quotation of Tiscali stocks on the Italian New Market. Tiscali became the prime Internet Company at the Milan Stock Exchange, achieving, after only four months, a 1900% increase in the market value of its shares.

25 The linkages between Video On Line and Tiscali also emerge from recent interviews with Grauso: 'I have not invested a dime in Tiscali. But it's as if I were there myself'

(*Herald Tribune*, 23 November 1998); in other words it is as if there is a 'genetic continuity' between the two entrepreneurial projects.

26 In one interview, Soru stated (at the moment of the starting up of Tiscali): 'I bore in mind Video On Line's mistakes, for instance, that of thinking globally from the beginning. At the time, I worked, instead, to create strong roots in the island'.

27 It was estimated that the tariffs applied by Telecom underwent a downward revision in the range of 35%.

28 About the Internet business models see Drèze and Hussherr (1998); O'Donnell (2002); Wright (2001).

29 Tiscali was the third Italian company to sign the reverse connection agreements with Telecom Italia (concerning the interconnection schemes of the access of Internet-oriented telephone companies, see Wright, 2001). Tiscali exploited the mechanism of interconnection to obtain from Telecom Italia the payment of the so-called 'reversed access charge'. Free net users connect to Tiscali Pop, dialling the telephone numbers owned by Tiscali itself. The call, consequently, turns out to be made on a different network from Telecom Italia, which, therefore, must grant Tiscali a share of the fee charged from its own customer. In this way telephone-licensed ISPs have been able to offer their customers free Internet access (Manenti *et al.*, 2001).

30 Unfortunately, as we will state below, Soru's insight turned out to be only partly correct, in fact the revenue model was radically changed because of the unsatisfactory growth of on-line advertising in e-commerce development; this situation led Soru, three years later, as many interviews show, to revise his free-Internet philosophy.

31 Some of Soru's recent words can be recalled here (*The Wall Street Journal*, 17 January 2000): 'It's futile to try to be No.1 in Italy, we want to be No.1 in Europe'. And again: 'You either expand or die ... for me it doesn't make sense to be the strongest in Italy. Someone could buy me still bigger from the outside. We're trying to build the European version of AOL' (*Forbes Magazine*, 3 July 2000). All this does not imply that Soru had a design oriented to that goal from the beginning; actually, he has recently clarified 'I would lie if I said that I had broad insight from the beginning' (*La Nuova Sardegna*, 31 January 2001).

32 These acquisitions are analysed in Ferrucci and Porcheddu (2004).

33 Subsequently this European supremacy of Tiscali was regained by T-Online.

34 The number of ICT firms in the area of Cagliari in the Intermediate Census of 1996 was 435 and this leads us to estimate a growth of the number of firms inside the cluster of more than 51% in only five years.

35 Data refer exactly to the municipalities of Assemini, Cagliari, Decimomannu, Elmas, Monserrato, Quartu S.Elena, Quartucciu, Selargius, Sestu and Sinnai. In the same year, the population domiciled in those municipalities was of 371,847 inhabitants, with 1,77 ICT firms per 1,000 inhabitants.

36 For the case studies of Energit and Abbeynet, see Ferrucci and Porcheddu (2004), while for the case history of Akhela, see Murroni (2004).

37 The risk is that it actually concerns '... isolated success stories in [an] emerging [cluster] ... without considerable contribution to reach the critical mass necessary for a growing cluster' (Fornahl and Menzel, 2003).

38 At present, some interesting coordination initiatives are being developed within the Parco Scientifico e Tecnologico della Sardegna (Scientific and Technological Park of Sardinia), which also contains an incubator (called Internet Farm) addressed to dynamic and small local firms working in the ICT industries.

39 Specificities, in particular, are of great importance, while, on the other hand, it is true that: 'Although single cases should be merely heuristic rather than scientifically definitive, one alone is sufficient to refute conventional wisdom, rather as Karl Popper noted when a *black* swan was discovered in Australia' (Cooke, 2001: 945–46).

40 For other experiences about high-tech industries in emerging regions, see Arora *et al.* (2000, 2001); Wong and Ling (2001).

41 The Nobel Prize winner Rubbia evaluated several spin-off projects from CERN and preferred Cagliari to a city in Spain for the foundation of a centre for research and higher studies.

42 In a recent interview the director of the ICT division of CRS4 stated: 'Towards the end of 1989, I was at CERN in Geneva . . . when the director of the computing division . . . informed me of the Regione Sardegna's project of creating a research centre. The idea of the political authorities at the time . . . consisted in founding a research centre on advanced calculus, around which they would subsequently create a real technological and scientific park. So one day at CERN we received a delegation of Sardinian politicians and entrepreneurs, and I had the honour and the pleasure to show them some advanced findings in the informatics field. I remember my colleagues being rather sceptical about the possibility that Sardinian politicians were really so far-sighted and had known that the only way to relaunch the Island's economics and development was investing in intelligence' (Ferrucci and Porcheddu, 2004: 30).

43 Recently Ramasamy *et al.* (2002: 32) have termed this case a sort of 'brainchild' of the Malaysian Prime Minister's, and have explained the difficulties of the project of Multimedia Super Corridor (MSC) although 'The policy-makers have ensured that all institutional ingredients that have contributed to the success of the SV [Silicon Valley] are in the place at the MSC'.

44 As stated by a local entrepreneur who witnessed the various steps of the ICT story in the area of Cagliari: 'In the early 1990s the CRS4 was a research centre with good connectivity to the Web and it was far enough from the centres that mattered to be able to play with the Internet' (Ferrucci and Porcheddu, 2004: 76). This situation is reminiscent of the 'positive initial distance' of the Silicon Valley from established economic and political institutions in the emerging of the semiconductor industry (Saxenian, 1994).

45 Numerous problems can determine this economic failure, such as unsatisfactory market growth, absence of technological standards, regulation problems or inefficient local division of labour between companies.

46 Metaphors aside, the history of the Cagliari ICT is highly indebted to a number of 'great men' (and not only).

47 'Unfortunately, in the Cagliari area there are no signs of spontaneous cooperation among companies. Not only the firms surveyed have no permanent or structured links with other ICT companies in the area, but also no "systematic preference" for the services of the Sardinian ISP [Tiscali] has emerged from our findings' (Murroni, 2004: 43).

References

AGCM (Autorità garante della concorrenza e del mercato) (1996), 'Provvedimento n.4009 (C2404) Telecom Italia/Video On Line', *Bollettino dell'attività*, 25.

Arora, A., A. Gambardella and S. Torrisi (2001), 'In the Footsteps of Silicon Valley? Indian and Irish Software in the International Division of Labour', *SIEPR Discussion Paper n.00-041*, Stanford University, Stanford (CA), June.

Arora, A., V.S. Arunachalam, J. Asundi and R. Fernandes (2001), 'The Indian Software Services Industry', *Research Policy*, 30(8), 1267–87.

Arthur, W.B. (1989), 'Competing Technologies, Increasing Returns and Lock-In by Historical Events', *Economic Journal*, 99(March), 116–31.

Bellini, N. and A. Piccaluga (2000), 'The Role of University in Constituency-Building for Industrial and Territorial Innovation: Reflections on an Italian Experience', in R. Lopez-Martinez and A. Piccaluga (eds), *Knowledge Flows in National Systems of Innovation*, Edward Elgar: Cheltenham.

Borges, J.L. (1977), 'The Modesty of History', in J.L. Borges, *Other Inquisitions*, University of Texas Press: Austin [1952].

Bozeman, B. (2000), 'Technology Transfer and Public Policy: A Review of Research and Theory', *Research Policy*, 29(4–5), 627–55.

Breschi, S. and F. Malerba (2001), 'The Geography of Innovation and Economic Clustering: Some Introductory Notes', *Industrial and Corporate Change*, 10(4), 817–33.

Bresnahan, T., A. Gambardella and A. Saxenian (2001), 'Old Economy Inputs for New Economy Outcomes: Cluster Formation in the New Silicon Valleys', *Industrial and Corporate Change*, 10(4), 835–60.

Bronson, P. (1999), *The nudist on the late shift and other true tales of Silicon Valley*, Broadway Books: New York.

Business Week (1996), 'Europe learns to love the Net', 26 August.

Business Week (2000), 'E-business leaders', 7 February.

Clark, D. (1996), 'Adding Service Discrimination to the Internet', *Telecommunication Policy*, 20(3), 169–81.

Cohen, W.M., R. Florida, L. Randazzese and J. Walsh (1998), 'Industry and the Academy: Uneasy Partners in the Cause of Technological Advance, in R. Noll (ed.), *Challenges to Research Universities*, Brookings Institution: Washington, DC, 171–200.

Cooke, P. (2001), 'Regional Innovation Systems, Clusters, and the Knowledge Economy', *Industrial and Corporate Change*, 10(4), 945–74.

Cooke, P. (2004), 'The role of research in regional innovation systems: new models meeting knowledge economy demands', *International Journal of Technology Management*, 28(3/4/5/6), 507–33.

Cooke, P. and C. De Laurentis (2002), 'The Index of Knowledge Economies in the European Union: Performance Rankings of Cities and Regions', *Regional Industrial Research Report*, 41, Centre for Advanced Studies, Cardiff University: Cardiff.

Corrocher, N. (2003), 'The Internet Services Industry: Country-Specific Trends in UK, Italy and Sweden', in C. Edquist (ed.), *The Internet and Mobile Telecommunications System of Innovation*, Edward Elgar: Cheltenham.

CRENOS (Centre for North South Economic Research) (2004), *11° Rapporto sull'economia della Sardegna*, CUEC: Cagliari.

CRENOS (Centre for North South Economic Research) (2005), *12° Rapporto sull'economia della Sardegna*, CUEC: Cagliari.

Di Minin, A., M. Lazzeroni and A. Piccaluga (2003), 'HTSFs in Peripheral, Knowledge Intensive Areas: an In-Depth Analysis in Pisa', paper presented at *The Eleventh Annual High Technology Small Firms Conference*, Manchester (UK), 12–13 June.

Di Minin, A., M. Lazzeroni and A. Piccaluga (2006), 'Economic growth in emerging knowledge intensive areas: The high-tech cluster in Pisa', this volume, pp. 183–202.

Drèze, X. and F-X. Hussherr (1998), 'Financing the Internet: Four Sustainable Business Models', *Communications & Strategies*, 32(4), 171–95.

Etzkowitz, H., A. Webster, C. Gebhardt and B.R. Cantisano Terra (2000), 'The Future of the University of the Future: Evolution of Ivory Tower to Entrepreneurial Paradigm', *Research Policy*, 29(2), 313–30.

Feldman, M.P. (2001), 'The entrepreneurial event revisited: firm formation in a regional context', *Industrial and Corporate Change*, 10(4), 861–91.

Ferrucci, L. and D. Porcheddu (2002), 'Start-up and evolution of an ICT district: the Cagliari case', paper presented at the International Workshop 'Software in Emerging Regions', Sant'Anna School of Advanced Studie, Pisa, 28 September.

Ferrucci, L. and D. Porcheddu (2004), *La New Economy nel Mezzogiorno*, Il Mulino Editore: Bologna.

Financial Times (2000), 'Tiscali Unveils Financing Plains', 15 February.

Forbes Magazine (2000), 'An Italian Upstart Joins Those Aiming to Become Europe's AOL', 3 July.

Fornahl, D. and M.-P. Menzel (2003), 'Co-development of Firm Foundings and Regional Clusters', paper presented at the Conference on 'Clusters, Industrial Districts and Firms: the Challenge of Globalization', Modena (Italy), 12-13 September.

Fry, L.W. and B.O. Saxberg (1987), 'Homo Ludens: Playing Man and Creativity in Innovating Organizations', *Discussion Paper of Department of Management and Organization*, University of Washington.

Godin, B. and Y. Gingras (2000), 'The Place of Universities in the System of Knowledge Production', *Research Policy*, 29(2), 273–78.

Herald Tribune (1998), 'A Sardinian Everyman Takes on Telecom', 23 November.

Il Mondo (1995), 'Il caso informazioni elettroniche la scommessa di Nicola Grauso va su Internet ma all italiana', 6 November.

Il Mondo (1996), 'Imprese e affari gruppo Grauso. dietro la scelta di vendere Video On Line', 13 April.

Il Sole24Ore (1994), 'Nasce il primo quotidiano interattivo', 7 December.

Infantino, L. (1998), *Individualism in Modern Thought: From Adam Smith to Hayek*, Routledge: London, New York.

Isiline Magazine (2000), 'Niki Grauso: ⟨⟨No ai portali, acquisto domini⟩⟩, 1.

La Nuova Sardegna (2001), 'Soru: opportunista e un pò filibustiere', 31 January.

Maillat, D. and J. Vasserot (1988), 'Economic and Territorial Conditions for Indigenous Revival in Europe's Industrial Regions', in P. Aydalot and D. Keeble (eds), *High Technology Industry and Innovative Environments: the European Experience*, Routledge: London, 163–83.

Manenti, F. M., A. Nicolò, P. Tedeschi and P. Valbonesi (2001), 'Caso AIIP vs Telecom Italia: nuovi mercati, antiche condotte', *Economia e Politica Industriale*, 112(28), 191–204.

Mansfield, E. (1998), 'Academic Research and Industrial Innovation: An Update of Empirical Findings', *Research Policy*, 26(7–8), 773–76.

McKendrick, D.G., R.F. Doner and S. Haggard (2000), *From Silicon Valley to Singapore. Location and Competitive Advantage in the Hard Disk Drive Industry*, Stanford University Press: Palo Alto (CA).

Mises, L. (1966), *Human Action: A Treatise on Economics*, Henry Regnery: Chicago (third edition).

Mongili, A. (1998), 'Modelli di innovazione e politiche dell'innovazione. Alcune considerazioni sul caso del Parco Scientifico e Tecnologico della Sardegna', *Quaderni del Dipartimento di Ricerche Economiche e Sociali (sezione sociologia)*, University of Cagliari, July.

Moore, G and K. Davis (2001), 'Learning the Silicon Valley Way', *SIEPR Working Paper*, Stanford University, Stanford (CA).

Murroni, C. (2004), 'ICT and local development: A case study of metropolitan area of Cagliari', *CRENOS working papers*, 2004/19, CRENOS, Cagliari, December.

Nelson, R.R. (2001), 'The Coevolution of Technology and Institutions as the Driver of Economic Growth', in J. Foster and S.J. Metcalfe (eds), *Frontiers of Evolutionary Economics. Competition, Self-Organization and Innovation Policy*, Edward Elgar: Cheltenham, 19–30.

O'Donnell, S. (2002), 'An Economic Map of Internet', *Working Paper of Center for e-Business@Mit*, Sloan School of Management, Massachussets Institute of Technology, 162.

Oakey, R. and W. During (eds) (1998), *New Technology-based Firms in the 1990s*, Paul Chapman Publishing: London.

Ono, R. and K. Aoki (1998), 'Convergence and New Regulatory Frameworks', *Telecommunication Policy*, 22(10), 817– 38.

Pelcovits, M. and V.G. Cerf (2003), 'Economics of the Internet', in G. Madden (ed.), *Emerging Telecommunications Networks. The International Handbook of Telecommunications Economics*, Vol. 2, Edward Elgar: Cheltenham.

Piccaluga, A. (2003), 'Il distretto tecnologico: lo strumento, le potenzialità, le esperienze', paper presented at the Conference 'La ricerca nelle strategie di sviluppo del Mezzogiorno', Rome, 13 November.

Popper, K.R. (1990), *La scienza e la storia sul filo dei ricordi*, Jaca Book – Edizioni Casagrande: Bellinzona, CH.

Porter, M.E. (1998), 'Clusters and the New Economics of Competition', *Harvard Business Review*, 76(6), 77–90.

Ramasamy, B., A. Chakrabarty and M. Cheah (2002), 'Malaysia's Leap into the Future: An Evaluation of the Multimedia Super Corridor', *CEABuR Reaserch Paper Series*, n.8/2002, Nottingham University Business School, Malaysia Campus, Kuala Lampur, Malaysia.

Rosenberg, N. and R.R. Nelson (1996), 'The Role of Universities in the Advance of Industrial Technology', in R.S. Rosembloom and W.J. Spencer (eds), *Engines of Innovation: US Industrial Research at the End of an Era*, Harvard Business School Press: Cambridge (MA).

Ruggiero F. and R. Van Kleij (1994), 'On-line Hypermedia Newspapers: an Experiment with L' Unione Sarda', *International Journal of Modern Physics C*, 5(5), 899–905.

Sarasvathy, S.D. (2001a), 'Effectual Reasoning in Entrepreneurial Decision Making: Existence and Bounds', *Academy of Management Best Paper Proceedings*.

Sarasvathy, S.D. (2001b), 'Causation and Effectuation: Toward a Theoretical Shift from Economic Inevitability to Entrepreneurial Contingency', *Academy of Management Review*, 26(2), 243–88.

Saxenian, A. (1994), Regional Advantage. *Culture and Competition in Silicon Valley and Route 128*, Harvard Business Press: Cambridge (MA).

The Wall Street Journal (1999), 'Making Waves', 11 October.

The Wall Street Journal (2000), 'Tiscali Seeks to Acquire Stake in Web Arm of Sanpaolo IMI', 17 January.

Time Digital (1996), 'World Watch. From Sardinia to Malaysia, Computer Technology is Inundating the Planet with Bytes and PCs', *Time Digital – Time's Technology Supplement*, 23 September.

Unioncamere (2005), 'Ricerca e sviluppo – Terza giornata dell'economia', paper available online at the following URL: http://www.starnet.unioncamere.it/intranet/Area-Terri/Lucca/Documenti/Giornata-E2/Consuntivo/ricerca-e-sviluppo.xls_cvt.htm.

Wong, J. and N.S. Ling (2001), *China's Emerging New Economy: the Internet and Electronic Commerce*, Singapore University Press: Singapore.

Wright, J. (2001), 'The ISP Reciprocal Compensation Problem', *CRNEC Working Paper*, University of Auckland (NZ).

11 Cooperation networks and regional development

Case of multisectoral partnership for innovation

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Introduction

In economic systems, the interaction between various actors allows for the sharing of knowledge, and this, in turn, results in increased productivity and efficiency. However, in contexts more inclined to promote competition than to nourish interaction and cooperation, this is difficult and costly. Interactions are sporadic and knowledge sharing infrequent, thus increasing the value of knowledge as a competitive factor. It can be argued that this is one of the building blocks of the *Knowledge Economy*, where knowledge has arisen as an ephemeral good, whose value increases with usage and whose most important characteristic is its capacity to promote further learning and ensure rapid technological innovation that renovates constantly the economic knowledge base (Norcia, 2002).

In this framework, the *Systems of Innovation* approach (Freeman, 1987 and Lundvall in Dosi *et al.*, 1988) has been increasingly developed and used to elucidate and stimulate both knowledge processes and innovative behaviours. The regional theory of Systems of Innovation (Cooke, 1996, 1997, 2004) evolved into a widely used analytical framework that highlights the importance of geographical and cultural proximity and interaction between relevant actors for the efficiency of knowledge processes.

In what concerns the interaction between actors, cooperation networks have served as an efficient instrument to increase knowledge flows at a regional level and, consequently, help invigorating the Regional System of Innovation (Asheim and Coenen, 2004). When these networks involve complementary economic actors from different industries and, desirably, Science and Technology institutions, better conditions are created for innovation, due to higher cultural, technical and *Weltanschauung*[1] diversity between the actors (Nelson and Rosenberg, 1993; Freel, 2000). This type of arrangement, when successful, might fill in system deficiencies, which make them attractive for policy-makers.

We look later in this paper into a multisectoral network which congregates firms and a Science and Technology institution. The network promotes innovation in the habitat field and is based in the Aveiro Region, Northwest Portugal.

We analyse the effects it may have in the reinforcement of the Regional System of Innovation. In the end, we suggest some strategic policy guidelines that could lead to the proliferation of such innovative networks and, in the process, stimulate and enhance the Regional System of Innovation.

Knowledge processes in the new economy

In the last decades, information and knowledge have become key concepts in economic and social development analysis. The fast-paced evolution of information and communication technologies (ICT) makes the dynamics of information and knowledge difficult to understand by firms and individuals. In fact, the associated terminology is sometimes unstable and even ambiguous.

Information, for example, is considered by some to be a group of data,[2] processed and linked in a way that makes sense to the receiver (Whitten *et al.*, 2004; Wilson, 1997; Laudon and Laudon, 2002; Krogh *et al.*, 2000; Nonaka and Takeuchi, 1995; Davenport and Prusak, 1998). It is a kind of message, whose significance depends on the sender, on the communication channel and on the interpretation given by the receiver (Saur, 2005). The significance of the same group of data may differ from one receiver to another due to distinct *Weltanschauungen*.

Knowledge has recently been looked upon as a fluid, dynamic mixture of values, behaviour, and contextualized information that is created in the very moment of its application (Davenport and Prusak, 1998); as an image of reality created and justified by the necessity to act upon that same reality (Krogh *et al.*, 2000); as an intangible, unpredictable and constantly evolving item (Nonaka and Konno in Cortada and Woods, 1999; Krogh *et al.*, 2000).

Differently said, knowledge is a dynamic and spontaneous interpretation of existing data and information by its human owners, which emerges from their *Weltanschauung*, depends on the context and results from a necessity to act, decide and/or understand a given situation. Knowledge reveals itself as an interpretative framework, which keeps on incorporating for future usage the data and information that it has been interpreting (Saur, 2005). Knowledge is a reaction to the need to interpret specific information or to a stimulus from the world; it is anthropocentric, dependent on individual experiences, and reflected in exclusive behaviour.

Data, information and knowledge are, therefore, related (see Figure 11.1 for one possible perspective,[3] focused on the role of human experience and values in knowledge creation and development), and uniquely distinct. For instance, apparently unrelated items (i.e. data) out of context have no meaning to an individual (e.g. Aveiro; 6; 10). When related, organized and put in context, they become explicit and useful, turning into information (e.g. Today in Aveiro: Minimum temperature: 6°C; Maximum temperature: 10°C). Yet, the context, the interpretation given to this information and the subsequent reaction (i.e. knowledge) are different and depend on individual *Weltanschauungen* (e.g. some will wear a shirt and jacket; others will put on a warm sweater).

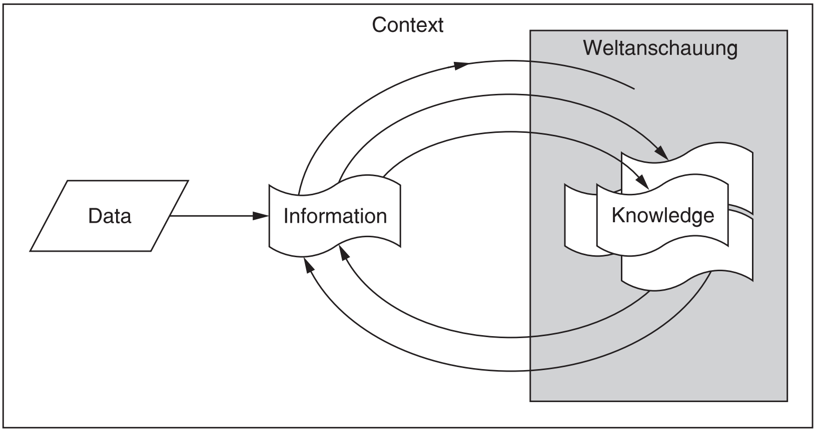

Figure 11.1 Data, information and knowledge.

Information and knowledge differ in many ways and essentially diverge in their transfer propensity. Whilst information can be easily codified, stored and transmitted by physical means (paper, digital format, etc.), knowledge is a pure human process, dynamic, evolving, amenable to transmission only through interactive communication between individuals.[4] In this sense, the transfer of knowledge is intimately related with human interaction. Though, for specific knowledge to be transferred it needs to be visible and explicit to the other individual; it requires comprehension of the specific context in which it was manifested, both in terms of what generated knowledge and in terms of what were the effects of knowledge onto this context. One may say that knowledge was transmitted only after successful utilization occurred in similar context, validating the learning process.

This holds true in economic systems. The interaction between the various actors that compose these systems allows for the sharing of knowledge, and this, in turn, results in increased productivity and efficiency. However, this is difficult and costly since it goes against the nature of a system that is more inclined to promote competition than to nourish interaction and cooperation. The evolution of ICT has helped overcoming some barriers to knowledge transfer. Yet, even during the richest digital interaction (e.g. videoconference), participants only perceive the context and interpret the behaviour of others based on text, image and sound, whilst the other human modalities cannot be used. With the recent progress of artificial intelligence and virtual reality, new gateways are open but, as a matter of fact, a lot more progress needs to be made in order to allow effective knowledge sharing processes using ICT (Saur, 2005). This reinforces the importance of rich face-to-face human interactions for efficient knowledge sharing. In a 'knowledge-based economy', the difficulties in transmitting and disseminating knowledge make it rare, and thus important as a competitive factor.

The 'knowledge economy' appears as an all-encompassing metaphor related to the competitiveness of contemporary economies. It emphasizes the increasing importance of knowledge-intensive products and services in sustainable competitiveness of firms, regions and countries.

Cooke (2004) defines the knowledge economy as 'an economy in which more than 40% of employees are employed in high-technology manufacturing and in knowledge intensive services'. It is hard to decide if this is really a definition or rather a target that modern economies should aim at or exceed. As a matter of fact, the phenomenon is not exclusively economical: as David and Foray (2002) point out, 'society as a whole [. . .] is shifting to knowledge-intensive activities'.

Some authors argue that the knowledge economy is intimately linked to the optimization of knowledge processes, mainly those concerned with knowledge creation and utilization and with the incorporation of knowledge in economic activities, requiring improved connectivity amongst economic agents (Adhikari and Sales, 2001). The knowledge economy is based on knowledge as a primary economic resource, subjected to highly dynamic environments where knowledge is quickly created, accumulated and depreciated in terms of its economic relevance (Fong, 2003).

Systems of innovation: a framework where knowledge and innovation converge

In the framework of this 'new economy', the concept of '*Systems of Innovation*' has been increasingly used to deal 'explicitly with knowledge creation, distribution and utilization as the key component of analysis' (Chang and Chen, 2004: 18).

This systemic approach to innovation provides instruments to analyse the interdependencies of innovation processes, such as the ways in which actors combine and manage available information and knowledge in order to innovate.[5] This notion implies an open and wide vision of innovation as a social and technical process, but also as an interactive learning process between firms and their environment, ensuring social and territorial integration together with cultural and institutional context (Lundvall, 1992).

This leads to the inclusion of a large number of interacting people and organizations in the innovation generation process and also to the expansion of a variety of innovative industry sectors, firms and regions (Seufert *et al.*, 1999; Szeto, 2000). The performance of all these actors plays a crucial role in innovation dynamics and leads to the concept of National Systems of Innovation as: '. . . elements and relationships which interact in the production, diffusion and use of new and economically useful knowledge' (Lundvall, 1992).

The literature on innovation systems has grown significantly in the last decade and various types of Systems of Innovation have been identified, based upon the assumption that the characteristics of each territory/situation ask for different perspectives and conceptual frameworks. Chang and Chen (2004) recognize three categories of such systems: (1) National Systems of Innovation (NSI); (2) Technological/Sectoral Systems of Innovation (TSI/SSI) and (3) Regional

Systems of Innovation (RSI) – which we describe briefly in the following paragraphs.

The NSI, described by Lundvall (1992), provided the basis for the earliest theoretical and applied studies, which revealed that different countries have different innovation systems, due to the idiosyncrasies of their economic structures, knowledge bases and institutions. The NSI include organizations and institutions that, acting at national level, determine the nations' innovative capacity. The systemic knowledge flows that promote innovation occur between various actors, such as companies, universities, government, public organizations, schools, financial institutions, workers unions, industrial associations, etc. Some studies suggest that flows and interactions are particularly relevant among the elements of the Triple Helix, namely universities, companies and governmental institutions (Chang and Chen, 2004; Etkowitz and Leydesdorff, 1997). In any case, they depend on institutional routines and social conventions accepted at national level.

The TSI focuses on technological flows between key elements, mainly: networks, institutional infrastructures and economic competence (Carlsson and Stankiewitcz, 1991), whilst the SSI approach is based on the specific dynamics of sectors and may reach across national borders, as part of a wider, global economy. In these cases, the knowledge flows are analysed at the level of technological interactions between actors of a specific economic/industrial area (Breschi and Malerba in Edquist, 1997).

The RSI emerged as a response to the increasing importance of the 'local supply of managerial and technical skills, accumulated tacit knowledge, and knowledge spill-over' (Chang and Chen, 2004) and evolved into a widely used analytical framework which constitutes an empirical foundation for innovation policy making (Doloreux and Parto, 2004). Cooke *et al.* (1997) identify the main elements of RSI: financial capacity, institutional learning and productive culture.[6] The RSI approach stresses that 'a successful innovation system needs to develop a collective identity' which activates social capital and enhances regional innovation capability (Chang and Chen, 2004). Moreover, it highlights the importance of geographical and cultural proximity for the efficiency of institutionalized relationships as sources of innovation and focus of knowledge processes (Chang and Chen, 2004). Knowledge sharing and spill-over are facilitated in these systems, due to the higher probability of face-to-face interaction and to the higher homogeneity of regional institutions. Therefore, the RSI approach arises as a framework to analyse innovative and economic performance regionally and to some extent technologically and sectorally and provides a valuable policy instrument to enhance localized learning processes and sustain regional innovation processes (Asheim *et al.*, 2003; Asheim and Coenen, 2004).

We argue that this last approach (RSI) allows for the specialization and development of regions, whilst keeping their identity and culture. We also claim that at this level, innovation appears as a valuing factor of the specificity of each region, facilitating competition by regional differentiation. Innovation can be more easily stimulated and new knowledge created, utilized and disseminated within the geographically delimited space and homogeneous cultural environment of a given region.

Cooke *et al.* (1997) suggest some crucial cultural success factors for an RSI: (1) culture of cooperation; (2) associative governance; (3) ability and experience to carry out institutional change; (4) coordination and public/private consensus; (5) productive culture with sub-elements of labour relationships, cooperation at work, company responsibility for society, and productive specialization; (6) existing interface mechanisms located in scientific, technological, productive and financial fields.

Actually, the relationships between the actors of a RSI frequently take the shape of cooperation networks, a form of organization that tends to reinforce the knowledge processes shared in the network, whilst promoting creative processes and innovation. It is important to underline that the learning processes associated with cooperation networks are not limited to regional boundaries, but are increasingly connected to other entities and systems of innovation (at a regional, national or international level) (Asheim and Coenen, 2004). As a matter of fact, successful cooperation initiatives and processes often arise in local networks with various externalities to more distant entities or systems of innovation, as this allows for more effective updating of their knowledge bases. This is particularly important when dealing with cooperation networks aiming for innovation and new product development, which frequently require the combination of external and endogenous skills and competences (Asheim and Herstad in Asheim and Mariussen, 2003; Cooke *et al.*, 2000; Bathelt *et al.*, 2004).

The role and importance of such networks in the optimization of knowledge and information flows is central to this paper, and is explored further in the next section.

Cooperation networks: knowledge flows optimization and innovation

The participation in cooperation networks stimulates and reinforces innovative attitudes within firms, as actors have access to wider sets of information and knowledge and face with more circumstantial diversity. Considering networks' configuration and the compromise they represent for the different participating firms and organizations, it can be argued that they provide learning-by-interacting opportunities. Strategically, networking needs to be understood as a permanent activity of a firm and to become an implicit element in its continuous decision-making processes. Networks provide an important framework for more effective innovation processes, since they facilitate and speed-up information and knowledge access, sharing and diffusion. Furthermore, they represent attractive organizational solutions for firms, due to their low overhead costs, good responsiveness and flexibility and adequate operational efficiency.[7]

Networks seem to benefit members in ways that transcend individual efforts. First, networks tend to reduce firms' transaction costs. This is due, in part, to fluid information exchanges between firms, which are closer, benefit from common communication channels and use the same language. Relevant information about good partners or economic agents (clients, suppliers and competitors) is shared easily. In addition, networks may constitute a mechanism to reduce uncertainty and tend to discourage opportunistic behaviours. These aspects are intimately related to the reinforcement of confidence and reciprocity between members of networks. Second, networks tend to facilitate the access to strategic information and knowledge, namely in what concerns markets, technologies, and new products, materials and processes. The very elements of the network filter the information they receive and share, facilitating the processing of large flows of information. Additionally, networks are propitious environments for firms to reveal their new products and services. Thus, joint competences and resources add value and generate benefits that a single firm could hardly achieve. Third, networks may lead to production rationalization. This happens because networks function as a structural element of the supply chain, taking advantage not only of economies of scale and variety in production but also of the competence range provided by the actors involved, which exceeds the capacities of each individual actor. Synergies do result from this process (Seufert *et al.*, 1999; Hamalaien and Schienstock, 2000; Arias, 1995; Akkermans, 2001).

Consequently, networks appear to be a privileged instrument to nourish innovative behaviours amongst their members (Seufert *et al.*, 1999) and they can be seen as learning experiments, a response to the appropriability of key knowledge (Cibora, 1991). Besides, the processes of knowledge creation and recombination and consequent innovation tend to become more efficient when actors/individuals with completely different backgrounds (i.e. actors from different industrial sectors or from different communities of practice) share their knowledge and experience. Consequently, cooperation between actors from diverse organizations with distinct activities and backgrounds is seen as an important factor in stimulating product, process and organizational innovation (Seufert *et al.*, 1999; Szeto, 2000). These arrangements can ensure multidisciplinary competence crossing and sharing of information (Freel, 2003). The knowledge resulting from these processes can be shared within the organization, stored or used by knowledge workers to create new products (Nonaka and Takeuchi, 1995). Seufert *et al.* (1999) emphasize the role of the network in knowledge creation and transfer, considering it as a privileged place for such processes while accelerating the innovation rate.

It is also argued that the complementarity of actors triggers mechanisms of growth and leads to more radical innovations (Malerba, 2002). Even 'diagonal networks', made up of actors with complementary competences acting in different sectors, have been emerging in the last decade (Shapiro, 2002). As innovations in one sector can spill over to other sectors (Dietzenbacher, 2000: 28) and ensure first mover advantage, firms have much to gain from multisectoral cooperation networks. Additionally, multisectoral cooperation processes may provide better conditions to elude the communication constraints associated with single-sector competitive environments (Szeto, 2000 and Shapiro, 2002). One may say that local and multisectoral cooperation networks provide better conditions for competence diversity and the wide set of information and knowledge required to innovate, due to higher cultural, technical and *Weltanschauung* diversity between their actors.

Consequently, multisectoral cooperation networks may be extremely successful in promoting innovation and may lead to sustainable technological development in participating firms (Nelson and Rosenberg, 1993). The involvement of scientific and technological (S&T) institutions brings to these cooperation networks up-to-date and easily searchable information sources, as well as multidisciplinary human resources (Westhead and Storey, 1995) that allow vigorous competence crossing. They are an important source of new scientific knowledge (Lofsten and Lindelof, 2005). And, although relationships between S&T institutions and firms are not pain-free, they can help overcome organizational limitations and promote successful innovation. S&T institutions look for sponsorship from firms for their basic R&D processes and the firms themselves seek to apply the results of this research to launch new products (Szeto, 2000; Lofsten and Lindelof, 2005). The cooperation for innovation of firms from various sectors and S&T institutions leads both to incremental and radical innovation and ensures that firms' tactics are in line with medium and long range strategic goals centred on innovation.

We claim that multisectoral networks, whose actors belong both to the industrial fabric and S&T institutions, may be particularly effective[8] in optimizing knowledge processes and consequently invigorating the RSI. These networks are more complex and rarely occur spontaneously. Many such networks fail due to organization and management shortcomings and, when successful, they are regarded as idiosyncratic elements, especially in geographical contexts characterized by low cooperation processes (Arias, 1995; Akkermans, 2001; Morreira and Corvelo, 2002).

Moreover, we believe that the presence of regional policy mechanisms that better promote the emergence and success of multisectoral networks with such specificities could help overcome these shortcomings and lead, indirectly, to the invigoration of the RSI. The institutions responsible for regional policies thus look closely at this type of network configuration, broader in terms of scope and based on diversity, coherence and complementarity, using them to help overcome the structural deficiencies of the RSI.

The most recent tendencies of regional innovation policies are based on integrated development perspectives and include strong strategic interventions. These policies aim at linkages between a coherent and diverse core of activities supported by long term strategic visions, whose importance is recognized by the actors of the RSI. Furthermore, these policies are based upon cooperation/communication between public and private actors, thus filling in some of the gaps of the RSI that public bodies alone tend to disregard (Raines, 2001; OECD, 1999).

We will look next into a specific, regionally based, multisectoral network involving firms and a S&T institution that promotes innovation in a multisectoral field, the habitat. We will also suggest policy guidelines that could lead to the proliferation of such networks and in the process stimulate and enhance the RSI.

The 'House of the Future' network: a multisectoral cooperation initiative

Brief overview

We next describe and analyse a multisectoral cooperation network, centred on the habitat meta-sector. We argue that this network invigorates the RSI of the Aveiro Region, in Northwest Portugal, to which most network members belong.

The Aveiro Region is located in the northern coastal strip of Portugal. It shows high economic vitality, and hosts a dynamic university and significant administrative and industrial support services. Entrepreneurial spirit is quite strong and there are a large number of export-oriented small and medium-sized firms (SME). However, like other regions, Aveiro is quite heterogeneous, exhibiting strong and weak attributes linked to the evolution of its industrial basis.

One can find in the region a number of building construction industry agglomerations. These industrial agglomerations are the outcome of overlapping local concentrations of firms, sharing the same labour pool and the same technical culture. They have the potential generally associated with spatially concentrated industrial clusters, generated by a process of extensive growth based on productive imitation.

Most of the firms employ traditional production processes and equipment, supporting their competitive advantage more on price than on technology and innovation-based differentiation. Competitiveness is mainly built upon the capacity to acquire exogenous technology and to adopt incremental innovations. In this, they reflect the attitude of the habitat meta-sector, which in turn mirrors the conservative demands of the buying public (Alves *et al.*, 2004a, 2004b; Marques, 2004). One may argue that the innovative effort of firms is mainly guided by reactive behaviour to external and internal pressures, rather than by a proactive attitude dictated by clear competitive strategies.

This type of behaviour is deeply rooted in the very characteristics of the regional industrial fabric, mainly: a large number of SME which lack the critical dimension required to innovate; the general lack of a qualified workforce and managers; the individualistic behaviour of firms; the scarcity of collaborative initiatives between firms and other innovation-support institutions (Castro *et al.*, 1998; Marques, 2004).

These characteristics constitute important barriers to the free flow of information and to the development of knowledge and learning processes indispensable for a knowledge economy and for the subsequent innovative environment.

In this context, and as a result of an initiative to promote cooperation for innovation between elements of the RSI (ADRI initiative – see Alves *et al.*, 2004c, 2004d, for more details), a cooperation network called 'House of the Future' emerged. In 2005, it included 11 firms belonging to the habitat meta-sector, and the University of Aveiro.

The network exists, on a self-funding basis, since 2000. In 2002, it evolved into a formal association called AveiroDOMUS and adopted an ambitious programme that aims at conceiving, constructing, maintaining and using a building called 'House of the Future'.

The programme contemplates three major phases:

1. **'House of the Future' Project** – a two-year initiative, seeking to create all necessary conditions to build the 'House of the Future', mainly the preparation of architectural and engineering blueprints and the development of innovative products and solutions (see Alves *et al.*, 2004a, for further details on this aspect).
2. **'House of the Future' building** – the actual construction of the first version of the House, including installation and use of the innovative products and solutions developed in the previous phase.
3. **'House of the Future' update and maintenance** – continuous process of updating the House with more innovative products and solutions, ensuring that the house will always be 'of the future'.

National authorities considered that this programme was an important instrument to promote the innovative capacity of the associated firms; furthermore, it was recognized that it can play a significant role in regional development and in the uptake of innovative attitudes by the habitat meta-sector. Accordingly, the first phase was co-financed by public funds.

Impact on the RSI

The 'House of the Future' initiative has been playing an important role in the RSI of Aveiro, and can serve as inspiration for regional policy measures focused on innovation. We analyse the potential of the initiative according to four different dimensions.

Attraction of new actors, knowledge creation and competence development within the RSI.

The 'House of the Future' initiative has been influencing the development of new scientific and technological competences related to the habitat, mainly in two ways:

1. The university created a programme centred on the habitat meta-sector, which focuses on both the development of R&D initiatives (thesis, dissertations, thematic R&D projects) involving students, researchers from various departments of the university and also firms belonging to the region, and on the education of regional human capital, essentially through postgraduate studies. Between 2003 and 2004, 11 master theses related to the 'House of the Future' initiative have started. A special programme focused on designing products for futuristic dwellings took place in the Communication and Art Department in 2004, and resulted in ten design projects presented to the firms belonging to the network.

These promising results encouraged the university to prepare a new multidepartmental Master's programme on new materials, solutions and technologies for the habitat. The Master was designed to function under an innovative umbrella providing lifelong learning opportunities to professionals from the habitat field. This contributes to the reinforcement of a richer knowledge base shared with the regional fabric, constantly updated by the academia and able to provide highly qualified human resources.

2 One of the activities developed in the framework of the 'House of the Future' has been the creation of multidisciplinary and multisectoral teams, in all the areas required to conceive and design the blueprints of the future house. This involves around 70 individuals, from the university and from industry and is supporting the development of cross-disciplinary skills and competences. The emphasis is on a 'horizontal perspective' that looks at the house as an integrated product that requires efficient communication between areas of speciality which mutually influence each other but that usually live in isolated corners.

The promotion of the activities of the network, one of the key preoccupations of the 'House of the Future' initiative, has been increasing its visibility and that of the region as a whole. The initiative has been covered by a number of national newspapers and magazines. A special role is being played by the University which is disseminating the initiative through a dedicated Web site,[9] a Newsletter,[10] communications and scientific papers presented both nationally and internationally. In time, this affects the attraction capacity of the region outside its borders due to the image of an indigenous, well-functioning and innovative meta-sector of the habitat; this helps reinforce the technical knowledge available in the region and its potential for innovation and competitive differentiation.

Linkages between actors of the RSI

At this level, the network has strengthened the internal linkages between network elements, as a result of:

1 Frequent formal (e.g. Strategic Meetings, Management Meetings) and informal encounters (e.g. lunches, firms' visits) between the representatives of network members that allowed the creation of a climate of trust and facilitated common business processes and relevant knowledge and information sharing. The personality and experience of the Project Manager and his ability in obtaining consensus after an intensive knowledge-sharing session or in overcoming communication problems have shown to be critical to ensure pleasant meetings and open communication.
2 Joint multidisciplinary teams focused on new products, systems and concepts related to the habitat, involving, on average, seven disciplinary specialists, i.e. academics and professionals from industry.

3 Creativity sessions focused on the conceptual model of the future house, aiming also to identify new product concepts using cross-sectoral perspectives. These sessions were carried out both in the university, involving around 30 professors from ten different departments, and in five firms, involving employees as well as top executives.

Additionally, the network encourages linkages of its members with external actors. We point out three types of external linkages: inter-firm, university–industry and inter-institutional linkages. This happened in the following situations:

1 The current members of the network have continued to cooperate with former members (that have left the association), as a result of trust and common interests developed during their membership. This extended the time frame of those linkages, both in terms of business deals and relevant information and knowledge sharing.
2 Due to the nature and objectives of the network, one of the top banks in Portugal accepted to provide the network with working capital under very favourable conditions before public co-financing can be made available for the 'House of The Future' Project. This was justified by the importance and credibility of the network at regional level.
3 The existence of the network and the creation of a structure inside the University that helps with partnerships between firms and academic researchers have facilitated the development of joint R&D and new product development projects linked to the habitat.

Moreover, one of the objectives of the 'House of the Future' initiative is the development of new horizontal products, which necessarily implies cooperation between firms of different sectors. Multisectoral teams have thus been created and have been actively cooperating, which is not common in the meta-sector of the habitat.

The University has reinforced its image in the RSI as an important S&T institution that values cooperation with industry and supports innovation processes. This made both the university and regional firms more receptive to other linkages/cooperation arrangements in the future, increasing the probability of their success.

Creation and strengthening of innovation support structures within the RSI

Networks contribute to innovation promotion within regions, yet frequently fail due to management and coordination difficulties. The 'House of the Future' network is considered a success as it has been operating for six years, outliving the life expectancy for these cases (Moreira and Corvelo, 2002). It has been stimulating the innovation capacity of the involved firms and establishing new bridges between them and academia. A cohesive core of participants has been created and trust was developed, as a result of regular interactions between network members and of joint successful enterprises.

The challenge to develop new products to be incorporated into the House of the Future revealed that member firms faced great difficulties, and sometimes were unable to assemble and maintain internal development teams devoted to this task. This led to the creation of a new product development unit that operates as an arm of the association. This unit is composed of one architect, five engineers and one designer; it is responsible for the conception, design and engineering of new products and works intimately with the internal development teams of the firms in the network. If successful, this unit might offer its services to the market, and thus fill an important gap in the RSI.

Furthermore, all activities developed under the framework of the 'House of the Future' project are accompanied by a technical monitoring body. This is a new group, involving both private and public institutions, S&T organizations, industrial and sectoral associations; it looks closely at this initiative and draws best practices that could be adapted and duplicated to increase the efficiency of the RSI.

Alteration of institutions/behaviours in the RSI

Just by participating in the network and being faced with clear deadlines and tangible challenges for the development of new products and sometimes radical innovations, firms in the network are reinforcing the role and visibility of innovation in their strategic objectives and organizational routines.

The University has included the promotion of academic activities linked to the habitat in its strategy, and it has at the same time reinforced interdepartmental cooperation.

The 'House of the Future' initiative allowed for the identification, creation and dissemination of mechanisms to facilitate innovation processes. These include the creation and testing of new methodological approaches (creativity methods, new product development techniques, etc.) inspired in the multidisciplinary nature of the working teams and the complexity of the overall 'House of the Future' initiative. For instance, academic researchers developed a specific new product development methodology for complex multidisciplinary projects, using a double approach of literature review and continuous testing. Between 2004 and 2005, different approaches to creativity and fuzzy front-end product development have been applied, resulting in a catalogue with nearly 700 innovative ideas for the House of the Future.

The development of new products linked to the habitat and the opportunity to test and disseminate R&D and innovation induced results in a 'laboratory' (i.e. the House of the Future) open to the public may also change perceptions and lead visitors to accept the advantages of multisectoral development and cooperation. It may lead to imitative behaviours within the region and help with the adoption of innovative attitudes and dispositions in various sectors unrelated with the habitat.

Moreover, the adoption of a formal Intellectual Property Rights and 'good conduct' code by the network members has reinforced mutual trust and confidence. This code was instrumental in overcoming the traditional fear that ideas can be stolen if shared, and thus contributed to more openness and more frank knowledge and information flows.

Some innovation policy guidelines

As mentioned above, coherent localized multisectoral cooperation networks, involving both S&T institutions and representatives of the productive fabric may serve as an inspiration source for regional policies. Yet, they need to be based on the specificities of the region and take into account the various dimensions of the RSI: the actors, their specific competences, the linkages between them, the adjustment between the RSI and the productive fabric and the efficiency, coherence and visibility of the system.

This perspective is supported by the 'House of the Future' initiative, which in spite of the embryonic phase provides inspiring insights for strategic regional interventions aimed to strengthen the habitat meta-sector and the Aveiro RSI. As its functioning impacts both on the institutions and on the actors/organizations of the Aveiro RSI, we believe that governmental intervention may facilitate/speed up the process of expanding the current network to more industrial sectors (n.a. linked to the habitat). We also believe that it may lead to a wider proliferation of attitudinal changes amongst the participants and remaining actors of the RSI and of the innovation support structures based on regional knowledge complementarities that fill in existing gaps (ex. new product development joint structures, co-ownership active interfaces between academia and industry, etc.).

Possible policy guidelines[11] may be drawn on this rationale, oriented towards:

- The promotion of multisectoral cooperation networks around charismatic themes, capable of attracting actors belonging to a variety of sectors.
- The promotion of debates about multisectoral and multidisciplinary partnerships (involving firms and S&T institutions), favouring the dialogue and trust between the various actors.
- The strengthening of inter-firm cooperation arrangements based on projects that lead to new product development that influence horizontal sectors.
- The creation of mechanisms that help disseminating good practices of multisectoral innovation.
- The creation of mechanisms to articulate R&D, education and training to reinforce complementarities within the regional productive fabric.
- The promotion of instruments that ease the dissemination of and access to relevant information for innovation (patents, technological trajectories, etc.).

Conclusions

The RSI approach has been increasingly used to elucidate knowledge processes and innovative behaviour, which makes it an interesting framework for analysing aspects associated with knowledge economies.

Multisectoral cooperation networks for innovation built on the attributes of a geographically delimited industrial fabric, and involving S&T institutions, enhance the efficiency of a particular RSI. We illustrated this with the 'House of the Future' network, a knowledge/innovation 'laboratory', active on various dimensions: attraction of new actors, knowledge creation and competence development; linkages between actors; creation and strengthening of innovation support structures; institutional change.

One question that emerges is: What would happen if multisectoral networks with comparable characteristics/effects proliferated in a region? What would be the ensuing impact on regional development?

This points out interesting research issues centred on the implications of the proliferation of this type of regionally rooted networks on the evolution of the regional RSI. It may actually reveal the need for a new conceptual framework that, integrated within the RSI approach, could explore ways for regional specialization and competitiveness enhancement based on regional complementarities, in a perspective of a more coordinated and complex collaborative innovation.

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Notes

1 *Weltanschaaung* is a widely used concept in knowledge theory that means 'vision of the world', or 'mental model of individuals' (Saur, 2005).

2 Data are atomic, autonomous, unrelated facts, without significance, that refer to items or events (Saur, 2005).

3 For other approaches related to knowledge and underlying differences between this one and information, see e.g. Rizzello (2004), Hofer (2001), Boisot and Canals (2004), Braganza (2004), Shin *et al.* (2001).

4 We refer strictly to knowledge transfer and aim to point out that knowledge, when codified and stored, turns into information. Otherwise said, the 'explicit knowledge' (Nonaka and Takeuchi, 1995) is part of an interactive communication process between individuals (e.g. a professor teaching students, or a master teaching an apprentice) and, as soon as it is taken out of this context, it turns into information. In our understanding, 'codified knowledge' (Nonaka and Takeuchi, 1995; Nonaka and Konno, 1999) is information.

5 Innovation results from new knowledge creation or from the re-combination of existing knowledge and solutions. These processes can result from individual achievements. Yet they are strongly stimulated when the current mental models of each individual are challenged by (multidisciplinary) group discussion and initiatives. This usually results in an increase of participants' individual knowledge and of the group's knowledge (Nonaka and Takeuchi, 1995).
One of the bases of innovation is organizational knowledge creation and absorption (Nonaka and Takeuchi, 1995). To create knowledge, two factors are essential: competence crossing (to share tacit knowledge) and easy access to relevant and diverse information, namely related to science, technology, markets, production, social trends, economic climate, etc. (Hamalaien and Schienstock, 2000).

6 A complementary view over the components of RSI was proposed by Cooke *et al.* (1998, cited in Asheim and Coenen, 2004), which argue that a RIS exists only when the actors of following two subsystems are engaged in interactive learning (knowledge sharing): (1) 'the regional production structure or knowledge exploitation subsystem' – which consists mainly of firms, especially when these ones are part of a clusterization phenomenon; (2) 'the regional supportive infrastructure of knowledge generation subsystem' – which involves public and private research labs and institutions, universities, technology transfer agencies, training organizations, sectoral organizations, etc.

7 The complexity of scientific and technological inputs, the uncertainty of economic conditions and the risks associated with tentative technological trajectories have reduced the advantages of vertical and horizontal integration and made hierarchies a less efficient way of responding to market imperfections. The need to respond to and exploit market imperfections has pushed inter-firm networks to the forefront of organizational strategy.

8 This effectiveness depends strongly on the specificities of the regional productive fabric especially if this is characterized by a clusterization phenomenon.

9 http://www.egi.ua.pt/casadofuturo/En/inicial.htm

10 http://www.egi.ua.pt/casadofuturo/En/NewsletterEn/imagilar.htm

11 These policy measures focus mainly on the promotion of similar experiences involving multisectoral actors and on the reinforcement of the regional coherence of innovation support structures, looking to draw upon the empirical experience of the authors in what regards multisectoral experience in Aveiro RSI.

References

Adhikari, K., Sales, A. (2001): Introduction: New directions in the study of knowledge, economy and society. *Current Sociology*, vol. 49, 4, pp. 1–25.

Akkermans, H. (2001): Renga: A systems approach to facilitating inter-organizational network development. *Systems Dynamics Review*, vol. 17, 3, pp. 179–93.

Alves, J., Saur, I., Marques, M. J. (2004a): Envisioning the House of the Future: a multisectorial and interdisciplinary approach to innovation. Paper presented at the *E-Core Conference 2004*, Maastricht, Holland.

Alves, J., Marques, M. J., Saur, I. (2004b): Role of Networking in Innovation Promotion and Cluster Modernization: 'House of the Future' Case. Paper presented at the *44th European Congress of the European Regional Science Association: Regions and Fiscal Federalism*, 25–29 August, Porto, Portugal.

Alves, J., Amorim, C., Saur, I., Marques, M. J. (2004c): How to promote interdisciplinary R&D in the academia: the case of the 'House of the Future'. Paper presented at the *R&D Management Conference 2004: Managing people and managing R&D*, 7–9 July, Sesimbra, Portugal.

Alves, J., Amorim, C., Marques, M. J., Saur, I. (2004d): Innovation Cooperation Networks: Case of a Multisectoral and Interdisciplinary Partnership. Paper presented at the *Workshop on Management of Innovation*, Vedbaek, Denmark.

Arias, J. (1995): Do networks really foster innovation? *Management Decision*, vol. 33, 9, pp. 52–6.

Asheim, B., Coenen, L., Svensson-Henning, M. (2003): *Nordic SMEs and Regional Innovation Systems*. Nordic Industrial Fund: Oslo.

Asheim, B., Coenen, L. (2004): The Role of Regional Innovation Systems in a Globalising Economy: Comparing Knowledge Bases and Institutional Frameworks of Nordic Clusters, Paper presented at the DRUID Summer Conference on *Industrial Dynamics, Innovation and Development*, Elsinore, Denmark, 14–16 June.

Asheim, B., Herstad, S. J. (2003) Regional Innovation Systems, Varieties of Capitalism and Nonlocal Relations: Challenges from the Globalising Economy, in Asheim, B. and Mariussen, Å. (eds), *Innovations, Regions and Projects*, Nordregio: Stockholm, pp. 241–74.

Bathelt, H., Malmberg, A., Maskell, P. (2004): Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation. *Progress in Human Geography*, vol. 28, 1, pp. 31–56.

Boisot, M., Canals, A. (2004): Data, information and knowledge: have we got it right? *Journal of Evolutionary Economics*, vol. 14, 1, pp. 43–67.

Braganza, A. (2004): Rethinking the data–information–knowledge hierarchy: towards a case-based model. *International Journal of Information Management*, vol. 24, 4, pp. 347–56.

Breschi, S., Malerba, F. (1997): Sectoral Innovation Systems: Technological Regimes, Schumpeterian Dynamics, and Spatial Boundaries, in Edquist, C. (ed.) *Systems of Innovation: Technologies, Institutions and Organizations*. London: Pinter Publishing.

Carlsson, B., Stankiewitcz, R. (1991): On the nature, function and composition of technological systems. *Journal of Evolutionary Economics*, vol. 1, 2, pp. 93–118.

Castro, E., Rodrigues, C., Nogueira, F., Pires, A. (1998): Regional Innovation Systems – The analysis of the Portuguese case based on the Triple Helix concept. Paper presented at the *Triple Helix Conference*, New York.

Chang, Y., Chen, M. (2004): Comparing approaches to systems of innovation: the knowledge perspective. *Technology in Society*, vol. 26, 1, pp. 17–37.

Ciborra, C. (1991): Alliances as Learning Experiments: Cooperation, Competition and Change in High-Tech Industries, in: Mytelka, L.K. (ed.) *Strategic Partnerships: States, Firms and international Competition*. London: Pinter Publishers.

Cooke, P. (1996): The new wave of regional innovation networks: analysis, characteristics and strategy. *Small Business Economics*, vol. 8, 2, pp. 159–71.

Cooke, P., Boekholt, P., Tödtling, F. (2000): *The Governance of Innovation in Europe, Regional Perspectives on Global Competitiveness*, London: Pinter

Cooke, P. (2004): The role of research in regional innovation systems: new models meeting knowledge economy demands. *International Journal of Technology Management*, vol. 28, 3/4/5/6, pp. 507–33.

Cooke, P., Uranga, M. G., Etxebarria, G. (1997): Regional Innovation Systems: Institutional and Organisational Dimensions. *Research Policy*, vol. 26, 4–5, pp. 475–91.

Davenport, T., Prusak, L. (1998): *Working Knowledge: How organizations manage what they know*. Boston: Harvard Business School.

David, P., Foray, D. (2002): An introduction to the economy of the knowledge society. *The International Social Science Journal*, vol. 54, 171, pp. 9–23.

Dietzenbacher, E. (2000): Spillovers of Innovation Effects. *Journal of Policy Modeling*, vol. 22, 1, pp. 27–42.

Doloreux, D., Parto, S. (2004): Regional Innovation Systems: Current Discourse and Challenges for Future Research, Paper presented at the *44th European Congress of the European Regional Science Association*, 25–29 August, University of Porto, Portugal.

Edquist, C. (1997): Systems of Innovation approaches – Their emergence and characteristics, in Edquist, C. (ed.) *Systems of Innovation: Technologies, Institutions and Organizations*. London: Pinter Publishing, pp. 1–35.

Etkowitz, H., Leydesdorff, L. (1997): *Universities & the Global Knowledge Economy*. London: Pinter Publishing.

Fong, P. (2003): Knowledge creation in multidisciplinary project teams: an empirical study of the processes and their dynamic interrelationships. *International Journal of Project Management*, vol. 21, 7, pp. 479–86.

Freel, M. (2000): External linkages and product innovation in small manufacturing firms. *Entrepreneurship & Regional Development*, 12, 3, pp. 245–266.

Freel, M. (2003): Sectoral patterns of small firm innovation, networking and proximity. *Research Policy*, vol. 32, 5, pp. 751–70.

Freeman, C. (1987). *Technology Policy and Economic Performance. Lessons from Japan*. London/New York: SPRU/Pinter Publishers.

Hamalaien, T. and Schiestock, G. (2000): Innovation Networks and Network Policies. *Focus Group on Innovative Firms and Networks*, Focus group meeting, 16–18 February, Vienna. OECD.

Hofer, B. (2001): Personal Epistemology Research: Implications for Learning and Teaching. *Journal of Educational Psychology Review*, vol. 13, 4, pp. 353–83.

Krogh, G., Ichijo, K., Nonaka, I. (2000): *Enabling knowledge creation: how to unlock the mystery of tacit knowledge and release the power of innovation*. Oxford: Oxford University Press.

Laudon, K., Laudon, J. (2002): *Management information systems: managing the digital firm*. Upper Saddle River (NJ): Prentice Hall.

Lofsten, H., Lindelof, P. (2005): R&D networks and product innovation patterns – academic and non-academic new technology-based firms on Science Parks. *Technovation*, vol. 25, 9, pp. 1025–37, published online 2 April 2004.

Lundvall, B.-A. (1988): Innovation as an Interactive Process: From User–Producer Interaction to the National System of Innovation, in Dosi, G., Freeman, C., Nelson, R., Silverberg, G., Soete, L. (eds), *Technical Change and Economic Theory*. London: Pinter.

Lundvall, B. A. (1992): *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publishers.

Malerba, F. (2002): Sectoral systems of innovation and production. *Research Policy*, vol. 31, 2, pp. 247–64.

Marques, M.J. (2004): *Industrial Clusters and Regional Development: Policy building*. Master Science Thesis in Innovation and Development Policies. Aveiro: University of Aveiro.

Moreira, P. and Corvelo, S. (2002): *Cooperação interorganizacional: das trajectórias às redes*. Lisbon: INOFOR.

Nelson, R.R. and Rosenberg, N. (1993): Technical innovation and national system, in: Nelson, R.R., *National Innovation Systems*. New York: Oxford University Press.

Nonaka, I. and Takeuchi, H. (1995): *Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford: Oxford University Press.

Nonaka, I., Konno, N. (1999): The concept of 'Ba': Building a Foundation for Knowledge Creation, in: Cortada, J., Woods, J. (eds), *The Knowledge Management Yearbook 1999–2000*, Boston: Butterworth–Heinemann.

Norcia, V. (2002): The Knowledge Economy and Moral Community. *Journal of Business Ethics*, vol. 38, 1, pp. 167–77.

OECD (1999): *Managing National Innovation Systems*. Paris: OECD.

Raines, P. (2001): *The Cluster Approach and the Dynamics of Regional Policy-Making*, European Policies Research Centre, University of Strathclyde, Glasgow, Regional and Industrial Policy Research Paper, 47.

Rizzello, S. (2004): Knowledge as a Path-Dependence Process. *Journal of Bioeconomics*, vol. 6, 3, pp. 255–74.

Saur, I. (2005): *Information and Knowledge Management: case of a multidisciplinary innovation and R&D project*. Master Science Thesis in Information Management. Aveiro: University of Aveiro.

Seufert, A., Krogh, G., Back, A. (1999): Towards Knowledge Networking. *Journal of Knowledge Management*, vol. 3, 3, pp. 180–90.

Shapiro, C. (2002): *STI Working Papers 2002/11: Competition Policy and Innovation*. OCDE.

Shin, M., Holden, T., Schmidt, R. (2001): From knowledge theory to management practice: towards an integrated approach. *Information Processing and Management*, vol. 37, 2, pp. 335–55.

Szeto, E. (2000): Innovation capacity. *The TQM Magazine*, vol. 12, 2, pp. 149–57.

Westhead, P., Storey, D.J. (1995): Links Between High Education Institutions and High Technology Firms. *Omega*, vol. 23, 4, pp. 345–60.

Whitten, J., Bentley, L., Dittman, K. (2004): *Systems analysis and design methods*. Boston: McGraw Hill.

Wilson, M. (1997): *The information edge*. London: Pitman Publishing.

12 The new knowledge regions

From simple to complex innovation theory

Lars Qvortrup

Introduction

From January 2007, Denmark will have a new regional structure, with a smaller number of municipalities and five large regions. One of the many questions is how development and growth can be stimulated in these new regions. How can the new regions become innovative regions?

One of the answers is that better interaction must be generated between research and business companies. How, though, is this interaction to be supported? In order to be able to answer this question it is necessary to understand what the mechanisms underlying research-stimulated innovation are, and to look critically at a number of antiquated models.

In this article I would like to begin by demonstrating the insufficiency of the traditional causal theory of innovation. This linear theory of innovation, which still dominates policy-based innovation strategies (at least in Denmark), combines the romantic idea of the genius with the rationalistic idea of scientific management. However, the alternative of intensifying interrelations and blurring boundaries, which is suggested by for instance the mode II position is not an appropriate answer.

As an alternative, I will outline the elements of a complexity-theoretical model inspired by sociological systems theory developed by Niklas Luhmann and others. Here, openness is not an appropriate alternative to traditional innovation theory. On the contrary this theory argues that operative closure is a necessary precondition for structural coupling, and that it is this combination, which creates the basis for social – and regional – innovation.

Subsequently, based on these theoretical concepts the article indicates how the complexity-theoretical approach can be used to outline the way in which innovative regions function in an interaction between research and public enterprises and private companies.

Finally, with reference to the case of ECCO Footwear in Denmark I will present a model of knowledge categories for understanding the dynamics of an innovative, knowledge-based region. Just as we have to give up a linear model of innovation – from research via technology to business – we must leave the model of knowledge as an essence, which can be transported from place from place, i.e. from the research laboratory to the enterprise. Instead, a more complex theory of knowledge forms is presented.

The conclusion is that neither is knowledge created in the ivory tower of research and then transferred to the business sector, nor is it created by simply combining the different knowledge sectors into one borderless system of mutually open actors. Instead, regional innovation emerges out of the structural coupling of operationally closed knowledge systems of research, art, culture and business.

The traditional innovation idea

The traditional conception of research-based innovation builds on the idea that there is a simple, causal relationship between research, technology and innovation. This idea is based on a monocentric actor-theory according to which societal development is run by a central innovative body, no matter whether this body is research, technology or an economic motor.

Innovation models

On the basis of this conception, it is possible to identify a number of mutually related models.

One model places *research* centre stage. It is this mental model that lies behind the Danish Ministry of Science's slogan from 2004 'From research to invoice'. Some people do the research, others bring the results to the business people, who in turn set about production and earn money for the benefit of the community. Although, people like to add, the researchers could take as much trouble as possible to promote this process by targeting their research and pushing pure research in the direction of applied research.

A second model places *technology* centre stage, the idea being that he establishment of a technological – or preferably a 'high-tech' – centre will guarantee social and economic innovation.

It is this mental model that lies behind a number of recent European innovation strategies and that particularly informs the current national research strategy in Denmark. It is believed that it is both possible and sufficient to select a limited number of technological areas to concentrate on – nanotechnology, pharmaceutical technology, IT, etc. – and to convert them into centres for growth. The outputs of these centres only have to be grasped by the companies in order to become products and create profit.

There is finally a third model within this paradigm, which thinks *hierarchically*. At the top there are the scientists. The citizens, the ordinary people are down at normal ground-level.

It is this mental model that lies behind the idea of research mediation, i.e. that certain people – the researchers themselves or scientific journalist – have to 'translate' the research into a language that others can understand. There is a kind of linear connection between the clever ones above, the mediators in the middle and the common people below.

The romantic conception of the genius and the machine

Behind all these models lies what one could call the 'Ur-model' of innovation thinking: The romantic idea of the genius or the machine. This can be the literary genius, it can be the research genius, or it can be the energy machine – the steam locomotive, the electricity works – that tames and utilises the primeval forces of nature, and that in reality is simply a technical incarnation of the human genius. This figure has roots that stretch back to the idea of the alchemist – the thought or matter alchemist, or the alchemist laboratory – and the wizard.

All of these innovation agents – the poet, the researcher and the machine – have the special ability to be able to read the book of nature. The poet reads the nature of the soul. The researcher reads the nature of energy. The machine is a kind of translation apparatus, a reading machine which, by virtue of its mechanical organisation, does the same thing as the researcher does. This conception actually enjoyed a 'revival' with the computer, which was immediately given the name of 'artificial intelligence'.

The rationalistic conception of simple, **a priori** *research planning*

Ironically, the romantic idea of the genius-man and the genius-machine is often combined with the rationalistic idea of linear, centralised planning.

The planning idea is that innovation can be created by a political actor, who identifies one or more national or international innovation centres – laboratories, scientific programmes, technological complexes or research centres – which, by virtue of the results they produce, will generate economic and social growth.

But if the relationship is not so simple as is assumed here, it is illusory to believe that growth and renewal are generated in so simple a way. In that case, one will have to think in far more complex, societal relationships. Growth is generated not only by producing a 'growth motor'. No, growth is stimulated by the creation of appropriate conditions for the development of a growth environment, e.g. in a region. In that case, the basic paradigm has to be one of complex regional networks and not of simple innovative motors.

The Mode II conception of innovation

In the book from 1994, *The New Production of Knowledge*,[1] Michael Gibbons, Camille Limoges, Helga Nowotny, Simon Schwartzman, Peter Scott and Martin Trow suggested that one should make a distinction between Mode I and Mode II knowledge production. My critical presentation of the linear conception of innovation is closely related to their criticism of the Mode I knowledge production of the industrial society. However, according to Gibbons *et al.*, in a knowledge society the relationship between research and industry is different. Here, the relationship between research and enterprises should be made much closer. The interrelations should be intensified and boundaries should be blurred, thus challenging as well the sharp division between basic and applied science as the division between science and arts.

The position of the present article is that this does not represent an appropriate answer to the linear innovation model. While I share its critical points, I fear that the Mode II model throws the baby out with the bathwater. It is a precondition for research that it operates within an operatively closed system of science, and it is also a precondition for private enterprises that they operate in a goal-oriented mode. This does not imply that these systems cannot be combined, but the answer is not to blur boundaries, but to combine operative closure with structural coupling.

The strength of the research system is that it is devoted to the production of new knowledge, and that it has developed specialised theories and methods in order to achieve the aim of creating scientific results. In comparison, the strength of the business system is to produce commodities and services, which meet an instant need. Similarly to the research system it has developed specialised theories (ways of systematic self-reflection) and methods (budgets and accounts) to achieve its aims. Therefore the real challenge is not to replace the model of causal links between separated functional systems by the mirror alternative, i.e. the model of borderless, networked integration. The challenge is to combine functional differentiation with structural coupling, and to implement such a model at the regional level.

In the following sections, I would like to present some of the elements of such a regional network paradigm in which the two basic concepts are operative closure and structural coupling. For even if it is illusory to believe that there is a simple causal link between research, technology and innovation, and even if it is illusory to believe that innovation can be created via simple political initiatives, this does not mean that the antithetical alternative of radical openness is true. Innovation is not created by taking away the differences or the boundaries between research and business production, but by understanding that functional division and structural co-operation do not exclude, but rather support each other.

Complexity-theoretical innovation model

Pasteur's quadrant

The crucial problem of the causal model of research-based innovation is that the kind of thinking on which it is based is wrong, or at least only valid for a very narrow cross-section of reality.

This has been shown by, among others, the American researcher Donald E. Stokes (1997). In his book *Pasteur's Quadrant* he demonstrates that the linear model from research to use does not have general validity. There are admittedly examples of pure basic research being able to be transferred, after many years' work, into applied research, which in turn via R&D work becomes products and services. Conversely, there are also examples of practical work on product development being able to be generalised into research results.

In the vast majority of cases, however, the relationship between research and use is not linear but complex. The basic example here is Louis Pasteur (1822–1895).

This French chemist and bacteriologist discovered the significance of micro-organisms for fermentation and putrefaction processes and was thus able to demonstrate that bad fermentation in the production of beer and wine can be prevented with the aid of pasteurisation, i.e. heat treatment. If this heat treatment takes place in the correct way, it kills the bacteria that produce putrefaction without affecting taste or nutritional value.

Donald E. Stokes' point is that Pasteur worked practically and theoretically to an equal extent. He did not complete his research on micro-organisms and then transferred his results to the factory floor. Conversely, he was not just working experimentally at the factory and subsequently generalising his practical results. No, he worked alternately in both fields. Partial research results or partially justified hypotheses were transferred to the production complex, where the results gained were tested and refined, after which he returned once more to the research laboratory.

It is in this way, Donald E. Stokes claims, that the vast majority of modern research takes place. Some of the time, the researcher works in the laboratory or at the research office. At other times he or she leaves the university in order to share experience and practice with product development. Thus, the point of this theory is that one has to take account of the fact that innovation emerges from the coupling of two different procedures – discourses is the term I will use later – with their separate languages, rhythms, time horizons and goals. That is true of much medical research. It is also true of humanists' work on computer games, as it is when computer scientists work on pervasive computing, or when social scientists develop new epistemological insights into the division and development of knowledge.

While this model forms the basis of the development of appropriate conditions for research stimulated innovation, it is my assumption that we still lack a full theoretical understanding of the model. Here, neither the linear innovation model nor the integrated Mode II model are appropriate. We still need a theory, which addresses the fact that closure and coupling do not exclude each other. On the contrary, no innovation-oriented coupling can take place without the existence of mutually closed research and business systems.

Post-causal innovation theory

My point of departure is that research-based or research-stimulated innovation can only exceptionally take place in accordance with the simple, linear causal model. It is therefore insufficient to support innovation by setting up large national or international research centres or laboratories. They may be necessary for implementing research that is technically highly demanding and costly, but they are definitely not a sufficient prerequisite for innovation. Here it is necessary to think in complex, so-called 'post-causal' models.

My leading question is how, on the basis of these theoretical insights, it is possible to develop an understanding of how so-called innovative regions function. This insight has arisen in the interaction between the experiences from my practical work with Knowledge Lab DK – the research and development centre at The University of Southern Denmark that I have been head of since 2002 – and my theoretical work on complexity models such as Niklas Luhmann's general theory of complex social systems (Luhmann, 1984), Ilya Prigogine's theory of dissipative structures in nature (Prigogine and Stengers, 1979), Maturana and Varela's theories of biological autopoiesis (Maturana and Varela, 1992), Per Bak's work on self-organised criticality (Bak, 1996) and my own theories of hypercomplexity and knowledge (Qvortrup, 2003, 2004a and 2004b).

Some of the concepts I will introduce and repeatedly exemplify *en route* in relation to the way in which innovative regions function are: hypercomplexity, operative closure, structural coupling, research autonomy, discourse regimes, horizontal partnerships, project arenas and triple helix structures.

Research and companies: operative closure and structural coupling

As argued, there are good reasons for abandoning linear causal thinking when the relationship between research and companies is to be described. But how then is this relationship to be described? My proposal is that the basic concepts in the understanding of the relationship between research and companies are: operative closure and structural coupling. To begin with, I will justify and present these concepts. In the following sections I intend to operationalise them.

A vital characteristic of the development of present-day society is that the common main challenge for society's companies and institutions is complexity – and that the answer is complexity management. In addition, however, we have the fact that the complexity that is established does not only relate to an outside world but also to itself. It applies quite literally that many information systems are, for example, developed so that an organisation can handle its own inner complexity. But it also applies in a more general sense that it is characteristic for us to have become unsure about the nature of our own state of complexity. So complexity has to be applied to complexity; the observation of the outside world by complex observers has to be supplemented by self-observation, i.e. by these complex observers (individuals and companies) observing not only their environment but also their own state of complexity.

During large parts of the twentieth century, people believed in the advance of simple rationality. When something did not turn out as it should, this was because rationality had 'not yet' triumphed. It was believed that the labour market could be regulated, and that certainty could be achieved via scientific management.

This entire belief in causal rationality was given its *coup de grâce* in the early 1930s, almost as dramatically as when the incarnation of all human technical insight, the *Titanic*, had run into an iceberg some years earlier.

The iceberg, which the rational conception of knowledge ran into, had the name Kurt Gödel. In 1931 he proved that there are mathematical truths which can never be explained within logical systems unless it is at the expense of the non-contradictoriness of these systems (Gödel, 1931). Gödel's proof includes statements that say about themselves that they cannot be proved. Such statements can be translated into mathematical formulae. If these formulae can be proved within the framework of a finite and non-contradictory logical system, this system contains a self-contradiction. If they cannot be proved within such a system, there are arithmetical theorems that cannot be deduced. This means that the system does not contain all true arithmetical theorems. Ergo, the system is either self-contradictory or incomplete. And since the system claims to be an exhaustive expression of human knowledge, human knowledge is therefore either self-contradictory or incomplete. We cannot know everything, or: there is either something that we know we do not know, or there is something we do not know that we know.

If this is to be translated into everyday experiences, the consequence is that we are on the way to a state of affairs that can best be characterised as hypercomplex (cf. Qvortrup, 2003). That society is 'hypercomplex' is not just a term that turbo-charges the degree of complexity. That a society is *complex* means that it contains more possibilities than one as observer can immediately latch onto. But that it is *hypercomplex* means that it in addition relates to contingency of its own descriptions of the outside world. It is not only uncertain of its outside world but also of its own uncertainty, and it constantly relates to this double uncertainty. Thus, hypercomplexity can be defined as quadratic complexity. In Social Systems, Niklas Luhmann defined hypercomplexity in the following manner: 'We term hypercomplex a system that is oriented to its own complexity and seeks to grasp it as complex' (Luhmann, 1984: 637. English translation Luhmann, 1995: 471. See also Qvortrup, 2003: 35).

There are two mutually complementary answers to the complexity challenge: The building up of inner complexity and dynamic stabilisation.

Society builds up a high degree of *inner complexity* because, as Luhmann says, only complexity can reduce complexity (Luhmann, 1984: 49; Luhmann, 1995: 26). This is an everyday experience. An enterprise with a complex environment will develop a large number of rules and procedures. In order to handle complex problems a person will develop complex skills and competencies. In society the same mechanism occurs, for example, via the development of a whole series of mutually operatively closed function systems: The economic, the political, the scientific, etc. All these systems operate on the basis of their own pre-assumptions and consider the other systems as the outside world, i.e. as potential resources for their autonomous eigen-function.

But how can the building-up of inner complexity have a stabilising effect? Does it not create yet further confusion? Does it not result in chaos? The answer is that the complexity strategy is double-sided. In his final volume, *Die Gesellschaft der Gesellschaft* – society's construction and conception of itself as society – Luhmann explicitly states that while the development into functional differentiation implies that society can react immediately to external changes (in systems theoretical terms that the level of irritability grows), the cost is a lack of possibilities to coordinate these irritations (Luhmann, 1997: 789). Society develops into a highly nervous system.

Thus, for growth in inner complexity to have a stabilising effect, differentiation has to be complemented by the development of flexible interdependencies, i.e. structurally linked relations between the various functional systems. The inner complexity must not stiffen, e.g. in a comprehensive bureaucratic or centralistic system, for in that case it will become vulnerable and lose efficiency. But it must not be allowed to be split into disconnected atoms either, for then it will become chaotic. In other words, the second answer to complexity in the outside world is *dynamic stabilisation* (cf. Per Bak's distinction between chaos, stability and self-organised criticality in Bak, 1996).

The consequence for the understanding of the relationship between research and companies as the basic axis in an innovation system is firstly that one has to respect the relative autonomy of the systems. A system only functions appropriately if it is allowed to operate according to its own premisses. The consequence secondly is, however, that appropriate structural links must be established between these operatively closed systems, for only thereby can they use each other as resources: the research produces new knowledge. The companies produce economic prosperity.

Complex, research-stimulating innovative regions

If the basic concepts of a theory of complex, research-stimulated knowledge regions are operative closure and structural coupling, one must firstly identify the operatively closed systems that function in these knowledge areas. My claim is that there are three such systems, or, as I intend to call them, discourse regimes: the research system, the business system and the public system.

Secondly, one must identity the forms of structural coupling that contribute to these relatively autonomous discourse regimes' mutual stimulation. They cannot influence each other causally, i.e. by the one system supplying products that the other system can immediately use as input. But it is also meaningless to believe that they do not have some mutual relevance. The question is, therefore, how one can create relationships that both respect the relative autonomy and create a mutual contact. My answer is that 'buffer zones' have to be created, ones that are characterised by precisely this duality of operative closure and structural coupling.[2] One such 'buffer zone' is committees, with representatives from the other function systems. Another buffer zone is so-called partnerships.

Thirdly, one must ensure that the projects which are the result of these structural couplings are also given a dynamics over time. For that reason, it is important not only to think in terms of single projects but to ensure that the one project with its actors stimulates the next project with the same or with other actors. In other words, one has to think in terms of clusters of projects, or with the concept I wish to propose: project arenas.

Fourthly and finally, instead of subscribing to a model of traditional knowledge transfer, it is my suggestion that 'transfer' should be understood as translation and re-contextualisation: knowledge created in one regime must be translated and re-contextualised in order to become valid within another regime. One way of achieving this is by education and in-service training. A person from a company that moves from the company to the university and back with the new knowledge he or she has acquired is a double translator. He or she comes with experiences from business life to the university and translates both during the period of study and, when he or she returns to the company, the university's research-oriented knowledge language to the company's result-oriented knowledge language. Such a person moves like a troubadour from regime to regime – such a person is a knowledge-troubadour (cf. Serres, 1997).

All of this can be summed up in the concept of 'triple helix', which is an overall concept for the interaction between the three basic discourse regimes: the research system, the business system and the public system (cf. Etzkowitz and Leydesdorff, 1997).

But first, I would like briefly to justify why the use of research is conditioned in an apparently paradoxical way by its relative autonomy, and that by linking research directly to business interests and forcing it to adopt the *modus operandum* of private companies one would be throwing the baby out with the bathwater.

The relative autonomy of research

In the summer of 2004, I met Stein Bråten, professor of sociology at the University of Oslo. He told me that in the early 1970s he had met the then young sociologist Niklas Luhmann and had introduced him to a completely new concept: autopoiesis. The concept had been created by the Chilean biologists Maturana and Varela. It says that living organisms are closed systems, and that precisely by means of this they are able to make contact with their outside world.

Bråten challenged Luhmann: could something similar not be said about social organisms? That people, organisations and societies are closed systems – and precisely by means of this they are able to communicate with the outside world?

Initially, Luhmann rejected the idea. But ten years later, the challenge had borne fruit. In 1984, he published what was probably the most important sociological work of the twentieth century: *Soziale Systeme*. In it he argues in favour of closure being a prerequisite for openness. We do not suck our outside world – apples, cars, other people – into ourselves. No, we create a conceptual system about the world and only by means of this are we able to establish contact with our outside world, namely by calling it apples, cars and people.

What does this story have to do with an understanding of the relationship between research and society? Two things.

One thing is that it demonstrates that the university functions as a closed system. From Varela and Maturana via Bråten to Luhmann – who after ten years of reflection advances a theory that revolutionises our knowledge of society.

The second thing is that closure and external relevance do not exclude but presuppose each other. It is via the operative closure of the university that it creates new knowledge and thereby makes itself useful in society.

The point, however, is that the process that led to a revolutionary new theory about society could not be organised from the outside – it could not in fact even be predicted. It only functioned as it did by virtue of the special functional conditions of the global knowledge system: an extreme internal openness, an indefatigable urge to create new knowledge and an unusual self-centredness. Only by virtue of this way of functioning can research come up with something that other functional systems are unable to supply.

But the consequence of this way of thinking is not that the university must regress to its role of ivory tower. No, a modern university has to *combine* closure and openness. It must be closed, because that is a prerequisite for amassing knowledge and developing concepts and theories. This closure must, however, be combined with structural coupling mechanisms, because a knowledge society needs research-based knowledge, and because universities live through contact with their outside world.

Discourse regimes

It has gradually been generally recognised that the development of European society from the Renaissance onwards can be described as a process of functional differentiation, i.e. a process where a constantly increasing number of functional systems have broken off, each with its particular, autonomous system (cf. Luhmann, 1997: 613). Very early on – i.e. long before the Renaissance – the religious system separated off, with its special code, its special medium and its special function. But from the Renaissance onwards, something similar happened to the economic system, the political system, the scientific system, the judicial system, the art system, the mass-media system, the educational system, etc. (Luhmann, 1997: 707–76).

A corresponding tendency can be seen at the organisational level. Here too, an originally craft-based organisation, where all the workers separately carried out the same process, and where each individual worker carried out the entire production process, has changed into coordinated specialisation, where each individual employee or groups of employees carry out a specialised subprocess, which is subsequently harmonised and coordinated by the organisation as a whole.

As can be seen, these subsystems – in society and in organisations – are not autonomous in the strict sense of the term; they can rather be characterised as both autonomous and structurally coupled together. The one system supplies services to the other systems and functions in relation to the total or organisational system – not because it is 'integrated' into the other systems but by virtue of its specialised functionality. The system of science strives for truth and precisely for that reason is able to produce new knowledge. It would not be able to do that if it was subject to the economic system's targeted ways of functioning. The judicial system distinguishes between justice and injustice, and it would not be able to do that if it was a mere extension of the political system.

At the same time, the various function systems must be coupled to each other via what is referred to as 'structural coupling mechanisms'. The institutions of the scientific system enter into cooperation agreements with the companies of the economic system that both strive for a high level of coordination and respect the differences that are the prerequisite for a high level of efficiency. The political system is autonomous, but constantly in touch with the other function systems of society. New laws within the judicial area are submitted to representatives of the judicial system, just as industrial bills are discussed with representatives from business life and employer organisations. In other words, it is demonstrated – as Emile Durkheim (1919) predicted early on – that specialisation and division of labour do not lead to division but, on the contrary, strengthen the cohesive force of society.

These mutually differentiated, operatively closed but structurally coupled function systems can also be characterised as 'discourse regimes', i.e. as systems that are characterised by their separate discourses: they communicate internally in a special language which is determined by a code, a service and a goal. In order to evaluate itself, each of the systems undertakes self-observations: they observe whether and how they reach their own goal and they measure the degree of success in relation to their specific programme.

If one is to look at the way in which a knowledge region functions, it is important to identify three strategically central, mutually closed but structurally coupled functional systems and read the discursivity of each of these systems: The scientific system, the economic system of enterprises and the public sector system.

The scientific system (cf. Luhmann, 1990) communicates and functions in accordance with the code true/false. Is the knowledge produced true or false? For this reason, this system expends a great deal of energy on testing its own results, e.g. in academic discussions, in comparing results and in comprehensive falsification attempts. The way in which the research system observes itself is by the development and use of methods and theories, since these are, so to speak, the research system's programme for and reflection on the generation of new knowledge. The goal of the research system is to produce original research results, which is why an important yardstick is mutual assessment of research results and the publishing of research-evaluated books and journals rather than whether this new knowledge is useful or not. But precisely by means of this the research system provides the service that the outside world benefits from, i.e. new knowledge.

The economic system communicates and acts in accordance with the code profit/loss (Luhmann, 1988). Are the products and services produced profitable or not? For that reason, this system is result-oriented to a very great extent. It praises competition as an incentive to raise productivity and to reduce costs, and it emphasises a targeted self-description, for example in the form of business plans, goals and criteria for attaining those goals. The way in which this system observes itself is by means of accounts and budgets, because precisely these make profit/loss visible. By means of this, companies make their special contribution, which is useful products and services – and financial profit. However, the companies also observe their outside world via this optic: they attempt to impose targeted behaviour on both the universities and the public sector and encourage both parties to focus on use-value and to cut away that which does not have a use-effect in the short term.

The public sector (cf. Luhmann, 2000: 189–227) communicates and acts in accordance with the code right/wrong:[3] are the services supplied right or wrong in relation to a politically defined need, i.e. are they politically correct or incorrect, cf. the concept 'public service', which is a service concept that cannot be assessed on the basis of the ideal of the greatest possible use at the lowest possible price, but that has to be assessed on the basis of the named criterion – whether the service in question is 'right' or 'appropriate' for its users. For that reason, the public sector observes itself and its own degree of success via a political, or rather a politicised, optic. By means of this, the public sector supplies its special product, which is welfare services, often as a form of compensation to services from companies. However, the public sector observes the outside world through the same optic: management measures in relation to the research system will therefore seem to researchers to be politicising ('politically correct'), and in relation to private companies a central task is to regulate their behaviour on the basis of collective welfare criteria.

A precondition for creating an innovative knowledge region is that one on the one hand respects the relative autonomy of each of the functional systems mentioned. If one makes the research system too 'business minded', one prevents it from generating new knowledge. If one places too many restrictions on companies, one reduces their production of goods and services. And if one effectivises public institutions, one prevents them from supplying public welfare.

At the same time, it is important for structural couplings to be established between these function systems, so that the one system produces services that the other systems cannot supply themselves. The research system produces new knowledge that is vital for knowledge-intensive companies. Companies supply practical experiences and test new knowledge as well as contributing with management effectivisation and targeting. The public sector produces the general conditions for both companies and research institutions: infrastructure, public regulation, etc.

Earlier, these various systems were able to function with a high degree of mutual autonomy. But in a knowledge society, where companies are dependent on new knowledge and highly qualified employees, it is important for the structural coupling mechanisms to function efficiently and smoothly.

So this is the decisive strategic challenge for the new innovative knowledge regions: to create structural couplings – buffer zones – that at one and the same time translate the one system's products into immediately accessible services for the other, but that at the same time respect the mutual relative autonomy between the function systems.

Buffer zones

One way of combining structural closure and openness is by developing buffer zones between the university and its outside world.

A 'buffer zone' is a zone that separates and links at the same time. University or research committees with an external majority are a good example of such a zone.

When they were introduced in Denmark in 2003, researchers expected them to result in the autonomy of research being done away with, with research being forced to submit to a direct and blatant influence from what in the old days used to be called 'vested interests'.

There is, however, no reason to suppose that this is what will happen, and there is nothing to indicate that this is what is happening; for these committees function precisely as buffer zones. On the one hand, they create contacts. They demand results that are relevant for society. They compel research representatives to talk in a language that the committee – and thereby the outside world – can understand. On the other hand, such committees are buffers between research and the outside world, because by virtue of their very existence, they indicate and respect the fact that there is a difference between research and non-research. Actors from companies cannot go directly to the researchers and insist that they do this or that. They have to go via the committee. Such committees are thus a kind of translation body between university and society.

Partnerships

Formerly, the mediation of research was considered to be a linear process in which pure research was transformed into applied research, which in turn was converted into production resources. The relationship was thought of as being vertical: at the top were the researchers, at the bottom the citizens and companies.

If the theory that simple causality has been replaced by complex interdependence is correct, and if it is correct that the relationship between functional systems is not hierarchical but based on functional specialisation, the mediation of research ought rather to be based on so-called partnerships, i.e. interactive relationships between equal partners in a horizontal exchange relationship.

As already emphasised this does not mean that everybody becomes like everybody else. Researchers manage other resources and experiences than companies and citizens, but both parties are resources for each other. Research contributes with research-based resources of knowledge, while companies and citizens contribute with practice-based resources of knowledge. In a partnership, a contract-based forum is created where these resources can stimulate each other, while the differences between the various actors continue to be maintained and respected. The research system can do something else than the companies (operate with longer time-horizons and other success criteria) and if one does not respect these differences and allow them to be maintained, one ruins the source of innovation.

Project arenas

In the cooperation between research institutions and companies there has been a tradition for perceiving the project as the smallest unit. The individual project appears as the unit that marks a starting point and end of a process.

It has, however, become apparent that this gives research and development work a stop-and-go nature, with too little continuity and transfer of experience from project to project. So it would seem to be a good idea if instead the project arena was described as the natural basic unit for research and development work.

A project area is a 'field' – a laboratory, a theme or a locality – of related projects. It is a framework for various discourse regimes – to use the concepts presented above.

This means that one project inspires the next, that learning is transferred between projects and that the actors can move from project to project. Let me give an example from my own application oriented research laboratory, Knowledge Lab, one to do with interactive TV: this project is actually a project arena. An interactive 10 Mbit network with several hundred users is made available for developing new formats for advertising, for TV and for e-learning, at the same time as researchers take part in the work on development and testing, and the cluster of projects are made into an arena for competence development among the actors, e.g. with the aid of intensive workshops, in-service training and the exchange of experiences. Here a great number of actors, each with his or her own experiential background (advertising agencies, news producers, e-learning companies, IT companies and researchers), are placed within a common functional framework and with a common overall aim. Here the actual arena is thus the translation framework, while couplings are also made across actors and time, i.e. from one cluster of projects to the next one.

Knowledge troubadours

The most important way to transfer knowledge between universities and the outside world, however, is probably via education and in-service education. A person with a university degree who gains employment at a company is one who carries out a translation project from research to company. A person from a company who carries out a research-based in-service educational programme, or a business PhD who operates at the same time within the context of a company and the world of research – all these persons are 'knowledge translators'.

Knowledge translation takes place within the person, e.g. by his or her establishing a double-view: 'How is this statement to be understood here, at the university, and how would they understand it back at the company?' At the same time, it is important for the universities to be aware of this double-view when organising business-oriented educational programmes and in-service programmes, and when working with business PhDs.

In order to understand this issue it is important to return to the already mentioned theoretical assumptions: knowledge is not spread in the form of knowledge transfer. One cannot simply develop new knowledge in one place and then transport it into another knowledge regime.

No, a 'translation' has to take place. As the French philosopher Jacques Derrida has said, all communication between two knowledge regimes has to take place in a double language (Derrida, 1988; see Andersen, 2003). On the one hand, there is the research-based knowledge in the language of research discourse. On the other hand, it is not simply to be translated into but also legitimised by the language of company discourse. One must – to quote another French philosopher, Michel Serres – identify a 'troubadour' who is able to travel from regime to regime and present outside impressions and experiences in a way that is both understandable and acceptable (Serres, 1997).

But in a society that is characterised by constantly accelerating innovative processes, the possibility for competence development has to exist as a lifelong offer. This means that tailored courses and MAs must be developed. But it also means that competence stimulation has to be developed as an aspect of working life. The development of 'pervasive computing', i.e. of intelligent systems everywhere and in everything, also has potential in the form of on-going competence stimulation. Systems must be self-instructing, and pedagogical resources must be built into systems of production and administration.

To sum up, the concept of competence stimulation must firstly be detached from formalised educational thinking so that one does not simply learn at a school desk or on courses but everywhere. Secondly, the concept must be understood on the basis of the principle of knowledge transfer as knowledge translation: that in-service education is always faced by what one could call the problem of two languages: that it admittedly takes place in one language and on the premises of one culture, but that it must always speak into another language and another culture.

Triple helix and innovative regions

All this and a great many more aspects have to be combined to form a total picture of the innovative region of the future, i.e. the targeted establishment of regional innovative systems. A conceptual framework for this is the concept of the 'triple helix', i.e. of the close interaction between research, companies and public institutions, launched by the Dutch knowledge researcher Loet Leydesdorff (cf. Etzkowitz and Leydesdorff, 1997). Former boundaries between private and public research or between pure research and applied research are crumbling. This does not mean that the concept of research is dissolving, or that the justification for universities is disappearing. But it does mean that 'the place for research', which was formerly the exclusive preserve of the universities, has to be re-defined and that new cooperations and institutions for research and for research work have to be developed. This is being experimented with in research centres, projects, science parks, etc. It is to make these new relations between university and outside world more clearly visible that Etzkowitz and Leydesdorff use the concept 'triple helix'. Helix is the term used for a particular kind of snail and it refers to the spiral way in which various bodies are intertwined, as for example in a double-winding staircase. As far as the relationship between university, industry and state is concerned, the point is that the boundaries on the one hand are not to be done away with but that the mutual contact between them on the other hand is to be intensified and that relationships be made far more flexible and intertwined. So it can be compared to a triple-winding snail, the individual parts of which are both separate from each other and yet closely interlinked.

In the future region this could for example take place with an 'innovation council' as a body that has both decision-making and resources-distributing competence, i.e. one that can plan and co-fund innovative institutions and systems, and that has representatives of both academic institutions, private companies and the public sector.

The knowledge region

Just as we have to give up a linear model of innovation – from research via technology to business – we must leave the model of knowledge as an essence, which can be transported from place to place, i.e. from the research laboratory to the enterprise. Similarly, we must give up the idea that knowledge can be defined only as codified knowledge. This is still the assumption in current theories of society, cf. for instance Manuel Castells' analysis of the network society, in which knowledge, in accordance with the definition of Daniel Bell (1973: 55) is defined as '. . . a set of organised statements of facts or ideas, presenting a reasoned judgment or an experimental result, which is transmitted to others through some communication medium in some systematic form' (Castells, 1996: 17). For me, the concept of knowledge is multidimensional, and it cannot be perceived as something which is created in the ivory tower of research and then transferred to the business sector. Instead, knowledge – which exists in many forms – emerges out of complex systems of research, art, culture and business. Let me illustrate this by referring to one of the modern, knowledge-based enterprises in Denmark, ECCO Footwear. This company both demonstrates the points of complexity-based innovation theory presented above and the points of creating a knowledge-based social context of research, art and cultural institutions in an innovation-stimulating knowledge region.

The knowledge-based enterprise

In the southern part of Denmark lies one of modern Denmark's most forward-looking industrial ventures: ECCO Footwear.

ECCO Footwear was established in 1963. The company expanded and, at its height, employed many hundreds of local employees in footwear manufacture.

This is no longer the case. If one visits the large industrial complex in the small town of Bredebro, or the centre of design and education/training in Tønder close by, one will hardly meet a single unskilled shoe-worker. Footwear is designed, and it is here that management and administration is conducted. Actual production takes place in Slovakia, Portugal, Indonesia, Thailand and China.

The story of ECCO Footwear is one of globalisation and of the transition from an industrial to a knowledge society. What makes a difference is not mass-production but design. That ECCO Footwear is at present the fifth-largest manufacturer of footwear in the world is mainly due to the fact that their design is distinctive and better than that of their competitors. For a shoe is not just a shoe. It is a lifestyle and a self-staging. When men don their 'City Walkers', they assume an identity as a modern man-about-town – elegant, self-aware and cultivated. Here, roots stretch back to the *flaneur* of the Parisian boulevards of the early twentieth century – to which the greatest degree of material awareness possible has been added. When women purchase 'Sharks' – an ankle boot with an elegant, slender shaft that snugly fits the lower leg and with a large sole that grips upwards in the form of teeth (shark's teeth, of course) – they are not primarily buying practical footwear but also staging themselves as modern, erotically self-aware women. They are donning a narrative made of first-class materials.

The obverse of the medal is design. ECCO Footwear depends on its proficient Danish designers, who in turn are dependent on good educational programmes in design, first-rate design research and a modern design tradition that stretches back to the Danish tradition from the mid-twentieth century, spearheaded by such designers as Poul Henningsen and Arne Jakobsen, which, yet again, represented a Danish interpretation of ideas and aesthetic ideals from the German Bauhaus tradition.

In addition, there is management and production methods. The entire global company is run from Southern Jutland. In the virtually empty factory buildings experiments are carried out with industrial robots to try to make production as efficient and precise as possible.

The reverse of the medal is a large-scale ejection from the labour market. What are the hundreds of unskilled works who are unable to live up to the readjustment mantra to do? Who are unable to retrain to become symbol analysts? Who do not go around with a designer, production developer or in-service training consultant inside them waiting to get out? They become redundant. They take early retirement. They are put in one of the many 'schemes' that at least conceal the problem from themselves and from society. And then many of them have part-time work during the summer months, when they service tourists on Danish bathing beaches.

Similarly, the reverse of the medal is a global division of labour, according to which the new knowledge-intensive regions exist on the basis of knowledge-extensive and low-paid regions in Third World countries – in the case of ECCO Footwear its mass production units are located in China, Indonesia and elsewhere.

In this way, ECCO Footwear is the incarnation of the possibilities and problems facing the European regions and the global division of labour in the transition from an industrial to a knowledge society.

From material production to complexity management

One way of expressing the above-mentioned change in society is that present-day society is rapidly moving away from being an industrial society, the basic function of which is to develop mechanical systems of production and organisation that can transform nature into industrial products, towards a knowledge society, the basic function of which is to handle complexity with the aid of knowledge, no matter whether this knowledge exists as a resource in the individual worker or as knowledge systems in companies and organisations.

Previously, business life was dominated by companies engaged in production, the main aim of which was to produce as many physical units as possible per units of work. Today, the tendency is towards production-preparing companies, the main aim of which, via design and production planning, is to handle as much complexity as possible. Just take the above-outlined example: in the 'old' days, ECCO Footwear in Southern Jutland was a company that produced footwear. Today, ECCO Footwear in Southern Jutland is a company that prepares the production of footwear. Shoes have to be designed, the market analysed, shoes production planned and organised. Actual production, though, does not take place in Southern Jutland but in other parts of the world.

The main challenge today is not the processing of materials but the handling of complexity, be it material, psychological, organisational or societal. For people, organisations and societal systems alike, the answer to the growing outer complexity is to develop a matching inner complexity. As far as people are concerned, this means developing competencies. As far as organisations are concerned, this means developing flexible and instructive strategies. And as far as society is concerned, this means developing a flexible structure of functionally differentiated systems.

Seen from the point of view of society's production of knowledge, the task is to find out if this handling of complexity can be supported. The question for society's education system is what competencies are to be supported by employees in companies that do not orientate themselves in relation to their capacity to handle materials but to their capacity to handle complexity. The question for companies and organisations is how their own function is to be organised when the task is to combine production with the maintenance and development of knowledge resources. The question for the knowledge system of society is what research-based knowledge is to be produced, and how the interaction between research and knowledge businesses is to be organised so that close cooperation is developed while the necessary differences are nevertheless maintained.

From simple to complex competencies

What must those employed at a knowledge-heavy company such as ECCO Footwear be able to do? It would be easy to follow Richard Florida in saying that they should be 'creative' workers. But although I agree with Florida, when he says that they concept of creative workers '. . . has a good deal more precision than existing, more amorphous definitions of knowledge workers, symbolic analysts or professional and technical workers' (Florida, 2004: 9), not only is his category of creative workers too narrow; his rather romantic idea of creativity as something emerging from social and cultural diversity is not appropriate. Yes, creativity is part of the competencies of an employee at ECCO Footwear, but there is more to it than just creativity. The existing definition of knowledge in the knowledge economy literature is too vague. My intention, however, is not to narrow it down to creativity, but to systematically identify the different aspects of knowledge – including the creative aspect.

Employees at a knowledge-heavy company such as ECCO Footwear must have considerable *factual knowledge*, i.e. a whole series of technical and professional qualifications: designers at ECCO have to have design knowledge, knowledge of materials, and be able to use advanced digital tools.

They must have considerable reflexive or *situative knowledge*. They must be able to work in teams, to handle unexpected situations with their colleagues, to improvise and empathise.

They must have *systemic knowledge*. They must constantly be able to rise above the i–you situation of the group and see things from above – how does what we are doing function in a broader perspective? But, first and foremost, they must be able to identify and re-interpret even basic assumptions that are perhaps not so self-evident as they appear at first glance. This is a prerequisite for being able to act creatively: to be able – taking the design and production of footwear as an example – to understand that shoes are not just shoes but narratives about and self-stagings of the person wearing them. One is not designing a functional technology but a culture–historically based creator of identity.

Lastly, they must be part of what is referred to as *metasystemic knowledge*, or *knowledge culture*. They must be able to adopt an attitude towards the company culture of which they are a part. They must function in a society where that is increasingly less like it used to be, whilst they also are able to keep a tight grip on what they themselves feel is important and is dear to them.

Knowledge categories[4]

Formerly, we used to believe that knowledge depended on reference, on indication. I point at something and say: 'I know that that is a tree'. In other words, knowledge was a reference. Today, we know that every indication depends on a distinction being drawn, i.e. on making a difference. When I point at the tree, this presupposes that someone or something has made a distinction between tree and non-tree. In other words, knowledge is not only other-reference, but also implies a self-reference.

In this relationship lies the basis of a description of knowledge and of the forms of the knowledge phenomenon, i.e. for advancing a systematic categorisation of knowledge. Still, the basic form of knowledge is knowledge of something, that is knowledge as other-reference. One must have factual knowledge, i.e. *qualifications*.

However, as already said, the concept of knowledge is recursive, i.e. it refers both to the world and to itself, and it is in this recursiveness that its secret is concealed: knowledge is always also knowledge of itself, or as the English philosopher of language Gilbert Ryle said: 'knowing-that' (knowledge of something) presupposes 'knowing-how' (knowledge of how I know what I know)

Table 12.1 Knowledge categories

Knowledge category	*Knowledge form*	*Knowledge designation*
1st order or simple knowledge	Knowledge about something	Factual knowledge: *Qualifications*
2nd order or complex knowledge	Knowledge about the conditions of knowing	Reflexive or situative knowledge: *Competencies*
3rd order or hypercomplex knowledge	Knowledge about the conditions of the reflexive knowledge system	Systemic or creative knowledge: *Creativity*
4th order knowledge	Society as dynamic knowledge horizon, i.e. the knowing society	World knowledge: *Culture*

(Ryle, 1949). This second category, not just knowledge, but knowledge of knowledge, can be expressed by the concept *competence*. Here, one knows how to make use of one's knowledge.

Knowledge of knowledge of knowledge is the third form, i.e. knowledge of the basis of knowledge, of what we normally take for granted or view as being natural or self-evident. The person who is able to observe the seemingly self-evident as something not-self-evident is well on the way to exceeding his knowledge boundaries. This form of knowledge, in other words, contains the germinating force of new knowledge, something one could express by the concept *creativity*.

We are, though, lastly also able to identify a fourth position, since – like Serres – we can describe the peregrinations of the troubadour in the knowledge landscape. So here we are dealing with knowledge of knowledge of knowledge of knowledge, i.e. knowledge to the power four, which is not an individual ability but is knowledge as a collective phenomenon, i.e. *world knowledge* or our total *knowledge culture*. Here we have the knowledge landscape that people formerly believed had a centre, but that we now view as a dynamic, self-generating landscape of knowledge forms and knowledge positions, and that one as an observer always has an incomplete picture of.

The ideal knowledge worker is a worker who includes all four categories in one individual person: firstly, he has a set of basic qualifications. Secondly, he is able to improvise, to organise his own work together with others. He knows how to use his knowledge. He is competent. Thirdly, he is able to go beyond the taken-for-granted assumptions. He knows what constitutes his knowledge categories. He is creative. And finally, he knows that his and others' knowledge sum up to a knowledge system, which constitutes their common knowledge culture.

The system of knowledge institutions

However, one can also translate the knowledge categories into knowledge institutions, which together create a 'social knowledge landscape'. A knowledge landscape, with its institutions of qualification, competence and creativity, makes up the ideal, innovative knowledge region or a regional knowledge culture.

Society can be described as a complex – even hypercomplex – system of subsystems that are separately autonomous yet interact. In order to describe this hypercomplex system one can use various criteria or optics for one's observation. One can, as does Luhmann, view society as a system of functionally differentiated subsystems. One can, as do traditional economists, view society as a system of value production and circulation. One can view it with competition as the descriptive criterion. Each actor is ascribed an urge towards self-maintenance and self-development as the fundamental imperative and, on the basis of this, society develops as a system of mutually competing and – if the use-imperative dictates it – cooperating actors and institutions.

But one can also view society as a system of knowledge production and circulation, where knowledge is produced, distributed and consumed in specialised knowledge domains. I will now briefly outline how such a system can be described, on the basis of the theory of knowledge and knowledge categories presented above.

The point of departure for the knowledge production and circulation of society is the domain that produces/domains that produce qualitatively new knowledge. What Claus Otto Scharmer (2001) refers to as knowledge emergence, i.e. the creation of new knowledge, takes place – according the categorisation of knowledge – in the domains that focus on systemic knowledge. Here one operates with what one does not know that one knows, i.e. with the premises for the knowledge that has already been recognised as valid.

The creation of new knowledge takes place in two functional systems – in the knowledge system of society and in its art system. Both these domains are characterised by the systemic or creative knowledge form being in focus, and by learning therefore being third-degree learning, i.e. the form of learning that can lead to relearning. Admittedly, one naturally finds all types of learning-stimulative processes, from repetitive rote learning of fingertip knowledge to project-based stimulation of competencies, but the ideal – and therefore the end-goal of the learning process – is independent scientific work on matter whose aim is to generate new knowledge. The ideal of such work is to change the premises for what one already knows.

Both art and science occupy key positions in society's total production and circulation of knowledge. ECCO Footwear, to return to the above example, would not be able to manage without technical and scientific research results: All hi-tech, automated and computer-based production is based on these results. But one is just as dependent on the aesthetic innovations that take place by virtue of the aesthetic knowledge production of society, for ECCO Footwear operates to just as great an extent in accordance with innovative principles of design, communication and organisation, i.e. principles that are based on results from the knowledge production of art and from the research world of the humanities and social sciences.

The next layer in society's production and circulation of knowledge is the storing and distribution of knowledge. How does one 'save' knowledge resources, and how does one give citizens access to these knowledge resources? The answer to this question is to be found in society's system of categorisation.

The education system has a special task when it comes to the total production and circulation of knowledge in society. Its function is to handle this – in principle insurmountable – challenge via teaching, i.e. goal-directed communication, to transfer the knowledge society has to individuals, i.e. to autonomous learning systems.

This gives rise to two main tasks that are closely interrelated. One is to administer a transfer of knowledge, i.e. to transfer factual knowledge to individuals. The other is to develop knowledge competencies, i.e. to make these individuals capable of learning. When I say that the two tasks are interdependent, this is because an individual can only acquire knowledge – also factual knowledge – via learning. Since Piaget we have known that learning does not depend on transportation but on active acquisition and own-construction.

From the perspective of the production and circulation of knowledge, private companies and public enterprises, i.e. what are referred to as the productive and reproductive sphere of society in socio-economic terms, have been the consumer link in the knowledge chain. Here the knowledge created and distributed by other societal domains of knowledge is made use of.

The consequence of this is that private companies and public enterprises are not designed to cater for the production of knowledge. Private companies function effectively because their activities have been planned and precise goals have been staked out. This, however, is at the expense of the level of creativity. Public enterprises, whose activities have been planned and scheduled, achieve for the same reasons a high degree of stability and predictability, but are precluded from the unexpected.

The societal expression for this separation of the various links in the chain of knowledge has been that only weak coupling mechanisms have existed. Society's production of knowledge took place at autonomous and isolated universities, whose transfer of knowledge to companies and public enterprises mainly took place via the research-based education system. New knowledge was transferred to companies and enterprises via newly qualified staff.

This situation, however, is undergoing considerable change. Both private companies and public enterprises are to an increasing extent dependent on the knowledge input they receive. This has various consequences. Firstly, the coupling potential between the knowledge-producing and knowledge-consuming domains of society are developing rapidly. Buffer zones are being established between universities and companies. Private companies are gaining seats on university executive committees and the collaboration between researchers and the outside world is becoming more flexible. Secondly, as already mentioned, the formalised stimulation of learning now permeates society. Companies are becoming 'self-instructive', which i.a. means that their leaders, apart from having an efficiency-raising view of production and profits, must also have a pedagogical view of management-level activities. At such a company, management also has a pedagogical task. Thirdly, and perhaps most radically, a breach is taking place when it comes to the monopoly previously enjoyed by universities and the world of art when it comes to creating new knowledge. New knowledge is also produced by private companies, no matter whether this takes place in a formalised way via the establishment of private research laboratories or informally via a closer linking of production, research and development. This means that the relations between universities and companies are changing: In certain instances R&D work is shared, in other instances the linkage is being made more flexible, so that production-related new knowledge is perhaps produced at companies but systematised at public research institutions.

The knowing region

One of the crucial challenges when organising the production of knowledge is to get various knowledge areas to interact in a productive way. Specialisation is, of course, necessary, but it is only when such special areas meet and interact that energy is released. Interference has to be created – or, as one of the pioneers within the theory of knowledge companies, Karl Weick, has expressed it: one must work on 'boundary crossing' (Weick, 1995). It is in the transitions between knowledge actors, knowledge areas or in that from one phase to another one, that the unexpected occurs and ideas come into being. This applies both internally within the company, in the composition of work teams and in the relationship between the company and its outside world.

As a leader, one has to be able to handle the various forms of knowledge, exploit their potential and make them interact. The leader of a knowing company is, in other words, a kind of knowledge designer. The task is not so much to create a transfer of knowledge (which corresponds to the traditional perception of teaching) as to create 'knowledge enabling', i.e. arenas and situations that encourage employees to create knowledge.

The relationship between the company and the outside is also important. Here, my example of ECCO Footwear can serve as an example. ECCO Footwear functions – as do other knowledge-heavy companies – among other things by virtue of close interaction with other knowledge institutions in society. Directly or indirectly, the company makes use of university research results within technical production, the development of robots, design, management, aesthetics, culture, etc. It also greatly benefits from the results of the culture industry. ECCO Footwear consolidates earlier Danish design traditions. Its website, www.ecco.com, also refers to modern artists, not only as a marketing gimmick but because they are the raw material of the company's product development. For behind the physical production of footwear lie basic cultural narratives, artistic innovations and design traditions.

ECCO Footwear, in other words, exemplifies the fact that a knowing society or region function by virtue of the interplay between various forms of knowledge capital, which together comprise what one could call the new knowledge industry. Cultural and intellectual capital are transformed – to use the concepts of the French sociologist Pierre Bourdieu – into economic capital (Bourdieu and Passeron, 1990).

Conclusion

So far, I have identified some of the elements needed to understand what innovative regions are. First I have argued in favour of the view that simple causal models are not only too simple but are also misleading. In order to understand how research-supported or research-inspired innovation takes place, it is necessary to think in hypercomplex models – and these do not obey the rules of simple causality.

Furthermore I have demonstrated that in order to create knowledge-based regions we must give up the idea of knowledge being an 'essence' that can be produced and transported. Instead we should identify the different knowledge categories and their complex production and circulation mechanisms.

Finally, the growing significance of art and culture should be understood. Art and culture are not just, as tradition would say, part of society's 'superstructure'. On the other hand, they are not replacing the production of values in the hand of a totally dominating 'creative class'. Rather, they are value-creating elements of society's economic structure and value-chain in which people and institutions representing different knowledge categories must work together in systems of specialisation and structural couplings.

It should be added that as far as social theory is concerned one can never create the pre-conditions for a direct 'how-to-do' set of instructions. Social systems are always inevitably unpredictable. What one can do – and can hope to be able to do – is to create concepts and analyse relationships, which enable one to handle the specific and concrete situation better and with a deeper understanding. In this context, too, there is nothing as practical as good theories.

Notes

1 Here, I refer to the 2002 version.
2 Strictly speaking one should make a distinction between 'structural' and 'operative' couplings. Structural couplings are couplings between systems operating in different operative modes, for instance social systems versus consciousness, while operative couplings are couplings between differentiated systems operating in the same operative mode, for instance functionally differentiated systems in society. In this article this distinction is not made.
3 This is not in accordance with Luhmann's analysis. He does not define the public sector as a functional system.
4 My development of a systematic set of knowledge categories has been fully presented in Qvortrup (2004a) and summarised in English in Qvortrup (2004b). It is inspired among others by Bateson 2000, Boisot 1995 or 1998, Gleerup 2003, Polanyi 1983 [1966], Qvortrup 2001 and 2003, Ryle 1949, Scharmer 2001, Serres 1997 [1991].

References

Andersen, Niels Åkerstrøm (2003) *Borgerens kontraktliggørelse* (The contractualization of the citizen). Hans Reitzels Forlag, Copenhagen.

Bak, Per (1996) *How Nature Works. The Science of Self-Organized Criticality*. Springer Verlag, New York.

Bateson, Gregory (2000) 'The Logical Categories of Learning and Communication' [1964 and 1971]. In: Gregory Bateson: *Steps to an Ecology of Mind*. The University of Chicago Press, Chicago and London, pp. 279–308.

Bell, Daniel (1973) *The Coming of Post-Industrial Society*. Basic Books, New York.

Boisot, Max H. (1995) *Information Space. A Framework for Learning in Organizations, Institutions and Culture*. Routledge, London and New York.

Boisot, Max H. (1998) *Knowledge Assets. Securing Competitive Advantage in the Information Economy*. Oxford University Press, Oxford.

Bourdieu, Pierre and Passeron, J.-C. (1990) *Reproduction in Education, Society and Culture*. Sage Publications, London.

Castells, Manuel (1996) *The Rise of the Network Society*. Blackwell Publishers, Malden MA and Oxford, UK.

Derrida, Jacques (1988) *The Ear of the Other*. University of Nebraska Press, London.

Durkheim, Émile [1895 and 1919] *Les règles de la méthode sociologique*. Akan, Paris.

Etzkowitz, Henry and Leydesdorff, Loet (eds.) (1997) *Universities and the Global Knowledge Economy: A Triple Helix of University–Industry–Government Relations*. Pinter Publishers, London.

Florida, Richard (2004) *The Rise of the Creative Class*. Basic Books, New York.

Gibbons, Michael *et al.* (2002) *The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies*. Sage Publications, London [1994].

Gleerup, Jørgen (2003) 'Videnshåndtering og læring i netværkssamfundet'. In *On Edge* no. 2, Knowledge Lab DK, pp. 6–8.

Gödel, K. (1931) 'Über formal unentscheidbare Sätze der Prinzipia Mathematica und verwandter Systeme I', in: *Monatshefte für Mathematik und Physik*, bd. 38, Leipzig pp. 173–98.

Kauffman, Stuart A. (2000) *Investigations*. Oxford University Press, Oxford.

Luhmann, Niklas (1984) *Soziale Systeme. Grundriss einer allgemeinen Theorie*. Suhrkamp Verlag, Frankfurt a. M. (English translation: Luhmann, Niklas (1995) *Social Systems*. Stanford University Press, Stanford CA.)

Luhmann, Niklas (1988) *Die Wirtschaft der Gesellschaft* (Society's Economy/Industry). Suhrkamp Verlag, Frankfurt a. M.

Luhmann, Niklas (1990) *Die Wissenschaft der Gesellschaft* (The Science of Society). Suhrkamp Verlag, Frankfurt a. M.

Luhmann, Niklas (1997) *Die Gesellschaft der Gesellschaft* (Society's Society). Suhrkamp Verlag, Frankfurt a. M.

Luhmann, Niklas (2000) *Die Politik der Gesellschaft* (The Politics of Society). Suhrkamp Verlag, Frankfurt a. M.

Machlup, Fritz (1962) *The Production and Distribution of Knowledge in the United States*. Princeton University Press, New Jersey.

Maturana, Humberto R. and Varela, Francisco J. (1992) *The Tree of Knowledge. Revised Edition*. Shambhala, Boston and London.

Polanyi, Michael (1983) *The Tacit Dimension*. Peter Smith, Gloucester, MA.

Prigogine, Ilya and Stengers, Isabelle (1979) *La Nouvelle Alliance. Métamorphose de la Science*. Editions Gallimard, Paris.

Qvortrup, Lars (2001) Det lærende sanfund (The learning society). Gyldendal, Copenhagen.

Qvortrup, Lars (2003) *The Hypercomplex Society*. Peter Lang, New York.

Qvortrup, Lars (2004a) *Det vidende samfund* (The knowing society). Unge Pædagoger, Copenhagen.

Qvortrup, Lars (2004b) 'The Mystery of Knowledge'. *Cybernetics & Human Knowing*, 11, 3, pp. 9–29.

Ryle, Gilbert (1949) *The Concept of Mind*. Hutchinson, London.

Scharmer, Carl Otto (2001) 'Self-transcending Knowledge: Organizing around Emerging Realities'. In Ikujoro Nonaka and David Teece: *Managing Industrial Knowledge. Creation, Transfer and Utilization*. Sage Publications, London.

Serres, Michel (1997) *The Troubadour of Knowledge*. The University of Michigan Press, Ann Arbor.

Stokes, Donald E. (1997) *Pasteur's Quadrant*. The Brookings Institution Press, Washington DC.

Weick, Karl (1995) *Sensemaking in Organizations*. Sage, Thousand Oaks CA.

13 Conclusions

Variety and miracles for successful regional innovation policies: from 'copy and paste' to 'copy and paste special'

Andrea Piccaluga

The chapters contained in the present book have the objective of further investigating the laboratory-like institutional capabilities which numerous regions are building with regard to policy experimentation in the fields of R&D and technological innovation. In particular, in his introduction, Phil Cooke has argued that (1) regional development policies have moved into an era where there is much greater variety on show than hitherto, (2) there is an ongoing passage from Globalisation 1 into Globalisation 2, and (3) required policies to moderate social and spatial imbalances are perforce 'associative'.

As a matter of fact, these kinds of policies have attracted a lot of scientific effort by scholars and practitioners, with several waves of original theoretical approaches and connected empirical evidences. In this context, which seems to evolve continuously together with the evolution of knowledge, technologies, institutional orders at regional, national and supra-national level, our contribution is to try and further investigate the complexity of policy making. We would like to start our conclusions with a rather unconventional approach.

In the Gospel, a young man approaches Jesus and says he is already following the rules given by Abraham and that he is also helping poor people. What else can he do? Jesus is quite happy and tells him that the next step is to sell everything to the poor and follow him. The young man looks down and goes away. In fact, he was very rich.

This episode can be of some help for policy makers who have responsibilities in R&D and innovation at regional level. In fact, the complexity (and importance) of regional R&D and innovation policies has been discussed, in the last few years, with such an emphasis and so much empirical evidence that aware regional policy makers may believe they will never make it. The task may seem too difficult for them, and all they may have learnt in previous experiences might be considered a sort of a starting point and not an advanced step of a challenging learning process. In other words, some policy makers might end up that dealing with R&D and technological innovation at regional level and designing and implementing successful plans is an almost impossible task. As a matter of fact, we argue this is not completely true.

It is certainly true that the design of regional innovation policies is an increasingly complex and challenging task, but policy makers can still be confident that their policies can be planned and implemented with success. Theirs is not an easy job, of course; in most cases it requires new and fast-changing skills as well as new approaches, but it can be done.

In his stimulating introduction to the present volume, Phil Cooke has presented several issues, some of them known, some others newer, which really deserve accurate attention. All the chapters, as well as the rich literature on the topic, further confirm that the broad framework of regional innovation policies is continuously changing. Our main arguments in these concluding remarks are that (1) learning and imitation processes among regions are now much more frequent than in the past, and this may imply that 'ordinary' administration is no longer sufficient and that trying to assimilate best practices from others may be not enough. Also, (2) the complexity of the context and of the instruments of regional innovation policies has further increased, and as a consequence particularly precious is the contribution from those who are capable of acting as coordinators and translators of analyses, ideas and projects at regional level and thus strengthen the intensity, as well as the flexibility of linkages among different players (see also Cooke and Morgan, 1998). These two arguments can be further explained through the following considerations.

Regional innovation policies are a must, but 'the place is rather crowded'

Policy makers all over the world, and Europe is certainly no exception, have learnt that specific and ambitious regional policies for research and innovation are absolutely necessary in the current international economic scenario. Moreover, central governments are further encouraging regional dynamism in this direction. However, if the fact that almost every region in Europe is now active in the field can certainly be considered as a positive aspect, we also observe that in many cases me-too strategies are adopted. In other words, several regional best practices can now be considered consolidated common knowledge at international level and regional governments try and include them in their planning exercises. Nonetheless, some of the objectives of those policies, such as attracting (science-based) multinational corporations, really require the implementation of real discontinuities and large-scale initiatives by regions, and not me-too, more limited imitative regional policies. As a matter of fact, the adoption of best practices now often represents a sort of a standard endowment which is required to start the game of regional competition at international level, and is far from representing a guarantee for an easy win. In general, the level of commitment and investments which are necessary to achieve visible discontinuities at regional level has also risen quite a lot.

In search of assets which are not easy to imitate

Therefore, we argue that it is certainly necessary to analyse and replicate best practices in regional innovation policies, especially as a starting point, but we also believe that 'copy and paste' is not enough. Each territory has its own history and economic, social and technological trajectories which have to be acknowledged. Real positive discontinuities, which are today desperately necessary in many European regions, arise from actions which are based on consolidated best practices but are also significantly different from what others are doing or have done in the past; in other words, rather than a 'copy and paste' function, 'copy and paste special' is the real starting point of regional planning. Also, 'copy and paste' might really involve difficult strategic decisions and competence destroying actions, since it is sometimes necessary to concentrate investments in order to achieve significant positive changes in knowledge production and adoption; this means that some people will be very disappointed (since their industrial or technological filières may have been considered useless and downsized) and some others quite enthusiastic (since investments will be heavily concentrated towards their competencies).

Open innovation and Globalisation 2

In his introduction, Phil Cooke also suggests important linkages between Chesbrough's Open Innovation and a suggested 'second phase' in globalisation processes (Cooke, 2005). In fact, the increasing importance of R&D outsourcing practices from large corporations determine quite new scenarios which to a certain extent have been somehow previously described by Gibbons *et al.* (1994) with regard to knowledge production modes and interaction among different types of knowledge producers and by Williamson *et al.* (2001) with regard to what they call *Metanational* Corporations, and their role in shaping and exploiting knowledge production processes worldwide. Perhaps, what still needs further research to be done is the need to continuously reinvent the interplay among universities, corporations and governments, which is increasingly taking place at regional rather than national level. Multinational corporations – such as St Microelectronics, Ericsson, Intel and many others – are in fact playing a crucial role in regional knowledge-based economic development and policy makers should be fully aware of their role and responsibilities in influencing location and investment decisions of large companies. The way regions can influence location decisions of R&D activities by large corporation and especially their efficacy in making those decisions as stable as possible, is likely to represent one of the fundamental issues in regional knowledge and innovation policies.

The importance of aligners and 'complicit brokers'

Regions would benefit from using their laboratory-like institutional capabilities of policy experimentation in order to play a role in innovation processes which have an increasingly systemic nature. Current systemic and rapidly changing innovation systems require regions to be particularly flexible in their approaches as well as ready to use trial-and-error approaches to a certain extent. Moreover, in strongly systemic environments a robust socio-technical alignment (see Molina, 1997) and a broad social and political consensus are necessary to promote an adequate innovation atmosphere at regional level. This makes it necessary that someone acts as moderator or aligner, in order to facilitate some kind of regional governance, since otherwise it is likely that the majority of active organisations will tend to protect – or at least take care of – their current interests and determine lock-in effects (preventing the emergence of new industrial and technological trajectories). At the same time, 'translators' are also needed to further stimulate connections and creative use of research results beyond spontaneous spillovers which are normally present in sufficiently interconnected regional and local systems. With regard to this last issue, the debate is still open about the comparative and relative efficacy of institutional transfer mechanisms (such as innovation centres and technology transfer agencies), versus a model according to which the different players (manufacturing and high-tech firms, universities, local governments, consultants, etc.) should further strengthen their competencies, absorptive capacities and orientation towards collaborative work, also through the use of more homogeneous 'contact languages', so that the final result would be a more intense – and rather 'spontaneous' – valorisation of research results.

Doing rather well is not enough

There are actions and policy interventions which have to be made in order to maintain current competitiveness levels. 'Ordinary administration', if we can call it that, includes a continuous analysis of regional innovation performance, actions to increase the levels of general education, basic actions to enhance the valorisation of research results and foster University–Industry relations, and measures to increase absorptive capacity in small firms. These actions are required to compete, to start the game, but they are not guarantee of success. Moreover, even ordinary administration may be a serious task. In fact, (1) consolidated industrial sectors – especially in non-high-tech manufacturing – attract a lot of attention and resources because of their difficult competitive situation and serious employment implications and often do not leave space for action in new emerging sectors; as a matter of fact, industrial crises often absorb most of economic resources which are then used in fire-fighting activities rather than for medium- and long-term projects; also, (2) regions differ significantly, and it is not obvious how to weight and attribute importance to the various actions which should be included in ordinary administration; finally, (3) socio-technical alignment processes are lengthy and absorb many resources, to the point that in some areas it is hard to convince relevant players that 'innovation tables' (or circle, or consortium) which might be proposed, will represent effective places for launching new projects and managing them, rather than a waste of time, as many similar experiences may have been in the past. Our argument therefore is that resources do have to be invested in 'ordinary administration', although they have to be intended only as starting conditions. At the same time, there is the risk that necessary economic resources will be spent in favour of current industrial and technological filières, some of which can be supported with the hope of positive results and some of which are simply indefensible. Discontinuities, on the other hand, may be too expensive and too risky, so that, at least, investments should be made in 'seeds of change', i.e. projects with potential and 'passion' for change, and possibly solid roots in local systems and traditions.

Variety in regional innovation policies

The governance of regional innovation systems has become extremely complex not only because almost every organisation aims at playing a role (and often with a marked individualistic approach), but also because the competencies and relative importance of the various organisations change quite rapidly. This calls for a continuous effort in analysing regional endowments, considering competencies which can be built, positioning each region in a dynamic international context. Recent studies carried out for and/or with the European Commission clearly show that regions are quite different from each other and that common recipes can be used only to a certain extent. The issue is particularly important for countries which recently entered or are on the point of entering the European Union. With regard to knowledge and innovation systems, Cooke interestingly compares the well funded American and Northern European model, the more supportive Canadian–Baltic one and the institutionally stimulated Mediterranean leadership one. Most probably, a creative combination of all of them will have to be used in the future in order to generate the necessary variety and originality in policy making at regional level.

Complexity cannot be managed

The complexity and uncertain outcomes of regional innovation policies suggest that ambitious objectives can and should be defined and firmly followed, but also that detailed and accurate planning is not a solution to deal with disturbing complexity and uncertainty. In other words, excessive efforts in programming might be more costly and less effective than having a certain degree of bottom-up freedom, letting different players make creative proposals, even if sometimes within poorly coordinated and homogeneous frameworks. The risk of the fragmentation of resources has to be taken into account, but a good level of freedom of action and intense flow of information might turn out to be among the most important ingredients of successful regional innovation policies. Policy makers, on their part, are therefore 'obliged' to engage in a continuous effort towards increasing their absorptive capacity, in order to be able to 'copy' and especially 'paste special' their own pathway to regional economic development.

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References

Chesbrough, H. (2003) *Open Innovation*, Harvard Business School Press, Boston, Massachusetts.

Cooke, P. (2005), Regional asymmetric knowledge capabilities and open innovation: exploring 'Globalisation 2' a new model of industry organization, *Research Policy*, 34, 1–22.

Cooke P. and Morgan, K. (1998) *The Associational Economy: Firms, Regions, and Innovation*, Oxford, Oxford University Press.

Doz, Y., J. Santos, and Williamson, P. (2001) *From Global to Metanational*, Boston, MA, Harvard Business School.

European Spatial Planning Observation Network (2004) The Territorial Impact of EU Research and Development.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S. and Trow, M. (1994) *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*, London, Sage Publications.

Molina A. (1997) Insights into the nature of technology diffusion and implementation: the perspective of sociotechnical alignment, *Technovation*, 17(11/12), 601–26.

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