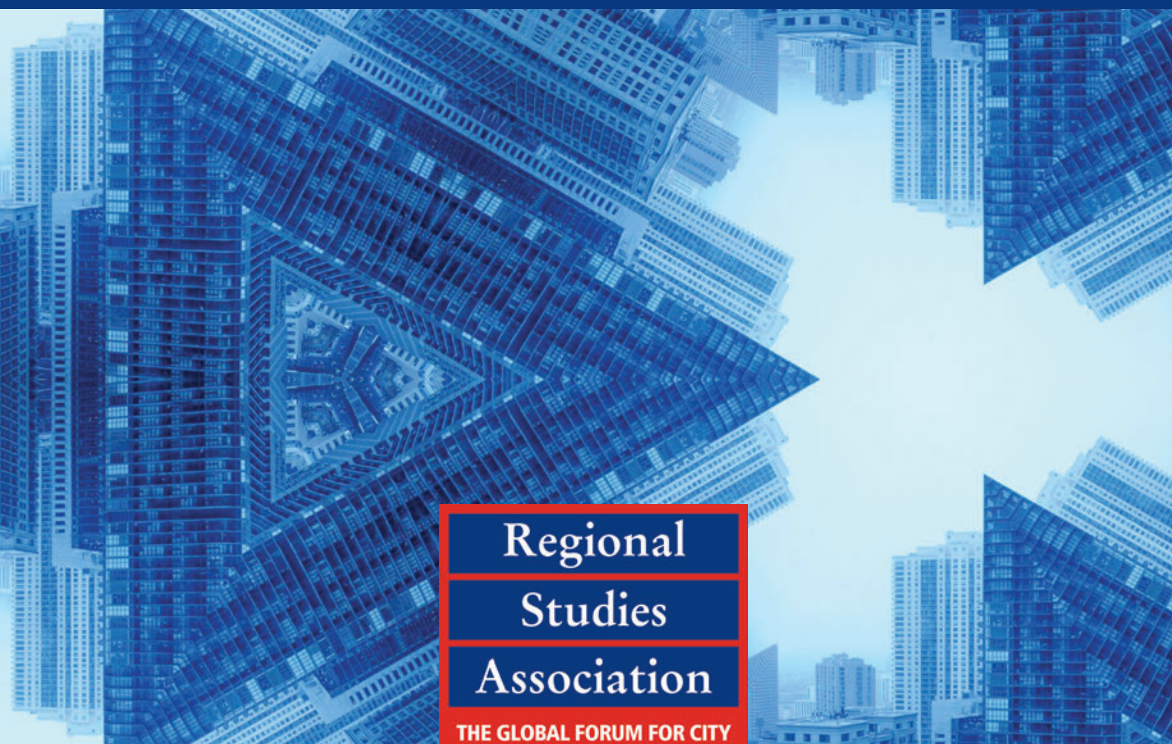
RE-FRAMING REGIONAL DEVELOPMENT

EVOLUTION, INNOVATION AND TRANSITION



Regional Studies Association

THE GLOBAL FORUM FOR CITY AND REGIONAL RESEARCH, DEVELOPMENT AND POLICY

REGIONS AND CITIES

EDITED BY PHILIP COOKE

ROUTLEDGE

Re-framing Regional Development

Turbulence characterises the current global scene. This book uses complementary theoretical approaches to understand and help prescribe policies to 're-frame' the regional development problem in turbulent times. These approaches are: evolutionary complexity; evolutionary economic geography; emergence theory; and resilience theory. From below, they address the four major crises creating a 'perfect storm' for societies and economics involving: the climate change crisis; the energy crisis; the banking and financial crisis; and the global economic crisis.

This book analyses and proposes ways in which regional economies, in particular, are having to be 'reframed' to address these crises. First, many must evolve in new ways, possibly moving back from the 'service economy' towards a new, greener form of manufacturing goods as well as services. Accordingly, regional economies are innovating in new ways. Amongst these are the quest for 'relatedness' within their own regional orbits, and promoting 'modularity' as a mode of analysis and a policy stance to stimulate innovation across industry and geographical borders.

Finally, regional economies and societies are discovering that, from a 'resilience' perspective, they must find answers to the higher levels of governance with which they increasingly struggle. In this respect regional economies are in 'transition' and regional processes are 'emergent'. The transition seeks to address the four crises, involving re-balancing, re-directing and re-framing future policy and practice. This book describes many of the novel 'framings' involved in understanding the new ways in which this major task is being addressed in theory, policy and everyday practice.

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Regions and Cities

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Preface

This collection has its origins in a *festschrift*, organised in Cardiff on 4–5 April 2011, to mark this editor's official demi-retirement as research professor and director of the Centre for Advanced Studies at Cardiff University, a post dating from the centre's foundation in 1993. According to Wikipedia, in academia, a *festschrift* is a book honouring a respected person, especially an academic, and presented during his or her lifetime. The German term is translated as *celebration publication* or *celebratory (piece of) writing*. A comparable book presented posthumously is called a *Gedenkschrift* (*memorial publication*). Fortunately, everyone involved favoured the former over the latter: however, as the evolutionary complexity perspective explored in parts of the volume holds, the evolution of living systems is unpredictable, so fingers crossed.

Coincidentally, the 4th of April was the hundredth anniversary of my father's birth, on Penparlas farm in the nearby Rhondda Valley, though he would now need more of a *gedenkschrift* than a *festschrift*. The penultimate chapter of this collection, by my long-term friend and writing partner Kevin Morgan, alludes to aspects of the evolutionary change experienced by such locales. 'A squirrel (or in some accounts, a monkey) could run from one end of the valley to the other without touching the ground' was the prelapsarian narrative. Then coal was discovered underground and its mining caused explosive economic growth as well as many less welcome colliery explosions that carried some thousands of Rhondda miners off to early graves.

In just over a hundred years 1875–1985 it was all over, and what was once a kind of Victorian Dubai descended into the stasis of de-industrialisation with fragile re-industrialisation. As complexity theory proposes, without any clusters with which to interact, no new growth can be anticipated. Doom and gloom: but, the beauty of the papers in this book is that they show repeatedly that connectivity with pre-existing or new points of economic energy (path inter-dependence) will allow for recombinations of knowledge and the prospect of renewed regional innovation and growth. Accordingly, bad, un-innovative policy informed by misguided neoclassicism, or worse, the myth of the neoliberal 'efficient markets' hypothesis, has delayed progress. We all hope the 'reframing' of the narrative of regional development proposed in this book and the idea that 'policy is innovation', which it also advocates, help produce a 'resilience shock' to our field that leads to superior outcomes for economic geographic understanding and policies informed by such ‘reframing’. All participants and organisers of the Cardiff Colloquium and *festschrift* are warmly thanked for their contribution to this aspiration.

Phil Cooke

1 Introduction

Complex systems integration, ‘emergence’, and policy modularisation

Philip Cooke

Introduction

This book assembles the thoughts of a substantial number of leading intellectuals whose careers have been devoted to understanding regional development processes and, for many, reflection upon what might be useful policy suggestions, advice or interventions to optimise regional evolution. To a greater or lesser extent, all are fascinated with the project of the book, which is to ‘reframe’ regional development, and their chapters give expression to this interest and perspective. This does not mean that all chapters are written according to a specific ‘new order’. Rather, the majority are, to a greater or lesser extent, experiments in thinking about regional development from the viewpoints of four innovative macro-perspectives or ‘frames’. In some cases, the frames selected are sufficiently complementary that they can be, and are used in the same chapter without difficulty. So what are they? In the order they are introduced below they include: evolutionary complexity theory; evolutionary economic geography; emergence theory; and resilience theory. The great ‘reframing’ all have made is to recognise the veracity of Beinhocker’s (2006) devastating conclusion from his major critical review of ‘Traditional Economics’ that its early founding fathers, Walras and Jevons, in their desperation to deploy prevailing physico-mathematic reasoning, led the field up a blind alley for more than a hundred years.

This happened because their physico-mathematics stopped with the first law of thermodynamics, otherwise known as the Conservation of Energy, which explained how everything in the physical world consumes, reincarnates but cannot augment energy. The tendency of all action or agency is towards closed system equilibrium and stasis. If this sounds like a different terminology for ‘death’, the thought was already expressed by complex systems pioneer John Holland at the first meeting of economists and physicists to discuss this at the Santa Fe Institute in New Mexico. The latter group received the ‘framing’ of what ‘Traditional Economics’ had achieved with a surprising mixture of astonishment and awe. Surprising for the economists was the analogy some drew between what they had just heard and a visit some once made to Cuba. For them Havana, particularly, presented the experience, common to Americans but also others, of stepping back fifty years in time. Long-disappeared car brands, such as, *Studebaker*, *Packard* and *De Soto* as well as vintage Chevrolets and Fords still plied the streets, patched up with tractor parts where originals could not be found or re-made. Just as tourists wondered at the ingenuity of Cuban mechanics in keeping such heirlooms on the road and functioning, the physicists were awestruck that economics had yet to integrate the second law of thermodynamics, let alone quantum mechanics in its physico-mathematical reasoning. Yet they were professing to describe modern economic processes through the frame of an idea first aired by Joule and others in the 1840s.

Framing and 'reframing' are not always so time-bound, but inevitably time is involved in the latter process. Ironically, time was comprehended in a new way when Lord Kelvin proposed the second law of thermodynamics, a little after the foundations of 'closed system' economics had been finished. Kelvin's insight was that in open systems, like our world, energy and everything else dissipates into a disorderly end condition ('rust never sleeps') of entropy. This allowed a reframed consciousness of the meaning of time. Because without the concept of entropy, including even the weathering of solid rocks, differentiation of past, present and future could not be accomplished (Beinhocker 2006: 68). The notion of 'entropy', which the second law captures as the irreversible tendency for things to fall apart, is central to the thought chains that are further explored under the rubrics of complexity, evolution, emergence and resilience in the chapters comprising this volume. But reframing can happen swiftly, especially in modern fields of knowledge. Most people would think of biotechnology as a relatively new and influential field. The discovery of DNA is considered by many to be the apotheosis of modern scientific inquiry. But it, and its claims to supremacy in the field of evolutionary biology, are equally prone to the criticism that they represent a cul-de-sac rather than an open, expanding vista. Consider the following:

> the double-helical DNA of Watson and Crick, the discovery of the 'genetic code' and the formulation of the theses that came to be known as the 'Central Dogma' of molecular biology, which proclaims the unidirectional flow of 'information' from DNA to RNA to protein . . . was *preformationist* (. . . the 'ghost in the chromosomes'); *genocentric* (it located agency exclusively in the genes); and *reductionist* (. . . 'we are our genes')
>
> (Hendrickson 2011: 48)

This can sound almost familiar to anyone sceptical of 'Traditional Economics' with its *linear* (for example, mechanical causality), *preformationist* (for example, rational economic 'man'); *genocentric* (for instance, utility maximisation) and *reductionist* (for example, consumer preference) master narratives.

However, this framing of the 'Central Dogma' is in crisis and being undermined by the 'Systems Biology Perspective' (SBP). Among the new views arising from the large amount of data, including the Human Genome Project, generated by molecular biology into the complexity of living systems are; the importance of context, connectivity, emergence, distributed causality and self-organising systems. This means such assumptions as the organism 'unfolding' *preformed* from its DNA coil is replaced by the idea that each organism is a novelty/

innovation; that only the *genes* count for everything is replaced by the notion of agency being distributed about the whole organism; and *reductionism* is superseded by considerations of context, emergent properties and the modular relations between the parts and the whole cell or organism system.

The SBP reframes the narrative from the workings of individual genes to those of the genome as a whole, emphasising two core concepts: networks and self-organising systems. Nobel laureate Barbara McClintock (1984), discoverer of 'jumping genes', found they change places through 'horizontal transmission' thereby modulating the genome according to context, including environmental conditions. These interactions change mutation rates. This affects the structure of DNA according to the state of the cell – a higher organisational level than the genome – giving the kind of *downward causation* with possible feedback envisaged from an 'emergence' perspective. So at all levels are found non-linear networks rather than linear causality, DNA is not the global controller ('master molecule') but there is a distribution of agency over all the elements, otherwise self-organising systems. What does this signify for the project of this book? First, that reframing is a cognitive way out of a mistaken or otherwise sub-optimal path dependent trajectory. Second, that determinism and reductionism had deep roots in western thought before they began to wither. Third, SBP signifies a return towards the Aristotelian idea of emergent form undirected by a master molecule ('silver bullet') or global controller. Fourth, such simplifications may be necessary to the early development of fields of knowledge ('low hanging fruit'). Fifth, every science is replete with metaphors ('brain is *like* computer' becoming 'brain *is* computer') which have communicative value but belong to the sphere of rhetoric.

The remainder of this introductory chapter devotes attention to: 'Concepts of reframing'; 'Evolutionary, complexity and related theory'; and 'Systemic integration of policy modules'. The chapters that follow are grouped in four sections and the brief summaries of their key messages similarly. They relate respectively to: Part I, 'Evolutionary transition space' with chapters by Allen Scott, David Wolfe, Ron Martin and Peter Sunley, and Phil Cooke. Part II, 'Innovation and diversity' has chapters by Helen Lawton Smith, Elvira Uyarra and Kieron Flanagan, James Simmie, and Pierre-Alex Balland, Ron Boschma and Koen Frenken. Part III, on 'Cluster emergence and destabilisation' displays chapters by Helinä Melkas and Tuomo Uotila, Phil Cooke, Luciana Lazzeretti, and Dieter Rehfeld and Judith Terstriep. Part IV, dealing with 'Evolutionary spatial policy' has chapters by Franz Tödtling and Michaela Trippl, Kevin Morgan, and Fumi Kitagawa.

Concepts of reframing

> It makes me so happy. To be at the beginning again, knowing almost nothing. . . . A door like this has cracked open five or six times since we got up on our hind legs. It's the best possible time of being alive, when almost everything you thought you knew is wrong
>
> (Tom Stoppard, *Arcadia*, 1993)

This quotation is a favourite with complexity theorists; both Eric Beinhocker (2006) and Melanie Mitchell (2009) use it as a prominent headline quotation in their volumes. Their books reveal a certain ecstasy at finding themselves on shining empty uplands waiting to be reframed or perhaps for the first time framed with new and better theoretical systems. Such are the hermeneutics of theoretical and empirical research, which is all framed, as Keynes realised, even for the most practical of persons, with the decaying theories of some long-dead economist (Keynes 1973). However, I thought it might be interesting to ask Tom Stoppard about his highly appropriate quotation. To which his website replied:

> When asked once about the origins of *Arcadia*, Tom Stoppard replied that he had been reading *Chaos*, James Gleick's (1987) book about mathematical theory and at the same time wondering about the contrasts between Romanticism and Classicism in style, temperament, and art. Few playwrights find source material in subjects as diverse, and unlikely, as Stoppard and his literary achievements are often considered more amazing for someone who left school at the age of seventeen and never attended a university. For some, *Arcadia* represents a pinnacle in Stoppard's career. After years of writing clever, witty plays with intellectual appeal, he managed to produce one that tugs at the heart as well as the mind. After its Broadway debut, Vincent Canby wrote in the *New York Times*, 'There's no doubt about it. *Arcadia* is Tom Stoppard's richest, most ravishing comedy to date, a play of wit, intellect, language, brio, and, new for him, emotion'.

Of course, we hope readers of this modest collection avoid the sense they have just read a 'ravishing comedy' or too many of the other dramatist's achievements. But the story reminds us of the proximity between art and science *pace* Lord Snow (1959) whom my Leavisite English Literature teacher and *Scrutiny* contributor, Frank Chapman, used regularly to rail against for his presumption that literature might not be the jewel in the cultural crown. Snow is also experiencing something of a revival at the hands of complexity theorists – like Alicia Juarrero (Juarrero and Rubino 2008), coincidentally co-editor of a book called *Reframing Complexity* (Capra, Juarrero, Sotolongo and van Uden 2007) and Stuart Kauffman (2008), winner of the MacArthur 'genius' award in 1987 – for drawing attention to the split in western ontology between the 'two cultures' of the humanities and the sciences. Snow bemoaned the secondary cultural status enjoyed by science in his day. Kauffman (2008: 7) celebrates the fact, as he sees it, of the humanities' relative contemporary impoverishment in the face of science's achievements and reputation with elites since then. However, this book celebrates more the contribution of innovator and entrepreneur Steve Jobs, co-founder of *Apple*, for whom the core of his and his firm's creativity lay in the company's consistent practice of 'recombining' (in the pure Schumpeterian, 1934 sense) the humanities and technology, embedding design principles in the deepest recesses of the firm's capability to de-stabilise prevailing product and services markets by its mantra to 'think different' and innovate better (Isaacson 2011). Accordingly, we agree with

Alicia Juarrero's (2000) judgement of the interpreter (scientist or artist) as an 'attractor' meaning an agent who can, by virtue of her interpretation influence system destabilisation and even phase-change (compare Jobs' 'reality distortion field'; Isaacson 2011). For this complexity variant of political 'spin' or in the world of financial innovation 'stoking the shares,' Juarrero calls in evidence Hans-Georg Gadamer:

> In dynamical terms, the tradition in which interpreters are situated is itself an attractor. As social beings, interpreters are embedded in [system] dynamics. As Gadamer (1985: 216) notes, 'The anticipation of meaning that governs our understanding of a text is not an act of subjectivity, but proceeds from the communality that binds us to the tradition', that *frames* our interpretation
>
> (Juarrero 2000: 54, emphasis added)

So, we conclude this opening foray (reader and interpreter) with that slightly nervous *frisson* of anticipation about finding out how to frame the object of interest to the volume, secure only in the knowledge that almost everything you thought you knew is wrong.

This first-level entry to the reframing phenomenon is pitched universally, unwilling to privilege science or humanities and holding firmly that both tribes tell stories, some more convincing than others, but irredeemably framed nevertheless. Redemption comes in reframing that recognises, for example, the 'the futility of utility'. The next step is to move to a level below, exploring the ways in which framing and reframing dialogues emerged in the fields of cognitive and social science where it is used in cultural analysis, media studies and political analysis to name a few. Possibly Erving Goffman (1974) wrote the seminal text, building on his earlier work problematising the presentation of self in everyday life. However, in Kauffman's (2008) celebrated 'tractor problem' whereby, in 1916, chief engineer Eugene Farkas solved Henry Ford's problem of engine block overload by dispensing with the chassis on his *Fordson F*, extending the rigid engine block base to replace it, accordingly also designing a more affordable product in the process, Kauffman refers to the difficulty of 'framing' innovation. There was no manual, directory or instructions, no 'algorithm', or prestatement, and no awareness by anyone of that potential engine block functionality. Frames *dominate* but by definition they also *exclude*; they are one source of the mysterious corporate myopia discussed in Cooke *et al*. (2010) and mentioned in Chapters 5 and 10, that often leads to extinction of, or at least, drastic change management in companies. Of course, this process, known as 'exaptation' in evolutionary biology (Vrba and Gould 1982) and 'preadaptation' in evolutionary complexity theory (Kauffman 2008) is a useful definition of what constitutes an innovation; it is not prescribed or predictable and therefore makes the lives of cognitive scientists trying to model human problem solving impossible. Accordingly, Farkas 'reframed' the dominant 'frame' and gave rise to the commissioning of a new set of manufacturing instructions for the tractor industry worldwide. For Kauffman therefore:

> the frame is a list of the relevant features of the situation. No one knows what to do about the limitations on problem solving that result once the relevant features are prespecified. . . . Yet we do it all the time. At its heart, this is part of a radical conclusion: the mind is not (always) algorithmic.
>
> (Kauffman 2008: 187)

In support of this rather engineer-channelled contention, Kauffman then proceeds to list ten known uses of a screwdriver, other than its design function – or ‘affordance’ as he calls it – of inserting a screw. Nevertheless, he concludes that the manner in which the mind, like a ghost ship, regularly slips its moorings freely to sail away wherever it will is key to our necessary understanding of creativity and innovation. Reframing is the act of creating a novel perspective on a misunderstood canvas, scene or system. We can understand how it occurred and how it prevailed but we cannot predict it.

A case of this kind of ‘creative framing’ occurs closer to home in the rather surprisingly linear perspective on ‘de-territorialisation’ adhered to by a melange of social and economic geographers commenting upon the potentially negative effects on local cultures of, first, industrialisation but more recently, globalisation. In a chapter on the ‘de-territorialisation’ of identity that geographers have seen as concomitant with globalisation (Roca 2010, an apparently strong linear causality is shared by Harvey, Massey, Lefebvre, Giddens and Agnew, amongst others. This basically says that a ‘local’ cultural framing is either effaced, invaded or dominated by a global, US-dominated consumer ‘framing’, hence the ‘de-territorialisation’ of culture. However, this view significantly contrasts with more nuanced insights from the likes of ‘postcolonial theorists’ like Appadurai (1996) and Bhabha (1994) who observe the ‘emergence’ of new cultural combinations of a non-linear kind, embracing regional, national and global elements of ethnicity, territory and identity instead. For Appadurai (1996), globalisation gives the opportunity for ‘framing’ the character of regions in terms of ‘potential’. This is entwined in the ‘emergence’ of what he calls a ‘technoscape’:

> which is the global configuration, also ever fluid, of technology and the fact that technology, both high and low, both mechanical and informational, now moves at high speeds across various kinds of previously impervious boundaries.
>
> (Appadurai 1996: 34)

In this space are found the ‘digital migrants,’ a term marking certain groups and their way of living by culture, also creating topographies of regional cultural difference (1996: 16). Globalisation does not necessarily result in homogenisation or Americanisation. Because different societies appropriate the materials of modernity differently, there remains a space of specific geographies, histories, and languages. Appadurai views the genealogy of cultures in their circulation across regions, while the history of these forms is their steady domestication into local practice. He also stresses that locality itself is a historical product and subject to the dynamics of the global. The geographical divisions, cultural differences, and national boundaries become isomorphic, and world processes are seen in this spatial imaginary through the frame of a global-regional narrative. Accordingly, globalisation itself is a historical, uneven, and even localising process.

Although criticised for certain 'neocolonial' traits in his own discourse and career, *that may well be subtle proofs of his thesis*, Bhabha (1994) frames these 'strange attractors' in terms of a 'third space', a reframing of nationalism, representation, and resistance that stresses the ambivalence or *hybridity* that characterises the site of colonial contestation – a 'liminal' space in which cultural differences articulate and, as Bhabha argues, actually produce imagined 'constructions' of cultural and national identity. In his case, such constructions or 'reframings' reject the perception of culture as homogeneous in favour of one expressing differentiation. This can embody tensions and conflicts juxtaposed with, or even exclusive of, uniform shared values and symbols. In other words, local culture may occupy a niche in the presentation of self in the incumbent's home village; national culture may replace local idiom – except for decorative purposes – in representations in national narratives; and global 'culture' may be expressive of self-presentation in the MNC corporate or MLG – multilateral governance – settings of the World Bank, United Nations, international conference or edited collection. Such 'parallel universes' are also at the heart of human creativity, endurance and survival against the entropies of a 'Big Mac' and a 'Diet Coke'. In fact the present post-millennial era seems, if anything, to present a heightened 'framing' of the 'local' in relation to transitions away from homogenised cultural hegemonies, whether in 'local food networks', 'local renewable energy' schemes, or 'slow city' movements (Morgan, Marsden and Murdoch 2006; Hendry and Harborne 2011; Knox and Mayer 2009).

In Cooke and Rehfeld (2011) these insights are deployed to try to answer the question of the extent to which regional and corporate cultures also occupy 'parallel universes' or whether, by contrast, they intertwine for particular or more general 'affordance' purposes. The answer is remarkably differentiated but strongly inclined away from the 'de-territorialisation' thesis. This is shown in comparative and contrastive ways. Thus the Basel region of Switzerland is a small city with a distinctive Alleman (Franco-German) culture that nevertheless hosts global life sciences corporate giants like *Novartis*, *Roche* and *Syngenta*. Its historic river-port wealth gave rise to many local foundations that nowadays frame the city as creative, innovative and cultured as well as globally significant. This is given expression in the annual *ArtBasel* international fine art fair, the *BaselWorld* international watch and jewellery fair and by each foundation giving competitive commissions to signature modern 'starchitects' (*inter alia* local practice Herzog and de Meuron, Santiago Calatrava, Richard Meier and Renzo Piano) to embellish Basel's built environment. English is the Anglo-American 'framing' language of the international 'set' that occupies high managerial or scientific positions in 'Big Pharma' or shops at *ArtBasel* or *BaselWorld* while the Alleman Swiss dialect is for the locals.

Two other regions examined, Westphalia-Lippe and Wales, have different 'framings' – both have strong cultures, the former derived from its business 'framing' as a stronghold of the family-owned and run *Mittelstand* but also its more global outgrowths like *Bertelsmann*, *Gildemeister* and *Nixdorf-Wincor*. A special niche relates to kitchen goods (*Miele*) and food firms like *Dr. Oetker* and *Melitta*. It was the firms that made the region famous. German is the cultural, linguistic, and devotional marker. In Wales, its ethnic 'framing' of language, culture and territory gives it some profile while its business 'framing' was heavy industry (*Corus*, now *Tata*), first replaced by inward investment (*Ford*, *Toyota*, *Sony*, *Sharp*) and nowadays indigenous 'green' agro-food (*Ty Nant* water, *Rachel's Dairies*, and EU Protected Geographical Indication (PGI) labelled Welsh lamb and Welsh Black beef). Except in the Welsh-speaking north and west, in company with the Cardiff-based 'cognitive-cultural' capital city cadres, English is the language of (often foreign) management and the shopfloor. But Appadurai and Bhabha would feel at home to a degree in the company of the Welsh-speaking 'digital migrant' in her home village, speaking estuarine 'mockney' in London's cognitive-cultural sector (Scott 2008), with a slight transatlantic inflection when ordering a latte in New York's 'Silicon Alley' multimedia district. Hence, these are methodological 'framings' centred on the following dimensions, some of which have been discussed; ethnic, business, landscape, labour and political, and they allow for the kind of co-creating analytical and policy methods discussed in Chapter 10 that characterise the evolutionary complexity perspective on regional development and change.

Evolutionary, complexity and related theory

In what follows, attention is drawn to the often complementary elements of four macro-frameworks that have been developed to facilitate understanding of key processes of political and economic transition. The theoretical analysis proceeds with the following sequence. The first of our complementary framings of interest to regional development and innovation is 'evolutionary complexity theory' (ECT) or the analysis of 'complex adaptive systems'. It is taken first because it embraces each of the key theoretical frameworks included in this introductory review. However, as we shall see, it displays framing biases of its own, including some important lacunae, which are better dealt with in one or other of the 'framings' discussed. The second to be outlined is evolutionary economic geography (EEG), which is perhaps closest to ECT but inevitably given its spatial focus, better at handling regional development issues but accordingly narrower in its conceptual span. It proves to yield up a number of valuable concepts that take the core evolutionary concept of 'variety' and the way in which it translates *potential* into system *re-organisation* through the emergence of novelty much further in analytical terms. Third, a further compatible, though more structured and often hierarchical 'framing' of co-evolutionary change with augmentation, arising as in ECT and EEG from what can often appear to be 'surreal recombinations' of knowledge with respect to innovation, is 'emergentism' (Juarrero and Rubino 2008) or as it is more commonly referred to nowadays, the 'Theory of Emergence' (ToE). Emergence is a different framing on causality from the kind of exogenous deductive reasoning associated with Traditional Economics. It finds its focus of interest in endogenous 'causality' of the kind discussed in the previous section in reference to the Systems Biology Perspective (SBP). Finally, we highlight the fourth perspective on co-evolutionary transition of direct interest to 'reframing' regional development, which is known as 'Panarchy' or the 'Resilience' approach (Gunderson and Holling 2002; Folke 2006). Panarchy is an ecological systems framework that is now being used more widely in economic geography of an evolutionary persuasion to account for the dual characteristics of all complex systems – stability and change. It shows how economic growth and human development depend on ecosystems and institutions, and how they interact.

Evolutionary complexity theory in an economic geography framing

Of special interest to the interface between complexity theory and economic geography is the innovative way innovation is projected as the process by which transition (transformation) occurs from interaction between diverse entities (variety). This is achieved by reframing the role of 'attractors' of path interaction that are better known to regional scientists as (regional) 'path dependence and 'path inter-dependencies'. One, possibly extreme, variant of these is 'strange attractors' where there is no a priori reason for even imagining they might coalesce. However, while mention is made of 'normal attractors' due, for example to cyclical or neighbourhood effects, 'learning curve' thinking, which complexity science admits exists and has value as a kind of probabilistic predictor for entities like 'scale-effects' in economic activity, their relative predictability means this is where incremental innovation or simple adaptation is found. At a preliminary level of 'emergence', which is one of our key 'reframings' discussed in our third sub-section, is the notion of *preadaptation*. Complexity science allows this as a more creative variant than 'normal attractors' but one that is also mainly an incremental rather than radical innovation form. Nevertheless, its penchant for interesting *ex post* analysis of retro-adaptation of innovative solutions, and stimulus to retro-innovation as a corporate or regional strategy, gives it added spatial flavour (see Chapter 5).

A more radically-inclined complexity framing of 'emergence' is identified as the system zone where stability and instability intersect. All of the above arises with reference to Kauffman's (1995) early complexity science work on stability and instability at the 'edge of chaos' where a crucial role is played by *clusters*. In complexity theory, these are metaphors for energy, but for regional scientists our more familiar usage concretises the concept more than adequately. Thus Kauffman shows how, when they are in isolation in a topological space, this explains spatial stabilisation and minimal change. Alternatively, in regions where inter-cluster communication is possible, this facilitates structural knowledge cross-overs ('knowledge spillovers') among clusters from which innovation springs in a 'self-organised' manner. Ontologically this approach leaves little apparent room for individual design or creativity in innovation. However, it is resolutely argued that the recombinant character of knowledge interaction that prefigures potential innovation is a fundamentally collective rather than individualistic process. Nevertheless, the nature of such processes is illuminated as follows.

Beyond what was outlined earlier on ECT, the two prioritised insights from complexity science that assist understanding of the creative process are termed *preadaptation* and exploration of the *adjacent possible*. These explain innovation in terms of either *preadaptation*, which takes already existing innovations from one industry setting and adapts them for wholly different industry solutions in another, or exploration of the *adjacent possible*. Accordingly, the *adjacent possible* is the unknown space close to the current state of the art in relevant knowledge into which a design effort must be made to execute an innovative improvement. Although this search process seeks novel solutions, many will also be incremental innovations, relatively close to the state of the art. Such novelty becomes radical innovation when the knowledge recombination search swiftly reveals numerous related innovation possibilities and potentials. Having a topological space with much cluster variety enhances the prospects of knowledge recombination based on the central complexity science thesis that:

> The more diverse the economic web, the easier is the creation of still further novelty . . . [leading to] . . . a positive correlation between economic diversity and growth.
>
> (Kauffman 2008: 151–60)

Complexity theory contains many more interesting and relevant concepts, some of which are shared with the other three approaches to be discussed. For example, it presumes complex economic systems display: dispersed interaction, for example, regionally specialised knowledge domains; absence of a global controller (no infallible top-down management); cross-cutting hierarchical organisation (multiple economic governance jurisdictions); continual adaptation; permanent innovation; and 'far-from-equilibrium' (prone to crises) system dynamics (Arthur, Durlauf and Lane 1997). It is further argued by Holland (1995) that the non-linearity and variety embodied in complex systems generates path dependence. This means 'regional regimes' of interaction can facilitate higher scale innovation at paradigm level as the system evolves, allowing qualitative shifts in system dynamics (for instance, local events may trigger global effects, as in the 'emergence' and 're-emergence' of *Apple* and Steve Jobs) (Isaacson 2011).

Evolutionary economic geography

We now turn to a brief introduction to key insights of relevance to this analysis coming from our second 'framing' which is much more tailored to regional analysis than the others, namely evolutionary economic geography (EEG). Taking two key concepts from spatial economics and technological history it finds particular utility in the idea of 'relatedness', on the one hand, and path dependence, on the other (Frenken *et al*. 2007; Martin 2010). Relatedness arises from research into regional economic growth where it is found that economies with 'related variety' among industries perform better than those without it. This is called the 'proximity' effect superseding the 'portfolio' effect from the viewpoint of industrial structure. More related variety means more lateral 'absorptive capacity' from related 'knowledge spillovers'. These can enhance the innovation potential of regions. Both path dependence and variety play significant roles in explanations from evolutionary economic geography regarding space-time variation in the incidence of innovation which, as in each of the other perspectives presented is also seen as a prime mover of significant socio-economic change. However, recent work by Martin and Sunley (2006; 2010) develops inherited views of the process from both equilibrium (David 1985) and complexity (Arthur *et al*. 1997) perspectives. In particular, two important improvements are offered. The first is that David's overly equilibrium perspective, which tends to emphasise 'lock-in' issues, is criticised in favour of a more open and innovation-friendly perspective. The second is that Arthur's reliance on 'chance' explanations for innovative events is questioned and a more socially constructive approach, reflective of Garud and Karnøe's (2001) notion of 'mindful deviation' by social agency to effect change is introduced. Moreover they align this adjusted perspective on path dependence to another key EEG concept, namely 'proximity' to move closer towards our mobilising explanation for innovation that is also able to incorporate the key complexity theory concepts of 'preadaptation' and the 'adjacent possible'.

EEG research has yet to go further into this cognitive dimension of the two complexity theory relationships although it has the concept of cognitive proximity with which to conduct such analysis. It is likely that progress will be made in the direction of 'cognitive dissonance' and 'cognitive distance' (see also Nooteboom *et al*. 2007). Thought is beginning to be given to relative strength of 'nodalities' in both networks and related varieties, as will be seen in Chapter 9 of this volume. This is further strengthened by recognition of the element of 'revealed relatedness' within the required variety to be both the independent variable and the probable cognate of 'strange attractors'. Moving on, 'path dependence' at the regional level can explain not only 'healthy' equilibrium or system stability but also system stagnation and inertia. However, in contexts such as that of a regional economy with related variety, path *inter-dependence* can be envisaged where two or more economic trajectories may intersect in regional space, conceivably producing unforeseen innovations from their 'revealed related variety', multi-regime interaction or *ex post* relatedness (Geels 2007).

Theory of emergence

This is also, as yet, not widely used in regional development analysis although, as can be read in Chapters 3 and 4 of this volume, it has much to offer exploration and exploitation for analytical and policy purposes of the field. We start with reference back to the notion of 'levels' of causality discussed for biotechnology in the preceding section. Emergence refers to the manner in which endogenous causality works. It has tended to be conceived as a primarily downward form of causality whereby the more complex organism level exerts causality on the intermediating genomic level, which in turn exerts further dynamic causality on the molecular level to change its composition. However, systems biology has thoroughly questioned that linear explanation of action and change, holding that molecules and proteins can be upward-directed causal mechanisms that can also trigger organic change. McClintock's (1984) 'jumping genes' are a mere fragment of what was once widely seen in life sciences as a wholly eccentric view of how life started. Beinhocker (2006) briefly alludes to it in discussing the replicative characteristics of molecules in evolution. In the context of an infinite number of molecules in the primordial mix, some 'learned' how to self-copy, the precursor to RNA, the earliest form and even today a regularly upwardly revalued factor in the evolution of the genetic code, embedded in the more recently evolved DNA. Copying 'errors' were thought to lead over time to variety, some of which involved the capability to 'attack' others and consume them, leading to an evolutionary response on the part of some of the more vulnerable to evolve a protective membrane. This heralded the emergence of what we nowadays call a virus.

However, McClintock was awarded a late Nobel Prize for explaining what such emergence actually entailed (Brooks 2011). In 1944, she observed a sporadic, non-random colour change (mutation) in a specific maize kernel cell division. Both the non-randomness and sporadic nature of this *transposition* ('jumping genes') were biological heresy. Once mutated, genes should have stayed mutated and a repeated cell division pattern of larger markings occurring early in the process and smaller ones later in the process should not be happening to a random evolutionary process. Within the maize genome, whole 'paragraphs' of DNA were being transposed by 'controlling elements,' thus giving an unexpected but more complete explanation of the endless variety found in living systems than the prevailing 'error' narrative. Here was a clear instance of 'downward causality' rather than an effect of 'chance': but her findings were ignored or rejected by the academic world. In 1965, three French male geneticists were awarded the prize for demonstrating that tissue development genes were accompanied by genes for *regulating* them. Thus negative feedback ('negentropy') was proven to be a universal 'controlling element' in living systems, which regulated potentially uncontrollable cell division processes, greatly assisting understanding of such diseases as cancer and immune system deficiency . How might such 'emergence' have occurred? Another female 'heretic' even more vilified by her neo-Darwinist 'normal science' male colleagues is Lynn Margulis, who proposed and demonstrated that interactive emergence can arise, not by chance, but through 'endosymbiosis', the union of, for example, bacteria and a blue-green algae host. Together, they are more powerful than apart, and for some functions the 'parasite' is the 'controlling element'. An even more 'heretical' position is that this also explains morphogenesis such as the caterpillar, chrysalis, butterfly emergence process (Brooks 2011).

This is important, because it shows controlling elements in 'emergence' can be ground-up as well as top-down. This feature was present in the earliest debates among the early 'emergentists'. Thus Juarrero and Rubino (2008) note that Samuel Alexander (1858–1938), one of the school of 'British emergentists' saw the universe as:

> fundamentally processual, an ongoing process consisting in time's continual formation of changing complexes displaying genuinely new qualities at different organized levels, and matter is the emergent quality of the lowest level complex of space-time.
>
> (Juarrero and Rubino 2008: 13)

Alexander also echoed 'emergence' founder G.H. Lewes (1817–78) to the effect that emergence requires *different* entities to combine at the lower levels for the emergence of complexes composed of new kinds of *relations* at the higher levels. Hence the process is far more than mere aggregation. C. Lloyd Morgan (1852–1936) extended this 'framing' by maintaining emergent evolution also operated when new and unpredictable entities such as molecules and atoms appeared. But, in a sub-text to the whole debate the emergence of new entities was seen as not inconsistent with the existence of a *deus ex machina* in ultimate control:

> Unlike Alexander, who works bottom-up and insists the quality at each higher level is emergent from the lower, Morgan bases his argument in part on an examination of what we today would call top-down causality: the descending order of the pyramid, so to speak, from higher to lower.
>
> (Juarrero and Rubino 2008: 14)

We shall return to this in a different context but, for the moment, presume that emergent system processes and policy interventions in the world of regional development, which can seem far away in time-space from such deliberations, may operate as a complex adaptive system, the triggering elements of which may be not only be unpredictable *ex ante* but difficult to reconstruct in relation to a plausible theoretical narrative *ex post* (on this, in the context of sustainability emergence in Transition Regions, see Cooke 2011). As is evident, this account invites further scepticism towards 'chance' explanation, is resolutely non-hierarchical and non-linear in terms of the direction of causality, but invites extra deliberation on the meaning of our core concept of 'variety'. This would open up questions of, on the one hand, controlled versus uncontrolled variety, including any power asymmetries in both and, on the other, the 'energy' sources of variety's key catalytic device, which is *difference* and how it contributes to system 'self-organisation' (Chapter 5). From the perspective of 'networks' both are innovatively broached in Chapter 9 by Balland, Boschma and Frenken.

Resilience theory

Allusions have been made to a richer and more integrated nature-society discourse called Resilience Theory (see Chapters 3 by Wolfe and 12 by Lazzeretti in this volume). It arose from observation of failed attempts to manage regional ecosystems that often culminated in their degradation because of linear management efforts focused on a single variable, usually economic. Accordingly, this transition approach is conditioned far more by the notion of ‘crisis’ as the stimulator of innovative action and change than the multi-level perspective (MLP) perspective (after Geels 2006), which is evidently a model of relatively smooth, albeit slow, progress of novelty from small awakenings to a strategic eco-market niche to dominant design and universal adoption. However, the resilience approach adds conceptual value since it models a multi-scalar adaptive cycle that promotes system innovation alongside an MLP for institutional intervention in the process. This operates as follows. In any evolutionary cycle there are four basic ecosystem stages. The *exploitation* stage is one of rapid expansion, as when a population (for example, of firms) finds a fertile (strategic) niche in which to grow. The *conservation* stage is one in which *slow* accumulation and storage of energy and material is emphasised and when a ‘dominant design’ reaches prominence. The *release* phase occurs rapidly, as when a population (of firms) declines due to entry of a competitor, changed conditions and ‘creative destruction’. Thereafter, *reorganisation* can also occur rapidly, as when certain members of the population are selected for their ability to survive (innovate) despite the competitor or changed conditions that triggered the release.

Accordingly, we see an evolutionary process of *emergence* of novelty followed by one involving conservation, consolidation and *accumulation* dynamics in respect of spatial or territorial dominance. Then comes system *destabilisation* caused by the arrival of a new, competitive incumbent ushering in conditions that allow for innovation through Schumpeterian ‘creative destruction’. Finally, system disequilibrium is moderated by successful innovation that facilitates system *re-organisation*. This will probably not restore the system to *status quo ante* conditions but to some changed, temporary equilibrium, possibly materially better or worse than before. Key process elements shared with all three other ‘framings’ are resonant in respect of the *emergence, dominance* and even *re-organisation* stages, ‘creative destruction’ being the trigger for innovation. Resilience, by definition, implies system ‘shock’ or crisis as the key motivator of ecological and economic change. As we have seen, in the (MLP) motivation is something more akin to collective ‘enlightenment’ based on growing awareness or gradual consciousness of indicators of the need to change. Actor networks influence, learn and ‘co-construct’ awareness of the need for novelty that takes advantage of ‘windows of opportunity’ for change (see Geels 2006). However, the ‘window’ metaphor has been questioned for its reliance, once more on ‘chance’ as an actor, the implied downgrading of *agency* in such an approach, and the absence of policy relevance ‘chance explanation’ implies. Contrariwise, the stronger dynamics of the ‘resilience’ perspective demand it goes further to advance testable explanatory propositions that assist understanding of the conditions for more robust system shock-absorption.

This it does by identification of two crucial evolutionary variables that can, first, moderate if not prevent system crisis and second, effect system re-organisation after its destabilisation through ‘creative destruction’; these are, respectively, system *potential*, and system *connectivity.* System *potential* sets the limits to what is possible – the number and kinds of future options available (for example, high variety of, say, industry structure provides more future options than low variety). System *connectivity* determines the degree to which a system can control its own destiny through internal controls, as distinct from being influenced by external variables (for example, a strongly networked region or one with high legislative and taxation control are examples of high connectivity). Accordingly the territorial dimension of paradigm (potential) and regime (connectivity) are foregrounded of necessity from the resilience perspective, facilitating more nuanced analysis of what differentiates a ‘transition region’ from any other. This is because, together, *potential* (variety) and *connectivity* (network controls) determine system *resilience* or how vulnerable a system is to unexpected disturbances and surprises that can exceed or break that control. Finally, such system ‘resilience’ is also revealed in the interconnectedness of levels between the smallest and the fastest (for example, lowest ‘emergence’ level, or in regional governance, the municipal) and the largest and the slowest (nation states, or in Europe, EU both of which, for example, took from 2008 to 2012, and counting, to ‘resolve’ the euro crisis while tiny Iceland responded much quicker). The large, slow cycles normally set the conditions for the smaller, faster cycles to operate. But the small, fast cycles can also have an impact on the larger, slower cycles. Thus, in respect of eco-innovation, a national and/or supranational regime may set favourable conditions for eco-innovation or a region may anticipate its slow-moving institutions and begin swiftly eco-innovating independently, expressing local collective demand or proto-market building by ecologically conscious or interested firms or organisations.

Systemic integration of policy modules

Rather surprisingly, perhaps, this book contains much valuable criticism, insight and originality in relation to both *policy* analysis and methodological *policy* prescription. Ideas such as:

- ‘system integration of policy modules’
- ‘innovation agency as external radar for myopic firms’
- ‘Red Queen effects’
- ‘policy being like innovation’
- ‘policy is always adaptive’

are new and rather challenging, but could be decisive for truly system-level policy deliberation. Let us proceed through these in the order raised, recognising that brief, passing mention has been made of a few of them in the preceding text. We have alluded to Beinhocker’s (2006) valuable critique of Traditional Economics and his reformulation of Complexity Economics on more than one occasion. With regard to ‘system integration of policy modules’ we shall broach a major lacuna in his treatment of path dependence, reference to which in general is noticeable in his book by its scarcity if not quite absence. Worse, perhaps, we shall broach a further lacuna or perhaps ‘nodding off’ by Beinhocker in relation to one of the centrepieces of Complexity Economics and complexity theory more generally, which also flags a potentially debilitating inconsistency in the work of Kauffman (1995; 2008). This refers to the work on 'fitness landscapes' which are a metaphor grounded in topographies of ruggedness and sleekness of landscapes, in which the strongest survival capability is represented as reaching, in effect, 'the peak of Everest'. 'Fitness landscapes' are a complexity device to measure survivability of species in a hostile world, whether the primordial soup or the contemporary economy. A moment's thought shows this to be a highly linear mode of discourse, on the one hand, and a particularly inappropriate one for conceptualising regional innovation, development and growth. For 'as any fule kno'[1] while revelation may occur on mountain tops, innovation takes place in *Valleys*.

To be fair to Beinhocker–Kauffman, yoked together like Braque and Picasso climbing their metaphorical mountain to reach Cubism, the metaphor is one of 'survival of the fittest'. Let us briefly run through Kauffman's dramaturgy before returning briefly to berate Beinhocker for not advancing further in his thinking about the implications of this 'problem', which is easily resolved, in regard to 'the origin of wealth' which is the subject of his treatise. The discussion is of the entire design space for all possible creatures that can be coded for by DNA. Each is represented by a rod whose length represents the creature's survivability at a given point in time. This is portrayed as an Alpine landscape caused by the mutations that define the lesser or greater fitness of the organism to its context. The aim is to find the highest peak, with three conditions: the landscape is constantly moving; it is night time; and the valleys contain poisonous fog – the last acting as a natural selection device, in case the other two don't get you first. You can walk with low risk from the valley bottom (thought it was poisonous, hmmmm) or use a powerful but riskier pogo stick, but you must climb or follow a *random jump* strategy with the pogo stick (for clearing poisonous valleys). Such bet-spreading is a metaphor for the workings of evolution. And here we come to the problem of path dependence, after Beinhocker. A few hikers reach the top of different peaks, all the rest are huddled on some plateau below, or fell into the valleys. Even the pogo won't get you from Monte Bianco to the Matterhorn – especially if you are a fish. Even if you are a rather fit fish, your landscape is changing, and you are becoming less suited to a higher mountain top than a different fish that has yet to reach that destination. In DNA terms the fish cannot make the *random jump* even when pogo-assisted:

> Because there are no sustainable, intermediate niches along the way between the first fish and the second, the fish is a prisoner of its history. Its particular path led to the cul-de-sac on its particular peak, and its options for the future are limited by its past.
>
> (Beinhocker 2006: 213)

But maybe a passing eagle picks up the fish and drops it on the appropriate mountain top. Even in this paranoia-inducing universe, this would be the innovative intervention to combine 'strange attractors' to facilitate path inter-dependence and enrich the hitherto threatened fish species, provided there was a tarn on the next mountain and an oppositely gendered fish in it.

But that is a separate discourse on a road taken by Kauffman in his discussion of innovation, which involves multi-valley modelling. In Kauffman (1995) simulations provide an analogy for regional development and innovation. In regions with many clusters and when connectivity is high, system dynamics are highly unstable because the conflicting constraints imposed on each other by agents are numerous. Moreover, at a state with neither too few nor too many connections, the dynamic of at the 'edge of chaos' arises. This is neither stable enough to obstruct potential for innovation and change nor so unstable as to destroy path dependence. The dynamic of 'living systems' is to be 'changeable' according to Kauffman. System evolution is influenced by 'clusters' with high internal but low external links to other clusters. Weak ties clustering across the system stabilises it. However, clustering towards the 'edge of chaos' with strengthening cluster interactions produces innovation, change and novelty. System self-organisation thus gives emergence first, to new clusters and second, their inter-connection in 'basins' of attraction. Accordingly, in this twist on the 'fitness landscape' metaphor, path dependences are economic entities like industries or clusters that move down the mercifully fog-free valleys, perhaps on the other side of the 'fitness' mountain range, according to the slow momentum of their history. These glacier-like members of the 'basin attractors' club may, on occasion bump into a tributary glacier or one diverted by a huge landslide into its path. As a result of such collisions 'emergence' of innovative mutations of the McClintock or Margulis kind may then ensue, of which the example of the 'housing and healthcare' strange attractors in Chapter 5 is indicative.

On 'innovation agency as external radar for myopic firms' we can be briefer. Bounded rationality, after Simon (1955) has, if anything, been abdicated during the intervening years of neoliberal experimentation in favour of 'efficient markets' and their policy correlates of 'new public management' and the 'audit society'. In support, Beinhocker (2006) quotes evolutionarily sympathetic economist William Baumol (2002) who saw free *markets* as 'innovation machines'. But a critic, let us call her Rachel Carson, might have said markets didn't produce innovations that ceased the 'silent spring', or another, George Akerlof, who said they do not innovate sufficiently to even up knowledge exchange in 'the market for lemons'. And even when markets innovated the 'green revolution' that saved millions from starvation they didn't innovate to stop chemical and pesticide pollution of the land. *So, markets are not perfect – scandal,* reads the headline in a parallel universe. Cooke *et al*. (2010) discussed corporate myopia as a failing of even, or particularly, the largest firms. It is the key reason for proposing regional innovation agencies to give firms the occasional 'heads-up' on developmental issues in Chapters 5 and 10 in this book. We called it the myopia-panic-folly model of corporate management when confronted with a 'reframed' world of unsustainable 'competitive advantage'. Beinhocker (2006) in a passage that, rightly, criticises Michael Porter for his failure to pay attention to time in his advocacy of that fleeting strategic goal, summarises the problem well:

> Then one day . . . a new technology is developed, a competitor has an idea, or consumer tastes begin to shift – and no one in the senior management team even knows about it. History has branched, and the world starts to change. At first the pattern-recognising minds of the company's leaders can't believe the changes are really occurring . . . . the world keeps changing and the avalanche accelerates. The company is now in the middle of a punctuation point, and the management suddenly finds itself in a new game and stuck with the wrong mental models, the wrong assets, and the wrong skills.
>
> (Beinhocker 2006: 329)

Accordingly, it is somewhat shocking that businesses are so apparently poorly managed that of the top one hundred firms in the US in 1917, all bar one of the eighteen who *survived* in that elite by 1987 had underperformed the stock market average. Clearly, evolution is a hard task-master and the corporate 'fitness landscape' seems something of a graveyard. Or is it? Some of those firms went bankrupt but many 'mutated' as they were acquired, while others survived but dropped out of the elite. Either way, they would be 'fitter' than they once were. Surely this is a more authentic test of the evolutionary nature of markets than expecting firms infinitely to maintain an equilibrium market position.

'Red Queen effects' are discussed in Chapter 7 by Uyarra and Flanagan, citing Potts (2009) on the need for more experimentation, learning and appreciation of knowledge in policy making. Beinhocker (2006) having concluded that *knowledge is the origin of wealth*, says the same thing about the evolutionary trajectory of firms, which must, like the Red Queen in Lewis Carroll's *Alice Through the Looking Glass* keep running to stay in the same place. Evolutionary biologists call the process by which species exist in an 'arms race' with each other as, for example, increased speed by a predator invokes improved camouflage by its prey, 'Red Queen races'. There can be no winner as the races never end, but they signify the short-lived survival based on long-term endurance that typifies existence in economy and ecology. *Only the Paranoid Survive* is the evidently apt title of the memoirs of former chief executive of *Intel*, Andy Grove (1996). Yet his former firm was described by Steve Jobs in Isaacson (2011) as 'too slow' in meeting the 98-2 customer delivery system whereby *Apple* required 98 per cent of 'build-to-order' volume to arrive within two days of the order being issued. So *Apple* ordered from Taiwan even though *Intel* was geographically proximate, being literally 'just along the road' in Silicon Valley, had evolved its own platform ecosystem of suppliers and was a pioneer of the 'modularisation' that had revolutionised the effectiveness and efficiency of ICT supplier networks (Gawer 2009). While this may be an excellent example of the workings of Jobs' notorious 'reality distortion field' which required the routine achievement of the impossible from everyone, it may also be a sign that, on the one hand, *Intel* became less paranoid after Grove retired, or, on the other, that its platform 'architecture' needed urgent attention. That this actually happened is testified to by an *Intel* press release in September, 2011 announcing:

> Intel Corporation and Google Inc. today announced. . . . . . . a joint effort designed to speed time-to-market of Intel technology-based smartphones running the Android platform
>
> (*Intel* 2011)

Since, as Chapter 10 shows, the Android platform sells nearly twice as many smartphones as *Apple*, evolutionary competition ensured *Intel* continued to be at the *Red Queen races*.

This kind of 'complexity management' of strategic assets is known to be rare among all but a few highly flexible firms that continue to find ways to capture temporary advantage over time – there are no firms that achieve the permanent competitive advantage that the likes of Porter extol. In the world of policy-making, no one knows, for two reasons: first, up to now there have been no authentic 'markets' for policy; and second, accordingly, policy-making bodies tend to be monopolies. But two aspects of policy learning may change that inheritance when the evolutionary policy 'frame' comes to prominence. The first is the idea, the corollary of *Red Queen races* mentioned by Cooke in Chapter 5, Uyarra and Flanagan in Chapter 7, Melkas and Uotila in Chapter 10, and as 'policy skunkworks' by Morgan in Chapter 15, is policy *as* innovation. In the first-mentioned chapter, it appears as part of an analysis and practice report of policy 'modularisation'. Modularisation facilitates policy 'emergence' from possibly existing, possibly new, local initiatives that display difference but also relatedness that allow them to be recombined at the regional level to meet a higher purpose. This in turn can be contributory to a more ambitious and complex policy purpose at the still higher national, georegional (for example, Europe) or global levels, rather like the sustainablility-inclined reframing of the 'Gothenburg Model of the Lisbon Strategy' (Cooke 2011). For Beinhocker's (2006) version of Complexity Economics, modularity is the core function of accomplished business planning: we have argued, independently, it is at the heart of authentic evolutionary policy making. It is especially apposite for innovation policy, because in the evolutionary framing of 'policy as innovation', discussed in Chapters 7 and 10, it is also based in recombinant knowledge and increasingly to be seen acting as the RNA to industry's DNA by catalysing both social and economic innovation. In passing, the first letter in RNA is ribo, which denotes sugar, an emergent chemical entity of the three atoms of carbon, hydrogen and oxygen (as also discussed in Chapter 5). Referring to the second point of Uyarra and Flanagan's Chapter 7, which avers that 'policy must always be adaptive', such vigilance is the price of evolutionary policy because policy entropy, thus far a little-researched topic, is nevertheless ever-present. Neil Young acted on this realisation in 1978:

> Neil Young's 1979 'Rust Never Sleeps' marked a major shift in artistic direction for both Young and the entire music industry. "Rust Never Sleeps" signalled Young's recognition that that there was a new force in music—namely punk. The album also represented a conscious recognition that Young's music had to evolve or he would become extinct.
>
> (Young 2011)

Whether or not Young's efforts to come to terms with the 'shock of the new (wave)' were musically successful is open to debate, for the album received a panning from many folk-rock inclined critics,[2] yet it did no harm to his efforts to avoid entropic extinction.

A brief introduction to the chapters

The book is divided into four parts which more or less echo the sessions in the Cardiff Colloquium that took place on 4 and 5 April, 2011 with the same title as this book 'Reframing Regional Development: Evolution, Innovation and Transition'. Part I, 'Evolutionary transition space' has chapters by Allen Scott, David Wolfe, Ron Martin and Peter Sunley, and Phil Cooke. Scott's 'A world in emergence: notes toward a resynthesis of urban-economic geography for the twenty-first century' chapter points to three major characteristics of today's capitalism that are 'reframing' the geographical reconstruction of the world as we know it, that is, digital technologies, the new division of labour, and the deeply intensifying role of knowledge and human sensibility in the labour process. The implications of these phenomena for urban form and regional development are discussed, with special reference to what he refers to as the cognitive-cultural economy of large cities. Recent transformations of the interstitial spaces between these cities are also considered. The argument goes on to put all of these issues in a wider spatial and organisational context in which the world is represented as a multifaceted, multitiered system of spatial convergence and differentiation. Wolfe's chapter, 'Regional resilience, cross-sectoral knowledge platforms and the prospects for growth in Canadian city-regions' involves a thorough exploration of the resilience perspective in urban and regional settings. It is interested in the way in which the intersection between path dependent trajectories of development, the resulting industrial structure of the region and the strategic choices made by regions affect their future development possibilities. Resilient regions are those best able to take advantage of emerging knowledge platforms by undertaking regional exercises to identify and cultivate their assets, institute collaborative processes to plan and implement change, and encourage a regional mindset that fosters growth. Martin and Sunley's review chapter, 'Forms of emergence and the evolution of economic landscapes' notes that most of the work towards the construction of an evolutionary economic geography has drawn on ideas of variety and path dependence theory. By comparison, evolutionary economic geography has thus far been much less influenced by complexity theory. Yet the theory of complex adaptive systems is, potentially, just as rich a source of concepts and metaphors for use in constructing an evolutionary account of the economic landscape. Emergence, along with self-organisation and adaptation, is held to be one of the key defining features or characteristics of complex systems. Viewing the economic landscape and its evolution from a complexity-theoretic perspective thus directs our attention explicitly to the questions of what the concept of emergence means in this particular context, and what explanatory leverage it provides. This line of reasoning is taken further in Cooke's chapter, 'Strange attractors and policy emergence: complex adaptive innovation' which integrates evolutionary complexity theory with its evolutionary spatial policy correlate. The chapter begins with a comparison and contrast of vertical and horizontal conceptions of regional innovation processes as they affect linear and non-linear approaches to analysis and policy. There follows a discussion of the virtues of a complex co-evolutionary framing of the regional economic development process for non-linear regional innovation policy formulation, drawing on appropriate illustrative material. Finally, accounts are given of various transversal policy instruments by which innovation policy, including 'emergent' policy making have ensued in real world settings in Europe and Asia.

Part II is entitled 'Innovation and diversity' and has chapters by Helen Lawton Smith, Elvira Uyarra and Kieron Flanagan, James Simmie, and Pierre-Alexandre Balland, Ron Boschma and Koen Frenken. Lawton Smith's chapter 'The health technologies sector in Oxfordshire: evolution or optimism in regional development?' has the theme of how regions are positioned in processes of change by key agents and the possibilities of intervention designed to shape technological and innovation trajectories through a co-opted alignment of stakeholders at regional and international scales. Three different frames of inquiry into how targeted intervention towards a sector could change paths of regional development are explored. These are, (i) path dependence, (ii) constructed/constructing regional advantage, and (iii) stakeholder theory applied at the regional level which draws on both (i) and (ii). As we have seen, Uyarra and Flanagan's 'Reframing regional innovation systems: evolution, complexity and public policy' first reviews the key insights of regional systems of innovation; second, discusses the implications of evolutionary and complexity approaches for our understanding of localised path dependent trajectories, institutional change and regional resilience; and third, explores the issue of evolutionary policy dynamics and suggests some directions for future research.

Simmie's chapter, 'Path dependence and new technological path creation in the economic landscape' is concerned with transition analysed through a lens in which path dependence theory is adopted as the starting point for the analysis of innovation and transitions in the economic landscape. Path dependence theory seeks to explain the long-term historical development of distinctive patterns of technological and industrial forms, and how, once established, particular trajectories of technological and industrial development become self-reinforcing via various forms of externalities and increasing returns effects. The chapter argues first, that historical explanations of the evolution of path dependent technological developments require, in addition to the restricted analysis of the processes leading to lock-in, explanations for both the initial conditions into which inventions and innovations are introduced and the processes that lead via invention and innovation to the creation of new pathways. Second, in addition, it argues they also need explanations of how existing pathways are de-locked and changed. Finally, Balland, Boschma and Frenken's chapter on 'Proximity and innovation networks: an evolutionary approach' is constructed as follows: the chapter consists of two sections. The first section assesses the advantages of adopting an evolutionary approach for analysing innovation networks by discussing the commonalities and differences with the institutionalist and interactionist approaches of the French proximity school. The second section discusses a number of challenging issues for developing a dynamic evolutionary approach on proximity and innovation networks. Among other aspects, the authors argue that it is crucial to include heterogeneity of actors and their proximities in network studies, but one should avoid taking the attributes of actors and their resulting degree of proximity for granted and fixed over time. Instead, they claim that the analysis of the spatial evolution of innovation networks should explain how networks also change the attributes of nodes and the proximities between nodes over time, a topic that is still unexplored.

Part III on ‘Cluster emergence and destabilisation’ has chapters by Helinä Melkas and Tuomo Uotila, Phil Cooke, Luciana Lazzeretti, and Dieter Rehfeld and Judith Terstriep. Melkas and Uotila’s chapter ‘Foresight and innovation: emergence and resilience of the Cleantech Cluster at Lahti, Finland’ also focuses on transition in its review of theoretical literature on foresight and innovation. It is argued that important policy issues involve finding ways to make this link clearer and better known. The selected model emphasises the roles of learning, exploration and exploitation of knowledge, absorptive capacity, and knowledge-generating and knowledge-exploiting subsystems in a regional innovation system. After looking into the interplay between the concepts of foresight and innovation, the authors move on to discuss a practical case of building and developing a Cleantech Cluster in the Lahti region of Finland. However, their focus is not on the development of the cluster itself, but rather on how different kinds of regional innovation policy instruments were used and applied in order to promote the emergence of the cluster from the resilience point of view (on success and failure factors in clustering from a *complexity* point of view, see Carbonara *et al*. 2010). Resilience is focused on as the capacity for renewal, re-organisation and development, or adjustment and adaptation. The research data consist of strategy documents, research reports and other reports from the last ten years. Cooke’s chapter ‘ “Twilight of the gods”: the rise of Asia Pacific and Californian convergent media and the demise of Nordic mobile telephony in the ICT global innovation network’ traces the reframing of a concept and process regime – ‘global value chains’ from an intermediary narrative of ‘global production networks’ to a contemporary one of ‘global innovation networks’. The industry selected for analysis is modern ICT, especially in the ‘smartphone’ and ‘tablet’ markets and evolutionary complexity theory, in association with the concept of ‘emergence’, proves a particularly acute diagnostic of global change in a dynamic series of territorial innovation systems and platforms. Lazzeretti’s chapter, ‘The remarkable resilience of cities of art: the challenge of a new renaissance in Florence’ takes a resilience perspective upon creativity and innovation in cities of art. According to theory, resilience is not only the capacity to absorb shocks and maintain function, but it also includes a second aspect concerning the capacity for renewal, re-organisation and development, to be taken into consideration for redesigning a sustainable future. In this sense, Lazzeretti discusses the idea that some creative cities are also resilient cities as they are capable not only of preserving and economically enhancing their material and immaterial cultural and artistic heritage, but also of transforming themselves in response to external pressures, generating local development and growth. Rehfeld and Terstriep's chapter, 'Socio-cultural dynamics in spatial policy: explaining the on-going success of cluster politics' studies cluster narratives and policies in the specific logic of their political dynamics, which is seldom carried out in academic research. Thus investigating clusters from this perspective, which includes 'framing' through theories and categories from political science, is little established, so far. Thereafter, it is structured as follows: the second section discusses the way in which the development trajectories of uncoordinated bottom-up cluster initiatives result in a dynamic process which in turn leads to institutionalisation and path dependence. The third section elaborates on the reasons for and the paths of the anchoring of the cluster idea in the political field. The fourth section analyses the division of labour within the European multi-level system.

Part IV, dealing with 'Evolutionary spatial policy' has chapters by Franz Tödtling and Michaela Trippl, Kevin Morgan, and Fumi Kitagawa. Tödtling and Trippl's chapter is entitled, 'Transformation of regional innovation systems: from old legacies to new development paths' and has the key aim of enhancing understanding of how processes of regional innovation system (RIS) transformation take place. The authors identify key actors and drivers of path renewal and new path creation and seek to find out to which extent such changes are related to existing economic and institutional structures. Based on a discussion of relevant theories and a critical literature review, Tödtling and Trippl develop a conceptual framework for analysing RIS changes. Besides the RIS approach they use ideas from evolutionary economic geography (EEG) which provide valuable insights into the long-run regional trajectories and sources of change in regional economies. The authors also discuss empirical examples of such shifts based on evidence from Austria and other countries. Morgan's chapter, 'Path dependence and the state: the politics of novelty in old industrial regions' explores ways out of regional lock-in where it exists in old industrial regions. Normally the state used to take the initiative for *unlocking* the process. But simultaneously, the state actually shapes the structure of the space economy in multiple ways – by what it does *and* by what it chooses not to do. Morgan explores three developmental vignettes, each of which raises key issues about the nature of path dependence and path creation. Each vignette also illustrates a different role of the state, namely: (i) the state as *producer* in the case of the coal industry; (ii) the state as *animateur* in the case of technology-based incubators; and (iii) the state as *purchaser* in the case of positive procurement policy. Finally, Kitagawa's chapter, 'City-regions, innovation and universities: the evolution and transition of UK urban governance institutions' also focuses in detail on the state and changing policy pathways in English higher education as it relates to innovation support policy. This has occurred in a context of effective 'privatisation' of the universities of England but not those elsewhere in the UK where scepticism of markets in public goods delivery is politically far higher. Thus the chapter examines 'city-regions' as an analytical concept in light of broadened scope of innovation. The third and fourth sections present expectations on the role of universities in their regions and 'city-regions' and models of institutional governance and debates on the role of higher education in regional and urban development as observed in the UK, particularly in England over the last decade. The fifth section illustrates two cases of city-regions in England, delineating the formation of city-region political boundaries, institutional partnerships and spatial identities with distinctive roles played by universities in the formation of innovation agendas. The chapter concludes by identifying issues, constraints, challenges as well as opportunities within the city-region as a political, economic and socio-cultural project, whilst under the current funding regime, universities' possible roles for innovation agendas through the evolution and transition of urban governance institutions at the city-region level remains unclear.

Notes

1 Nigel Molesworth is the supposed author of a series of books (actually written by Geoffrey Willans), with cartoon illustrations by Ronald Searle, who died aged 91 in January, 2012. Nigel's spelling is extremely uneven, a feature found endearing by fans. The phrase 'as any fule kno', appended to many of Nigel's pronouncements, has achieved fame beyond its author, sometimes in the UK press, e.g. satirical magazine *Private Eye* and particularly on modern social networking and discussion blog sites. 'Any Fule Kno That' is also the first song on the 1998 album *Abandon* by Deep Purple.

2 The title is borrowed from the slogan for *Rust-Oleum* paint, and was suggested by Mark Mothersbaugh of the New Wave band Devo.

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Part I

Evolutionary transition space

2 A world in emergence

Notes toward a resynthesis of urban-economic geography for the twenty-first century

Allen J. Scott

Beyond postfordism

How are recent mutations of the capitalist economic and social order expressed in the form and substance of the world's economic landscape? How, in turn, is the economic landscape implicated in the social reproduction of capitalism as a whole at the present time? In particular, how are these diverse phenomena expressed in patterns of urban and regional development? These questions motivate the entire essay that follows.

Since the early 1980s, with the waning of fordist mass production as the dominant paradigm of industrial organization and labor relations in the more economically advanced societies, there has been a constant flow of debate as to just exactly what new configurations of capitalism constitute the leading edges of growth and development today. Many of the key ideas about this matter have been systematized in postfordist theory with its central arguments regarding vertical disintegration, flexibility, product differentiation, and resurgent competition, and their geographical expression in local production agglomerations (see, for example, Amin 1994; Harvey 1989; Leborgne and Lipietz 1988; Scott 1988). The concept of postfordism has served urban-economic geography well as a source of research inspiration, but is now, I would argue, due for honorable retirement, and all the more so because its identity is expressed so forcefully, but unhelpfully, in what it is not. Moreover, a multiplicity of alternative claims about the paradigmatic features of the contemporary capitalist system have come to the fore of late, almost all of them revolving in one way or another around the development of new technologies of computation and communication together with the proliferation of labor processes requiring advanced cerebral and creative forms of human capital. Thus, the recent literature is replete with references to cybercapitalism (Peters, Britez, and Bulut 2009), technocapitalism (Suarez-Villa 2001), network capitalism (Castells 1996; Fuchs 2007), informational capitalism (Castells 2003; Schmiede 2006), knowledge capitalism (Burton-Jones 1999), cognitive capitalism (Rullani 2000; Vercellone 2007), and so on. Along with these advocacies has come a series of allied propositions about the transformation of work, as encapsulated in terms such as immaterial labor (Fortunati 2007; Lazzarato and Negri 1991), the cognitariat (Moulier Boutang 2007), and the creative class (Florida 2002). As the new capitalism presaged by these shifts in vocabulary and analytical emphasis has begun to play out across the global stage, authors such Hardt and Negri (2004), Harvey (2010), and Badiou (2010), among many others, have offered bold synthetic views about its wider social and political logic, its continuing challenges to democracy, and the renewed possibility of non-capitalist alternatives.

The multifaceted shifts in capitalism beyond postfordism hinted at by these remarks, suggest that the time is now apposite for some extended attempt to work out a few of their more important concrete expressions *on the ground*, that is, their effects on urban and regional development with special reference to their configuration on the geographic landscape. The current conjuncture is no longer just a postfordist period of transition away from fordism and toward some dimly apprehended future state, but represents a *sui generis* moment marked by a historically specific and durable articulation of the forces of production and the social and property relations of capitalism. The emergence of this new world makes it imperative that we take stock of the geographic circumstances that are at once an expression of its inner dynamics and a condition of its continued existence.

New historical frontiers of capitalist expansion

In order to initiate the discussion, I shall enlarge upon three significant dimensions of the new capitalism that is emerging on all sides today. These dimensions are essential moments of the current regime of capitalist accumulation and help to account for much of its shifting geography. They comprise, first, the new forces of production that reside in digital technologies of computing and communication; second, the new divisions of labor that are appearing in the detailed organization of production and in related processes of social re-stratification; and third, the intensifying role of mental and affective human assets (alternatively, cognition and culture) in the commodity production system at large. I shall briefly describe these dimensions and then provide an outline of their geographic impacts in the early twenty-first century.

Digital technologies of computing and communication

The digitization of vast swaths of the capitalist economy over the last few decades has had profound impacts on processes of production and exchange. Above all, computers can handle standardized tasks with enormous efficiency. The consequence has been a wholesale displacement of routine manual work (such as simple assembly and sorting tasks) as well as routine office work (such as filing and bookkeeping) by automated systems. Concomitantly, much standardized blue-collar and white-collar labor has been eliminated from the more advanced capitalist economies over the last few decades (Levy and Murnane 2004). Moreover, in sharp contrast with the economy of mechanization and repetition that prevailed up to about the 1980s, these new digital technologies make it possible to achieve hitherto unimaginable levels of process and product flexibility combined with high productivity (Corsani 2003).

At the same time, the new digital technologies of computing and communication have greatly facilitated modularization of the production system and its re-expression in network structures with enhanced capacities for inter-unit communication and coordination. These networks are associated with a diversity of governance relationships ranging from pure market coordination on the one side to complete ownership under one corporate banner on the other side, with every possible combination of outcomes between these two bounding cases. Even where ownership is relatively concentrated, as in the case of the modern multi-establishment corporation, organizational relationships are typically heterarchical, in contrast with the hierarchical structures of command and control that were typical of fordist enterprise, (Peters, Britez, and Bulut 2009). As we shall see, the modularized production networks that are so characteristic of capitalism today assume a range of geographic patterns from dense localized agglomerations at one extreme to dispersed value chains scattered across the globe at the other. No matter what the spatial scale of these networks may be, they also tend to be sites of insistent innovation, facilitated by the interactions between many different interlocutors in many different economic, social, and geographic contexts (Jaffe, Trajtenberg, and Henderson 1993; Noteboom 1999).

These comments underline the point that advanced economic development over the last half-century has taken a course far different from the steady trend to monopolization by huge machine-intensive corporations as foreseen by the later Schumpeter (1942). Rather, and in line with the model of creative destruction associated with the earlier Schumpeter (1912), the shifts in technology noted here have tended to promote forms of productive activity that are increasingly diverse, organizationally decentralized, and highly competitive. Crucially, they are also associated with a very significant re-agglomeration of production at a widening multiplicity of locations.

New divisions of labor

On the one hand, digital technologies are contributing to the elimination of large quantities of routine labor from the economy; on the other hand, they have simultaneously encouraged a great growth in destandardized production tasks where individual workers are called upon to deploy their knowledge and sensibility in highly discretionary modes of task performance. Computers, in other words, substitute for routine labor but complement the capacities of nonroutine labor (Autor, Levy, and Murnane 2003). This process is no doubt more insistent in high-wage countries than in low (given the relative costs of labor and equipment), but it can also be observed even in parts of the less-developed world. The loss of routine work – particularly in manufacturing – from high-wage countries has been further exacerbated by the chronic reassignment over the last several decades of low-grade labor tasks to offshore locations where an abundant low-wage labor supply is available. As these trends have gone forward, in combination with rising incomes and rising levels of human capital, so they have also been associated with the upsurge of the so-called “knowledge economy,” the “service economy,” the “cultural economy,” the “libidinal economy,” and so on, in the advanced capitalist societies.

These developments have given rise to two major outcomes in terms of the division of labor. First, the old Smithian division of labor in production and its expression in taylorist work organization has receded markedly in core segments of the economy, while other configurations of work (including project-oriented teamwork and new forms of craft labor) have developed apace. Second, a new overall social division of labor – replacing the old white-collar/blue-collar pattern of stratification typical of fordist capitalism – appears to have made its decisive historical appearance, at least in the more advanced capitalist societies. This new division of labor is represented by the increasing segmentation of the labor force into a high-wage upper tier of what Reich (1992) calls “symbolic workers” and a low-wage tier of workers who are increasingly occupied in a great range of miscellaneous service-oriented tasks, such as taxi-driving, street cleaning, janitorial labor, home repair, child care, restaurant work, and so on. The growth of the low-wage service-oriented sector (especially in large cities) has been all the more spectacular in view of the steady erosion of low-skill manufacturing employment in the more advanced capitalist countries.

Knowledge and human sensibility in the labor process

In view of these social and economic changes, there is much to be said for using the descriptor “cognitive-cultural” to identify the new phase of capitalism that appears to be in the process of consolidation at the present time. Unlike the term “postfordism”, this alternative vocabulary carries a clear and positive message to the effect that so much production today is posited on the mobilization of the mental and behavioral powers of critical segments of the labor force. These dimensions involve not only skills such as logical thinking, inductive judgment, analytical perception, technical insight, and creativity, as well as workers’ capacities for empathy, self-presentation, leadership, communication, social interaction, and all the rest (Scott 2008).

These cognitive and cultural human capital assets are most obviously on display among members of the upper tier of the labor force as they go about their business in all the representative sectors of the new economic order, from aerospace and biotechnology, through high finance and professional services, to film and music. Even members of the lower tier are being called upon increasingly to deploy related kinds of human capital, though at much lower levels of certified training. Demand for the skills of the upper tier of workers is notably high in sectors of the new economy where innovation is critical to success, and where firms seek to compete with one another by means of niche marketing either by offering high-performance product specifications or by seeking to infuse their products with distinctive aesthetic, semiotic, and libidinal qualities. Even run-of-the-mill products like cars, kitchen utensils, and office supplies are susceptible to this trend. This means that while economic competition in the twenty-first century is intensifying, it is becoming less and less like perfect competition, and more and more like monopolistic competition *à la* Chamberlin (1933).

The service-oriented workers who increasingly make up the lower half of the labor force – above all in large cities – usually lack formal qualifications, but are certainly not deficient in useful forms of cognitive and cultural know-how. These workers often face tasks that entail much judgment and imagination in regard to time management, coordination with others, social perceptiveness, ability to communicate in certain ways, equipment maintenance, vehicle operation, and so on. In short, even in the low-wage service-oriented segment of the economy, workers must generally have real capacities for knowing how to go on in varying and unpredictable situations, including many that entail a direct human interface. By the same token, the jobs carried out by these workers are often quite resistant to routinization and repackaging, and for exactly the same reason can neither be computerized nor sent offshore to low-wage labor depots (Gatta, Boushey, and Appelbaum 2009). It is tempting to refer to this lower tier of the labor force as a *new servile class*, not only because the work is systematically underpaid, but even more because so much of it is devoted to social reproduction of the upper tier of the labor force and to maintenance of the urban services on which the upper tier depends for its livelihood and pleasures. As such, the concept of the new servile class adds a much-needed counterweight to the theory of the creative class as posited by Florida (2002), though it should be observed that to speak of “class” in this manner conjures up the Weberian sense of the term more than it does the Marxian.

Toward spatialization

With these points in mind, we proceed to our chief objective, which is to identify the main geographical impacts of this new economic order. The discussion moves forward in four interrelated stages as follows:

a An analysis of how the changing economy is affecting intra-urban structures of production and work.

b A consideration of the new forms of social stratification and the built environment that increasingly characterize large metropolitan areas.

c A review of some important recent developments in the “rural” spaces that lie in the interstices between major cities.

d A few remarks about spatial convergence and differentiation in the modern world, with special reference to globalization and the new regionalism.

Metropolis (I): economy

I begin with the contentious but plausible suggestion that cities in capitalism are primarily economic entities, that is, dense centers of production, work, and exchange. This statement does not fully capture all that cities are, but it does represent a reasonably defensible statement about their moment of genesis and the main drivers of their development through time.

Agglomeration, decentralization, and the new economy

Thus, as agglomeration theory suggests, cities as we know them are clusters of capital and labor that come into being because immense pressures exist on both the production and consumption sides of the economy for selected activities to converge locationally toward their own collective center of gravity (cf. Cooke and Morgan 1998; Scott 1988; Storper 1997). No other version of clustering processes (least of all the search for community), I would argue, can account for the emergence of large metropolitan areas across the world over the last century and more, not to mention the continued growth of behemoths like New York, Los Angeles, London, Paris, Tokyo, Seoul, Mexico City, and so on, though other factors (such as the costs of infrastructure provision, selective governmental channeling of resources, housing availability, and so on) certainly can and do play a subsidiary role. Cities, in brief, are in the first instance sites of production and consumption, and above all expressions of the productivity and innovation imperatives of capitalist society.

In the same way, cities always reflect, even if in mediated form, the character of the specific version of capitalism that defines their historical and geographical context. So it is that cities in many different countries today are actively being reshaped by the constraints and pressures of the new cognitive-cultural economy, though in strikingly uneven ways and with many variants depending on local-*cum*-national circumstances. It is chiefly the major metropolitan areas of the more advanced economies that are developing in this manner, though a number of large urban centers in other parts of the world are also beginning to participate in this trend. To ever increasing degree, the internal production spaces of these cities are being remade in the image of the core sectors of the new economy, such as technology-intensive industry, finance and business services, fashion and media, and so on. Traditional forms of manufacturing are rapidly disappearing from these same cities, and are either relocating at places lower down in the national urban hierarchy or at cheap labor sites offshore (Scott 2009). As a corollary, big cities in advanced capitalism today harbor multifaceted reservoirs of high-level human capital supplying the main cognitive and cultural inputs to production. Conversely, they also contain large accumulations of low-wage service-oriented workers who directly and indirectly cater to the ever-multiplying demands and needs of more privileged workers within this peculiar version of urbanization.

In numerous instances, the pressures on key sectors of the contemporary economy to agglomerate together in geographic space are so intense that many of them coalesce out as identifiable industrial districts in intra-urban space. The theoretical and empirical features of these intra-urban clusters have been so extensively scrutinized (for example, by Amin and Thrift 1992; Asheim 2000; Gertler 1992; Santagata 2002; Storper 1992 and many others) that little further comment on these matters is needed here, except to say that their endogenous dynamics tend to endow them with increasing returns effects that then enhance the competitive advantages of all individual producers located within their spatial orbit. Yet despite the centripetal forces to which they are subject, and just as traditional manufacturing is susceptible to chronic decentralization to peripheral locations, so many elements within the new economy are now also showing signs of a similar syndrome of flight. As we would expect, decentralization of this sort is most evident in those segments of the new economy that are relatively routine in nature, but, increasingly, less routine functions are also becoming subject to the same pressures. Instantaneous digitized communication and embedded work stations facilitate the manageability and feasibility of this process. Such is the case, for example, with the selective relocation of full-package clothing production from the fashion centers of Western Europe to satellite nodes in Eastern Europe, or of software functions from Silicon Valley to Bangalore, or of film shooting and musical performance from Hollywood to Vancouver and London, respectively (see Bair 2006; Saxenian 1994; Scott 2005). Even so, the existing major centers of cognitively and culturally inflected production typically maintain a strong hold over the more high-end functions, and most conspicuously those that thrive on creative interaction and innovation.

The creative field and the city

With the expansion of the new economy of ideas and affects, and its dominant, though by no means exclusive concentration in large cities, a unique kind of creative field effect sometimes begins to take shape in intra-urban space. Of course, cities have always been centers of creativity (Hall 1998), but their potentials in this regard are multiplied many times over in view of the logic of production and urbanization that prevails at the present time. The leading sectors of this new economy are congenitally focused on innovation and ingenuity, not only in the sense that firms in capitalism always need to keep a watchful eye on new opportunities, but also in the sense that in a world of small batch production and rapidly intensifying competition in regard to product performance and design specifications – hence exploding niche markets – firms must be hyper-responsive to up-and-coming market trends. In addition, the advanced forms of human capital deployed in the core sectors of modern large cities mean that these cities are endowed with large pools of well educated individuals who are presumably relatively open to new ideas and fashions. The endless interactions between these individuals in project-oriented work, in inter-firm transacting relations, and in the life of the city at large suggest that continual streams of mutual learning and joint discovery are apt to ensue (cf. Edquist 1997; Glaeser 1999; Nonaka 1994). Moreover, by reason of their acquired attributes and generally rising prosperity, these cities are typically places that offer the sorts of high-quality amenities and cultural services that help to sustain the social reproduction and legitimacy of the elite as a privileged cadre of individuals (Bourdieu 1979). The creative field itself materializes as these constituents of the urban system come into mutual interaction on a daily basis, hence setting the scene for selective transfers of information and potential flows of innovation effects. None of these effects may be particularly dramatic in its own right but collectively they often sustain a powerful dynamic of continually improving performance by local producers on wider markets (Scott 2008).

In the light of these comments, and giving due consideration to the latent opportunities afforded by the new economy, it is less than surprising to note that policy makers in cities large and small around the world have turned almost obsessively of late to development programs seeking to enhance creativity as a way of boosting local technology-intensive and/or culture-intensive production capacities. This search is more often than not informed by a set of theoretical advocacies that can be traced back to the original work of Landry and Bianchini (2005) and Florida (2002; 2004). The latter author, in particular, advises urban policy makers to adopt programs focused on stimulating inward migration by members of the “creative class” whose talents, Florida claims, translate – somehow –into urban growth. The most appropriate strategies for this purpose are said to involve social engineering initiatives so as to induce the diversity and tolerance that members of the creative class are thought to prize, and public spending on amenities that enhance the cultural and environmental assets of the city. Other theorists go on to suggest that we have now entered an era of “consumer cities” where urban growth and prosperity are no longer rooted in production, as such, but in the hedonic attractions and amenities of cities, which in turn foster inward migration, most especially of well-qualified workers (cf. Clark *et al*. 2002; Glaeser, Kolko, and Saiz 2001).

Urban growth: a critique and theoretical reconstruction

It is certainly correct to aver that the social, cultural, and physical amenity levels of many cities have expanded greatly of late years. The rising overall amenities of cities also often play a significant role in helping to sustain the social edge of cognitive and cultural labor. A satisfactory theory of urban growth in capitalism, however, needs to go well beyond the supposed connection between these localized kinds of socio-cultural attractors and inmigration of representatives of the upper tier of the labor force. I shall argue that a more robust approach can be discovered in the logic of agglomeration and localized job generation (Storper and Scott 2009), not only in historical capitalism as a whole, but also in the current conjuncture when a supposedly creative class of workers is alleged to have become substantially footloose in the sense of having wide discretionary powers in regard to choice of residential location and, as a corollary, migrating preferentially to places that satisfy their appetites for “amenities.”

The logic of agglomeration and localized job generation is founded on a twofold spatial and temporal process. On the one side, as we have already seen, it involves an insistent search for cost-reducing proximities and increasing returns effects in complex production systems; and on the other side it is expressed in path-dependent processes of innovation, horizontal and vertical spin-off, entrepreneurship, and the collective accumulation of place-specific competitive advantages. The overall dynamic of urban growth is further dependent on increasing external demands for local products. As these processes operate, and even as the urban economy goes through many changes, the broad sectoral structure of the local production system tends to remain surprisingly stable or, at most, to shift relatively slowly. This remark is important because it points to the intense interdependence and hysteresis that characterize the kinds of production systems lying at the economic base of large urban areas (Frenken and Boschma 2007; Martin 2010). If growth were simply to ensue from the inmigration of a disparate creative class, irrespective of preceding developmental trajectories, a much more wayward pathway of development might be expected to ensue. Another way of expressing much the same idea is to say that inward migration of a heterogeneous mass of talent workers in and of itself cannot account for the durable forms of sectoral specialization that we so often find in individual cities (such as informatics in Silicon Valley, film production in Hollywood, financial services in New York, music recording in Nashville, and so on). A far more satisfactory explanation of urban agglomeration, specialization, and growth is to be found in the theory of localized increasing returns effects and job generation with its analytical machinery clearly focused on the endogenous formation of the urban-economic base and its exogenous drivers.

None of this is meant to deny that labor is devoid of causal powers in the matter of urban growth. On the contrary, growth is obviously dependent in many complex ways on both the quantity and the quality of labor available, but in the context of a recursive process that is driven ultimately by production system dynamics. As argued more fully in Storper and Scott (2009), cities assume a characteristic developmental trajectory that we can identify, according to Hirschman (1958) and (Myrdal 1959), as a process of circular and cumulative causation. Whatever the reasons for the initial location of production activities at any given site may be, a typically recursive pattern of development proceeds in which (in the order or analysis), (a) increasing returns effects in the production system attract specific kinds of new capital, (b) employment increases as a consequence, (c) the increased local availability of labor attracts further capital investment, (d) with the intensification of increasing returns effects, a new round of capital investment is then initiated, and so on, in round after round of path-dependent urban expansion. Labor plays a definite role in this process, but for the reasons already intimated in the previous paragraph the likelihood that it performs a primary or significantly autonomous part seems somewhat implausible. Further, and in any case, it is something of a stretch of the imagination to suppose that individuals of working age who have invested considerable amounts of time and money in securing professional qualifications will migrate on any significant scale to cities where there are not already appropriate opportunities for them to make a living and to capitalize on their hard-earned personal assets. A mounting body of empirical evidence claims, indeed, that jobs take precedence over amenities in the destination choices of migrants (Chen and Rosenthal 2008; Grant and Kronstal 2010; Greenwood and Hunt 1989; Hansen and Niedomysl 2009; Niedomysl and Hansen 2010; Scott 2010b), though I must add at once that this view is hotly contested in some quarters (see especially Partridge 2010).

These arguments suggest that the growth of individual cities can be most effectively understood in terms of a fundamental logic of productive agglomeration, employment, and specialization in the context of a path-dependent evolutionary process. More generally, the dynamics of urban growth are almost certainly not founded primarily on migrations of talent workers in search of amenities, but emerge centrally from the *primum mobile* of the production system in capitalism. Concomitantly, the structure of urban growth reflects the basic ontological constitution of capitalist society where path dependency is endemic and the final hour of static equilibrium never comes. These dynamics have been forcefully re-asserted in the era of cognitive-cultural capitalism marked as it is by revivified agglomeration processes and the resurgence of metropolitan growth.

Metropolis (II): society and built form

The division of labor and the social space of the city

In the old fordist metropolis the bipartite split between white-collar and blue-collar labor in the work-place was cast out, as it were, imperfectly but perceptibly, into urban social space in the form of a bipartite division of neighborhoods. In the period up to about the 1950s, this division assumed the form of a dominantly blue-collar inner city (further differentiated geographically along racial, ethnic, and cultural lines) and a dominantly white-collar suburban ring. In the later decades of fordism, the pattern became more intricately woven as blue-collar workers seeking residences close to employment opportunities in decentralized manufacturing plants moved steadily from inner-city areas to the suburbs.

Nowadays the former white-collar/blue-collar division of labor seems largely to be giving way, at least in major metropolitan areas, to the new overall division of labor that is emerging out of the changing technologies and structures of production in cognitive-cultural capitalism. As already suggested, the new division of labor in the more advanced capitalist cities can be described in terms of, (a) an upper tier of workers with high levels of cognitive and cultural human capital employed in activities such as science and engineering, financial and personal services, design, the arts, fashion, entertainment, and so on, and (b) a lower tier of mainly low-wage service-oriented workers employed in jobs that range from domestic help to maintaining basic networks and infrastructures in support of the ebb and flow of urban life generally. It is these service-oriented functions, much more than the manufacturing sector, that now absorbs the labor of the low-wage immigrants who continue to pour into large cities in the United States and elsewhere. The shift in low-wage employment from manufacturing to service-oriented jobs has been under way for many decades in these cities, but appears to have accelerated greatly as the new economy has come on stream.

This important point can be illustrated with the aid of some simple statistics. In 1980, employment in the New York–Northern New Jersey Metropolitan Area in a selection of low-level service occupations was 627,240, and employment in a selection of (mainly) production worker occupations in manufacturing (that is, operators, fabricators, and laborers) was 361,680 (see Appendix on page 227 for a definition of these occupations). By the year 2000, employment in the first set of occupations had grown to 905,606, that is, an increase of 44.4 percent, while employment in the second had declined to 210,891, that is, a decrease of 41.7 percent. I should stress that the category *service occupations* as identified in the Appendix does not incorporate the totality of low-wage *service-oriented workers* – far from it – for many of the latter can also be found in occupational categories, such as, retail sales, transportation, repair work, and so on. The trends observed in the New York–Northern New Jersey Metropolitan Area are echoed in other large cities in the United States (Scott 2009). This means that service-oriented occupations now account for the lion's share of low-wage work in these cities, and that they are rapidly displacing manufacturing as a source of employment for the lower tier of the labor force.

Like the white-collar/blue-collar form of social stratification before it, the new division of labor is inscribed in urban social space where it runs in part parallel to the old pattern of residential neighborhoods. However, in the contemporary city, the contrasts between the more and less prosperous parts of intra-urban space have become very much more accentuated (Walks 2001). In short, given the dramatically widening gap between the incomes of the upper and lower tiers of the labor force, urban neighborhoods all across the city are diverging markedly from one another in terms of socio-economic status. The concomitant disparities between different neighborhoods are accentuated by the proliferation of gated communities marking off more affluent enclaves from the rest of urban society. These trends are complemented in the inner city by two additional lines of social transformation. One is the creation of neo-bohemias focused on abandoned industrial and warehouse areas along with adjacent tracts of old working-class housing (Lloyd 2002). The other is represented by gentrification – which is often preceeded by neo-bohemian development – a phenomenon where members of the upper tier of the labor force systematically colonize parts of the inner city and upgrade local properties.

Gentrification and central-city redevelopment

Gentrification has been going on in large cities in Europe and North America since at least the late 1950s (Glass 1963), and has intensified steadily down to the present day. The mechanisms underlying gentrification have received considerable attention over the last few decades, and my intention here is less to comment on the detailed analytics of the process as reported in this literature than it is to resituate these analytics in the broader framework of the cognitive-cultural economy.

One widely held theory, first promulgated by Smith (1982), claims that gentrification is due to the so-called rent gap, namely, the discrepancy that exists between the actual land rent of inner city areas under their old use and the potentially much higher rent that could be obtained by property upgrading. The rent-gap theory certainly alludes to part of the mechanism underlying gentrification, as well as to the windfall profits that invariably accrue from gentrification in its initial stages, but it is far from sufficient as an explanation of gentrification as a whole. As Smith (1986) himself suggests, a fuller understanding of gentrification calls for further inquiry into the nature and timing of the social changes that have made this revalorization of inner-city land rent a concrete possibility in recent decades, and here, I argue, the changeover from fordism to cognitive-cultural capitalism plays a major role. On the one hand, then, as manufacturing has steadily evacuated inner-city areas, so, too, nearby working-class populations have declined. On the other hand, the great growth of economic activities that thrive on high-level cognitive and cultural labor inputs in recent years is reflected in the major expansion of office and service employment in and around the central business districts of large cities. The result has been greatly intensified demand by members of the elite labor force for suitable accommodation in adjacent areas. The net consequence of these intertwined events – flight by one social fraction (sometimes voluntary, sometimes hastened by rapacious landlords and complicit local planning authorities) and its replacement by another – has been the wholesale reconstruction of inner-city areas in large cities in all the advanced capitalist countries, accompanied by soaring property values that only the most affluent can afford.

The term “gentrification,” strictly speaking, designates the transformation of residential property, but it is also widely applied to the building and rebuilding of purely commercial properties in downtown areas. “Redevelopment” is a much more apposite descriptor in these cases (Smith 1982). Urban change of this sort has notably dramatic impacts on both the functional and visible aspects of the city, for on the one side, it almost always entails a classical process of land use intensification (that is, the expansion of floor space relative to ground area) due to inflated land prices at downtown locations, while on the other side, in the context of the cognitive-cultural economy, it increasingly assumes the form of spectacular architectural gestures with the object of dramatizing the urban landscape, no matter whether they be monuments to corporate power or shrines to public self-esteem. These sorts of iconic gestures are widely observable in flagship cities of the new global order (Kaika 2010; Zukin 1991). They in part symbolize the ambitions of particular cities to function as cynosures of the world system and as destinations for inward flows of capital and skilled workers. In parallel with these developments, expansion of downtown cultural facilities in the guise of museums, art galleries, concert halls, and so on, is proceeding apace in the same cities, along with public displays of art and sculpture, and the wholesale aestheticization of public spaces such as Times Square in New York or the Grove in Los Angeles. This is all of a piece with the social and economic mood of cognitive-cultural capitalism generally. In these ways, and in contrast with the gritty, hard-edged urbanism of the fordist era, a sort of environmental continuity or harmony is established over segments of urban space where work, shopping, leisure, and residential activities interpenetrate with one another in smooth mutual interdependencies. Beyond the allure of these privileged portions of the city, however, there remain large swaths of less visible, or at any rate, less mediatized urban squalor where the less fortunate denizens of the metropolis pass the greater part of their lives.

Celebrity and glamour in the cognitive-cultural city

Perhaps the most egregious instance of this kind of promiscuous superimposition of iconic glitter onto the drabness of everyday being for the mass of people in the world metropolis at the present time is to be found in the swirl of celebrity and glamour around the cadre of individuals whose images circulate constantly through the media (Gundle 2008). These are the stars and “personalities” who emerge mainly, but not without exception, from the symbolic/libidinal side of the cognitive-cultural economy (Currid-Halkett and Scott 2011). They function as both high-level producers and workers in their own right, but also as vehicles for branding and advertising (Barron 2007), and their public images are a constant source of new trend-setting product configurations. In some cases, they acquire a collective notoriety, as represented by “Swinging London,” “le Tout Paris,” Andy Warhol’s “Factory” or the “hallyu” phenomenon of Seoul, which in turn has significant branding effects on the cities with which it is associated. The role of celebrities relative to the symbolic economy today has certain affinities to that of the upper bourgeoisie relative to the *grand luxe* of a previous era, above all in the Paris of the *Belle Epoque*, but with the crucial difference that most celebrities today have a resolutely demotic appeal with much more extensive economic and social effects. As such, they are a visible element as figures in the landscape of a number of the world’s great cities from Los Angeles, through New York and London, to Tokyo, and beyond, but with global reach as well.

Interstitial geographies: new rural spaces

Just as large urban areas are undergoing far-reaching transformation in this historical moment of capitalism, so, too, are many of the interstitial non-urban areas between them. The interstitial areas that I have in mind here are not so much the vast untamed hinterlands or the endless tracts of industrial agriculture that occur all over the world, but those more bucolic rural spaces that lend themselves to relatively informal types of economic activity and cultural economic expression in the guise of crafts, design traditions, environmental attractions, or specialized crop cultivation for discriminating markets.

The urban and the rural – or the city and the country – have traditionally been distinguished from one another as deeply contrasting realms of life (Williams 1973). This distinction is based in part on a conception of the city as a dense hub of industry and trade, and of the countryside as a more extensive agricultural domain, each being marked by widely differing cultures and ways of life. As we move into the twenty-first century, there are no longer quite the same social and symbolic divergences – real or imagined – between the city and the country as formerly, but rather a continuity or interpenetration that reflects their increasing functional integration in the era of cognitive-cultural capitalism. Much, if not most of rural space today certainly remains dedicated to extensive agricultural pursuits, but there are also discernible trends in many areas – above all in the more advanced capitalist countries – that involve the emergence of more symbolically inflected forms of economic activity based on local products and traditions with distinctive aesthetic and semiotic properties. In the cognitive-cultural era, in other words, widespread incorporation of the rural into the urban is in progress as cities extend their influence and as the ethos of contemporary capitalism transforms the whole of geographic space. Unsurprisingly, in view of these comments, there has appeared of late an explosion of geographical and sociological interest in processes of rural change and regeneration (for a sample of recent studies see Bessière 1998; Daugstad 2008; Gibson and Connell 2004; Kalantaridis and Bika 2006; Munton 1995; Murdoch 2000; Ray 1998; Scott 2010a; Seaton 1996; Sims 2009; Squire 1993; Vergunst *et al*. 2009; Ward and Brown 2009).

All over the world, therefore, new economic currents are penetrating rural and peripheral regions in a manner that is closely articulated with the overall system of cognitive-cultural capitalism (cf. Ward and Brown 2009). As Ray (1998) has suggested, rural development of this sort can typically be characterized in terms of, (a) a territorial base, (b) a set of symbolic signifiers, and (c) a structure of economic synergies. In any case, enormous re-mobilization of rural assets is occurring at the present time as new opportunities multiply within the orbit of the cognitive and cultural economic order. Ray (1998: 3) goes on to describe this re-mobilization in terms of its roots in both cultural and natural heritage, for example:

> traditional foods, regional languages, crafts, folklore, local visual arts and drama, literary references, historical and prehistorical sites, landscape systems and their associated flora and fauna.

Practical examples of this proposition can be found all across the globe: vintage wine production in the Napa Valley and Burgundy, historical scenes and archaeological remains around the shores of the Mediterranean, picturesque landscapes in the English Lake District or the Scottish Highlands, ecological tourist sites in parts of Costa Rica, indigenous arts and crafts in any number of out-of-the-way regions, and so on. In many rural areas, these trends are accompanied by a turn to organic agriculture and a significant revalorization of local culinary traditions. Small towns all over the world have also been caught up in these sorts of transformations as illustrated by the advent of book towns, the spread of country music festivals, or membership in the *CittàSlow* movement (Bell and Jayne 2009; Gibson and Connell 2004; Mayer and Knox 2006; Seaton 1996). Today, many places outside major metropolitan areas are prospering on foundations such as these, either by physically exporting upgraded traditional products to distant markets, or by serving as centers of an increasingly profitable tourist trade.

These burgeoning new rural spaces and the small urban settlements that they encompass owe much of their success to the rising affluence of contemporary society, and particularly to the increase in the number of individuals in the upper income tier with their predilection for goods and services that combine a kind of authenticity with unique experiential encounters. By the same token, many rural areas have found that otherwise dormant natural and symbolic resources can be turned into lucrative assets, most notably if they can be staged in ways that stimulate the human faculty for “fancy, fantasy, and wishful thinking” (Shields 1991: 14). This means, however, that many if not most of these new rural spaces face a knife-edge developmental situation, for on the one hand, their prosperity is largely based on fragile regional endowments, while on the other hand, the economic exploitation of these endowments constantly subjects them to the threat of deterioration. For this reason, the dynamic of Schumpeterian creative destruction that is more or less endemic in the large cities of capitalism today is often quite dysfunctional in these interstitial regions of the new world order.

Urban-economic geography in a world of spatial convergence and differentiation

Thus far, we have looked at the geography of the current conjuncture by concentrating on the spatial organization of distinctively urban and rural places. We might ask, how can we rearrange this material in a more transversal manner so as to bring to light further important insights? Jessop *et al*. (2008) make the helpful suggestion in this regard that the multifaceted structure of geographic space can effectively be codified not only in terms of place but also in terms of territory, scale, and network. The point is that there is not just one kind of transversality but multiple and overlapping varieties. Specifically, the contemporary world is not moving unidirectionally toward a putative integration of all economic and social phenomena into some monolithic global totality (though we can certainly point to the deepening world-wide interdependence of different forms of life that is currently going on) but is critically characterized by a proliferation of places, territorial mosaics, and networks at every spatial level. The geography of the world in this increasingly complex state of reality is marked by ever-shifting patterns of spatial convergence and differentiation, but also with very specific empirical substance deriving in part from cognitive-cultural capitalism.

From internationalism to multistructured globalism

Over much of the twentieth century, the twin figures represented by the national (fordist) economy and the national government (with its basic Keynesian welfare-oriented policy apparatus) could be said to constitute the durable kernel of the advanced sovereign capitalist nation state. It was in this historical moment that large-scale industrialization and urbanization flourished in favored regions of each national territory (Brenner 2004). It was also the context within which the international order of the post-World War 2 decades came into being, with the more advanced economies forming a “First World” under the aegis of the *Pax Americana*, complemented by “Second World” and “Third World” blocs elsewhere.

By the early to mid-1980s, it was evident that this old order was starting to give way before another set of international arrangements, which increasingly came to be theorized as one form or another of “globalization” (despite strong objections from some analysts, for example, Hirst and Thompson 1996). Notwithstanding the debates that then raged and still rage about this issue, we can say with some confidence that a modicum of agreement now seems to exist around the proposition that globalization involves an expanding but unfinished functional integration of different national capitalisms with one another, together with the intensification of capitalist economic arrangements in formerly peripheral territories (most forcefully in Asia, as Arrighi 2007 has shown). These trends have been underpinned by the spectacular shifts in technology that have occurred over the last few decades, including both the near-universalization of digital communication, and vast improvements in logistics and physical transport technologies. At the same time, the social and spatial transformations currently proceeding as globalization moves ahead do not involve a simple reconstitution of everything at the highest possible scale of resolution, but are also evident in a growing multiplicity of spatial phenomena at other scales. In short, a new and tangled geometry of space is now coming into existence across the face of the earth (Badie 1995; Hardt and Negri 2000) with many detailed repercussions on the cartography of ground-level development. An insistent component of this new geometry of space is the phenomenon of the urban, not simply in the guise of individual cities, but more especially in the shape of a world-wide network or mosaic of cities caught up with one another in deepening relations of cooperation and competition.

As the different layers and facets of this geometry have evolved, numerous new challenges of regulation and institutional order have also come into being. National state apparatuses themselves have been subject to deeply seated processes of restructuring over the last few decades. To a very significant degree these challenges have been met hitherto with responses that are permeated by neoliberal ideologies and practices. The "Washington Consensus" that prevailed in international development agencies and think tanks over the 1980s and 1990s was one important influence in this respect. More recently, neoliberal approaches have been subject to a considerable degree of attrition as the economic miracles that they promised failed to make their scheduled appearance (while China's command economy grew by leaps and bounds), and they have come under additional severe stress in the light of the world-wide economic crisis of 2007–2010 (Harvey 2010). What new political advocacies, if any, will now come to the fore as alternative sources of prescriptive regulatory order and scientific inspiration remains very much a controversial question, though one such advocacy that is currently the subject of much discussion entails various versions of a social democratic politics. The disputes that have been sparked off by the most recent *World Development Report* are a revealing expression of this controversy, most notably in regard to the differential role of markets and governmental agencies in both regional and national development. (World Bank 2009, see, in particular, the round table discussion of this report published in *Economic Geography*, October, 2010.)

The new regionalism

In view of these remarks, it need scarcely be pointed out that the mosaic of cities forming one of the faces of global capitalism today is by no means uniform from one end to the other, but is divided up in different ways, not only in terms of economic specialization, but also in terms of political regulation, with a great assortment of institutional arrangements cutting through and over its entire extent. The principal nodes of the mosaic are themselves, with few exceptions, fragmented into multiple municipal jurisdictions. These nodes represent large city-regions, namely, multicentered (often coalescent) metropolitan areas with extensive surrounding territories over which they exert strong economic and political influence (Courchene 2001; Hall 2001; Sassen 2001; Ward and Jonas 2004), and they function increasingly as powerful motors of the global economy. In this manner, they are also subject to many internal political pressures involving the search for new kinds of joined up regulatory structures enabling them to act as political forces in their own right, especially with the goal of strengthening their overall competitive advantages. The resurgence of city-regions as economic motors and political actors on the world stage has encouraged some scholars to write about these entities as the basic units of what is often now referred to as the new regionalism (Etherington and Jones 2009; Keating 2008; Soja 2000).

Many of the more advanced city-regions of the world, like New York, Los Angeles, London, Paris, Amsterdam, Madrid, Tokyo, Sydney, and so on, are located in high-income countries where they also function as the principal centers of the new cognitive-cultural economy. That said, major city-regions (and, with them, important clusters of cognitive-cultural economic activity) are also growing rapidly in various parts of the former world periphery, as for example, in Beijing, Shanghai, Hong Kong, Seoul, Bangkok, Singapore, Mumbai, Mexico City, Rio de Janeiro, and Buenos Aires, to mention only some of the more obvious cases. Singapore, which, three or four decades ago was one of the world's main electronics assembly centers is now committed to re-branding itself as a "global city for the arts" (Chang 2000), and Hong Kong has followed a similar course of self-reinvention (Hong Kong Central Policy Unit 2003). Similarly, Shanghai, Mumbai, and São Paulo envisage much of their future as major financial centers. Even less advanced cities in other parts of the world periphery are caught up in the sweep of global industrial and commercial restructuring that is currently in progress, and many of them have been systematically brought into structures of global commodity production through international subcontracting and value chain development (Gereffi and Korzeniewicz 1994; Humphrey and Schmitz 2002; Schmitz 2007). Not surprisingly, much of this activity involves relatively low-technology and low-concept products, but the putting out of elements of the cognitive-cultural economy from high-wage to low-wage countries is also occurring on a significant scale, as illustrated by international outsourcing of software operations to Bangalore (Parthasarathy 2007), three-dimensional computer animation to Bogotà (Fuerst 2010), and diverse business services to the cities of Eastern and Central Europe (Stare and Rubalcaba 2009). International subcontracting offers one of the levers by means of which many low-wage cities can improve their developmental prospects, and, in time, accede to the global mosaic of city-regions.

One special aspect of global city-regions is the fact that so many of them now harbor vibrant concentrations of cultural and creative industries. As a consequence, the global output of locally inflected cultural products is growing by leaps and bounds, as is international trade in these products, not only from North America and Western Europe, but also from other far-flung parts of the world, for example, telenovelas from Mexico and Colombia, films from Mumbai or Beijing, mangas from Japan, music from the Caribbean or West Africa, fashions inspired by indigenous designs from Africa and Asia, gastronomic products from a host of different countries, and so on. As a corollary, the old cultural imperialism thesis (cf. Feigenbaum 1999; Mattelart 1976) to the effect that globalization is leading inexorably to the overall standardization of culture under the aegis of American multinational corporations no longer seems to carry quite the force that it once did. Certainly, globalization is inducing decay of many traditional cultures around the world, but on a more positive note, it is also ushering in a very much more polycentric and polyvocal system of cultural production (based primarily in large city-regions) than was envisaged by the erstwhile theorists of cultural imperialism.

City-regions, then, are functioning more and more as systemic units of the global economic and political system. Over much of the history of capitalism, the role of cities as potent agents of economic and political order remained relatively obscured so long as their functions were occluded by their overwhelming subservience within the classical nation state. With globalization proceeding rapidly ahead, major city-regions are now materializing as forceful stakeholders in their own right. In a nutshell, they are powerful and increasingly self-affirming configurations of social, economic, and political activity within a multifaceted, multitiered system of global emergence. In the light of all of this, and out of all the possible cartographies that might be drawn up of today's emerging world, the one that stands out with special clarity here is the global mosaic of city-regions together with its interstitial spaces. Even if development-resistant left-behind territories remain a stubborn problem, this particular cartography is steadily obliterating the old core-periphery arrangement of world development that dominated over much of the nineteenth and twentieth centuries, and, in the guise of the global mosaic of city-regions, provides us with an arresting new metaphor for thinking about global economic geography.

Postscript: into the future

I have tried to show how the frontiers of contemporary geography are being transformed by the recent consolidation of a version of capitalism founded crucially in digital technologies, in greatly expanded demands for disciplined mental and emotive labor, and in a labyrinth-like pattern of globalization. This version of capitalism is also intimately associated with the historical and geographical appearance of what I have referred to as a new servile class. While this latest – cognitive-cultural – incarnation of capitalism has by no means wholly displaced other forms based on older technologies and labor requirements, it is most certainly at the leading edge (in terms of growth and innovation) of spatial development processes today, just as it is an important factor in many of the social and political shifts that are also discernible at the present time. Of special interest for present purposes is the fact that in the context of a steadily globalizing cognitive-cultural capitalism, major shifts in patterns of regional development are occurring with important impacts on the character of selected urban and non-urban spaces.

Above and beyond these specifically geographical considerations, the emergence of a cognitive-cultural economy and all it implies raises a number of further important questions that take us back to the broad theoretical perspectives on contemporary capitalism as discussed in the introduction to this chapter. If twentieth-century capitalism can be described as the historical phase of the real subsumption of labor (to the needs and purposes of capitalism), so the twenty-first century is already giving signs that it may well turn out to be the phase of the real subsumption of all social life. This idea is clearly foreshadowed by work on various aspects of biopower (Foucault 2008; Hardt and Negri 2000), but it is posed with new urgency in a cognitive-cultural economy where so much cerebral and affective activity is caught up simultaneously in processes of production and consumption. It suggests that we need to turn our attention with some urgency to questions about just what kinds of human subjectivity and culture are being shaped in capitalism today and what this means for public life. For example, does the new capitalism signify that the gloomy predictions of the Frankfurt School philosophers are finally about to be realized (Adorno 1991; Horkheimer and Adorno 1972) or does it lend itself to some more progressive set of outcomes? In the face of these perplexities, two hopeful signs can be discerned. One is the reinvigoration in late years of the critique of capitalism in its current incarnations (for example, Badiou and Zizek 2010; Harvey 2010). The other is the widening appeal of the so-called "project of the multitude" (Dyer-Witherford 2001; Hardt and Negri 2004), which, for all its problems and ambiguities, sets a clear sight on global democracy, that is, on a world of equality and freedom, in opposition to neoliberal globalism, as the political project *par excellence* of the twenty-first century.

Appendix: Occupations used in calculating employment changes in the New York-New Jersey Metropolitan Area, 1980–2000[1]

Service occupations (except law enforcement and firefighting occupations)

405 Housekeepers, maids, butlers, stewards, and lodging quarters cleaners; 425 Crossing guards and bridge tenders; 426 Guards, watchmen, doorkeepers; 434 Bartenders; 435 Waiter/waitress; 436 Cooks, variously defined; 439 Kitchen workers; 443 Waiter's assistant; 444 Miscellaneous food preparation workers; 445 Dental assistants; 446 Health aides, except nursing; 447 Nursing aides, orderlies, and attendants; 448 Supervisors of cleaning and building service; 453 Janitors; 454 Elevator operators; 455 Pest control occupations; 456 Supervisors of personal service jobs, n.e.c.; 457 Barbers; 458 Hairdressers and cosmetologists; 459 Recreation facility attendants; 461 Guides; 462 Ushers; 463 Public transportation attendants and inspectors; 464 Baggage porters; 465 Welfare service aides; 468 Child care workers; 469 Personal service occupations, n.e.c.

Operators, fabricators and laborers

703 Lathe, milling, and turning machine operatives; 706 Punching and stamping press operatives; 707 Rollers, roll hands, and finishers of metal; 708 Drilling and

boring machine operators; 709 Grinding, abrading, buffing, and polishing workers; 719 Molders, and casting machine operators; 723 Metal platers; 724 Heat treating equipment operators; 726 Wood lathe, routing, and planing machine operators; 727 Sawing machine operators and sawyers; 729 Nail and tacking machine operators (woodworking); 733 Other woodworking machine operators; 734 Printing machine operators, n.e.c.; 736 Typesetters and compositors; 738 Winding and twisting textile/apparel operatives; 739 Knitters, loopers, and toppers textile operatives; 743 Textile cutting machine operators; 744 Textile sewing machine operators; 745 Shoemaking machine operators; 747 Pressing machine operators (clothing); 748 Laundry workers; 749 Misc textile machine operators; 753 Cementing and gluing machine operators; 754 Packers, fillers, and wrappers; 755 Extruding and forming machine operators; 756 Mixing and blending machine operatives; 757 Separating, filtering, and clarifying machine operators; 759 Painting machine operators; 763 Roasting and baking machine operators (food); 764 Washing, cleaning, and pickling machine operators; 765 Paper folding machine operators; 766 Furnace, kiln, and oven operators, apart from food; 769 Slicing and cutting machine operators; 773 Motion picture projectionists; 774 Photographic process workers; 779 Machine operators, n.e.c.; 783 Welders and metal cutters; 785 Assemblers of electrical equipment; 799 Graders and sorters in manufacturing.

All occupational categories are taken from the OCC1990 classification as given by IPUMS; both numerical codes are and descriptive titles are shown.

Note

1 The employment figures are derived from IPUMS (Integrated Public Use Microdata Series provided by the Minnesota Population Center, accessible at http://usa.ipums.org/usa/).

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3 Regional resilience, cross-sectoral knowledge platforms and the prospects for growth in Canadian city-regions

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Introduction

The evolutionary approach to economics suggests that economies change in path-dependent ways, shaped and constrained by past decisions, chance events and accidents of history. The trajectory of specific regions and cities is rooted in a series of economic, social and cultural factors that affect their development over time. The presence, or absence, of key institutional endowments of the local innovation system may affect both their innovative capacity and their ability to respond to external shocks, in other words, their resilience. As regions are buffeted by external shocks, ranging from macroeconomic to technological to environmental changes, their response is shaped by a combination of the existing structure of their economies as determined by past trajectories of development, the underlying institutional makeup of the region, particularly the capacity to develop and exploit new forms of related, or adjacent knowledge, and by the strategic choices made in response to those shocks.

This chapter explores the way in which the intersection between path-dependent trajectories of development, the resulting industrial structure of the region and the strategic choices made by regions affect their future development possibilities. Efforts to sustain the economic performance of regions through periods of disruptive change need to commence with the institutional capacity of those regions to manage their transition. Central to this rethinking is a focus on innovation as the centre piece of a 'placed based' approach to development policy. The focus on innovation as the centre piece of a 'place-based' approach to regional development policy arises from a growing body of research which demonstrates that competitiveness in the knowledge-based economy rests on the emergence of new platforms of knowledge that create new possibilities for innovation by linking across existing sectoral strengths and capabilities.

Resilient regions are those best able to take advantage of these emerging knowledge platforms by undertaking regional exercises to identify and cultivate their assets, institute collaborative processes to plan and implement change, and encourage a regional mindset that fosters growth. The potential to shift the path away from past sources of industrial strength is greatest where new knowledge platforms are emerging at the intersection of knowledge flows across related industrial sectors. The chapter expands on these themes by exploring the recent patterns of innovation and knowledge transfer in leading city-regions in Canada. It draws upon the research results of a national study of innovation, creativity and governance in sixteen cities across Canada (Wolfe 2009). It then looks at a number of these city-regions in Canada where such cross-sectoral knowledge platforms are being exploited to create new growth opportunities.

The concept of resilience and its economic application

Recent theoretical and empirical research on economic development describes city-regions as key drivers of economic growth and prosperity, as well as the primary locus where social dynamics of innovation play out 'on the ground'. This literature underlines the importance of agglomeration economies and proximity as key factors that facilitate the transmission of knowledge among the leading edge sectors that are increasingly concentrated in urban regions. The same evidence indicates, however, that the fruits of knowledge-intensive economic activity are distributed unequally between cities of different sizes, industrial specialization, and labour markets, as well as between people within those cities (Wolfe and Bramwell 2008). Efforts to improve the economic performance of city-regions, especially small and medium-sized ones, which are viewed as being relatively disadvantaged in the emerging global economy, need to address considerations of both industrial transformation and their mechanisms of local governance at the same time. Increasing analytical attention is focused on cities' capacities to formulate responses to their own particular set of challenges which is increasingly seen as a critical determinant of their resilience.

One aspect of resilience that underlies its recent popularity is the relative openness of the term and the ease with which it has been applied to the study of a number of different subjects. Like the earlier concept of 'general systems theory', the term originates with certain biological theories in the field of environmental studies. In this context, it describes the parameters or characteristics of an ecological system that allow it to absorb a sustained disturbance or external shock through changes in its underlying structure or forms of adaptive behaviour. From the ecological perspective, most definitions of resilience focus on the ability of a system to recover from an external shock and return to its previous state or trajectory of development. According to Walker *et al*., one of the widely cited authorities on the ecological approach and its socio-economic implications, "(r)esilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks" (Walker, Holling, Carpenter, *et al*. 2004: 2). From this perspective, the idea of resilience is closely related to two others, that of adaptability, which involves the capacity of actors in a system to affect its resilience and transformability, which signifies the ability to create a new system when the ecological, economic or social conditions of the current system are no longer viable.

Another approach that offers a second perspective on resilience draws from the discipline of engineering. It focuses on the susceptibility of different places to external hazards and natural disasters and the potential of such events to undermine the stability of the system, with negative social and economic consequences. The emphasis in the engineering approach is on attempting to anticipate the vulnerability of physical, ecological or social systems to these external hazards or potential disasters and to analyse the factors that might contribute to the continued stability of the system in the face of the disaster or help the system return to its equilibrium point after the disruptive event occurs. Both the ecological and engineering perspectives draw heavily upon aspects of systems theory and as a consequence, they tend to emphasize the way in which the interaction among component elements of the system contributes to or weakens its resilient capabilities in light of these external shocks (Pike, Dawley, and Tomaney 2010).

Both perspectives also emphasize the ability to return to a previous or new equilibrium point after the perturbation has occurred. For this reason, these perspectives have resonated with an economic approach to regional resilience, which focuses on the potential of the regional economy to return to an original or new point of equilibrium. In economic terms, this highlights the ability of the regional economy to maintain its pre-existing rate of growth or pattern of development, or how quickly it can return to its previous level of economic output and unemployment, after the shock occurs. This approach views the external shocks largely in terms of economic changes which affect the region's underlying competitive position,

Regional economies can be thrown off their growth paths through, (a) *structural change* resulting from global or domestic competition, from changes in the region's competitive advantages for various products, and/or from changes in consumer demand for products the region produces, or b) other external shocks (a natural disaster, closure of a military base, movement of an important firm out of the area, and so on (Hill, Wial, and Wolman 2008: 5).

From an equilibrium perspective, resilience involves the way in which market mechanisms determine the ability of regions to respond to these shocks. Regions which return quickly to their equilibrium growth path are called *economically resilient*, those which avoid being thrown off their growth path are termed *shock-resistant*, and those which are unable to return to their previous equilibrium point are labelled *non-resistant* (Hill *et al*. 2008).

Equilibrium approaches to the concept of resilience can be distinguished from a third approach which draws upon the evolutionary economics literature. The evolutionary approach differs in its view of the diversity of developmental paths which regions follow and the resulting variety in both the industrial and economic structure of the region. A key difference between these perspectives lies in the question of whether resilience merely involves the process of 'bouncing back' or returning to the previous growth path or whether it involves a process of adaptation and adjustment to a new growth path. Implicit in this latter perspective is the distinction between whether there is one equilibrium point or multiple ones that the region can reach through a process of industrial restructuring and the development of new industries (Christopherson, Michie, and Tyler 2010). The evolutionary approach also attaches greater importance to the institutional underpinnings of resilience and the extent to which political and civic institutions may frame the responses taken by different regions to the natural, economic and social disruptions they experience. Finally, it recognizes the extent to which regions are embedded in broader political geographies and that these 'nested scales' shape and constrain both the potential for, and the actual way, in which they respond to external shocks (Pike *et al*. 2010; Bunnell and Coe 2001).

The evolutionary approach to regional resilience draws upon the complementary concepts of path dependence, increasing returns, and lock-in to understand the historical paths taken by different regions and their leading cities. It argues that economic systems change over time, but in ways that are shaped and constrained by past decisions, random events and accidents of history. When applied to regional and urban phenomena, these ideas suggest that the developmental path of a specific city or region is rooted in a series of economic, social and cultural factors that lie in their past. The challenge is to reconcile the significance of random or chance events in endowing a region with its specific industrial structure and institutional capabilities, while allowing for the role of political leadership in fashioning subsequent changes to its broader institutional structures and development strategies. During the early phase of technology development, many different cities have the potential to emerge as the location where a technology and its corresponding industry takes root and develops. Once a city or region has established itself as an early success in a particular set of production activities, through a sequence of random occurrences and locational advantages, its opportunities for continued growth are strongly reinforced by the impact of increasing returns to the technological and institutional advantages it enjoys. By the same token, ailing places may face greater challenges in improving their fortunes when their principal industries and technologies in their region begin to decline. Once a path-dependent trajectory of decline sets in, the critical factor that determines a region's resilience is the capacity of local firms to shift to a new or emerging set of production activities, and the extent to which its institutional structures support this shift (Wolfe and Gertler 2006).

The evolutionary perspective on path dependence has important implications for the concept of resilience. Drawing upon previous work on the institutional transformation of post-socialist societies, Pike *et al*. make an important distinction between the concepts of *adaptation* and *adaptability*. Adaptation is seen as a short-run phenomenon that involves the movement back towards the original path of development based on strong linkages between different social agents and the institutional underpinnings of the regional economy. In contrast, adaptability involves the capacity to shift the growth path of a region towards multiple and alternative trajectories of development, based on the ability to forge new linkages between social agents and alternative or emerging institutional structures. Thus, there is a certain tension between adaptation and adaptability as alternative forms of resilience; at the heart of this tension is the question of whether resilience refers to a region's ability to retain its underlying economic and institutional structure in face of an external shock or whether it requires the ability to respond to the shock by adjusting those underlying structures. Adaptation involves the region's ability to adjust to a new competitive dynamic in the global economy in order to maintain a previously successful growth pattern, whereas "resilience through adaptability emerges through decisions to leave a path that may have proven successful in the past in favour of a new, related or alternative trajectory" (Pike *et al*. 2010: 62; Simmie and Martin 2010). It is the dimension of adaptability that has the greatest implications for the emergence of new knowledge platforms in city-regions.

Adaptability is the key feature that distinguishes between resilient regions that exhibit a strong degree of economic success over long periods of time in the face of different shifts in production technology, the emergence of new markets and changes in international competition from those that are able to adapt to short-run changes in the above conditions. Adaptability over the long run involves the ability to transform its industrial structure, labour market, productive technologies and supporting institutions to respond to external pressures and take advantage of new economic opportunities. Simmie and Martin view this capability as something akin to Schumpeter's 'notion of industrial "mutation" that takes place via a process of "creative destruction"' (Simmie *et al*. 2010: 30). The broader and more diverse the regional economy, the greater the potential there is for multiple equilibria to exist. As older industrial sectors decline in the face of new or emerging production technologies and new production locales around the globe, larger metropolitan regions have a greater potential to reinvent their local economies by nurturing and supporting the emergence and growth of new economic sectors (Swanstrom 2008). A widely cited illustration of a leading urban centre that has managed to do this repeatedly over four centuries is Boston. Boston's success at transforming its economic base repeatedly over this period lies in its continuing ability to adapt to external economic shocks by exploiting its underlying skills base and economic diversity to grow into emerging and related economic sectors (Glaeser 2005: 151–2).

As noted above, another factor that conditions the resilience of regions is their institutional underpinnings. The evolutionary perspective draws attention to the importance of the social dimension in charting the developmental paths of different regions, but what is often missing from these discussions is the recognition that political relations play an important role in determining the range of institutions that can shape a region's potential response to external shocks and thus help determine its resilience. This represents a key distinction between the equilibrium approaches that view resilience largely in terms of purely economic or market-driven responses to external shocks and more evolutionary and institutional perspectives. Central to the changing role of the regional scale in facilitating the adjustment to a changing economic environment is how institutional ensembles adapt to changes in the principal industries and technologies at the core of the region's industrial structure. The key issue concerns the ability of firms, industries and institutions in a specific city or region to adapt their existing knowledge base and localized capabilities to the generation and exploitation of new commercially valuable sources of knowledge.

Resilient regions tend to be those in which existing clusters of firms prove to be adept at making the transition out of declining industries, while simultaneously exploiting their local knowledge infrastructure to cultivate new, potential growth fields. However, regions and cities cannot just alter their trajectory of development by fiat or an act of political will. Their pattern of development is strongly influenced by the industrial structure of their existing economy, as well as by the broader set of institutions that have supported those sectors. Those sectors in which the urban economy has historically been specialized will constrain its future ability to grow, or create opportunities for new sectors to emerge. The basis on which those sectors can emerge will be influenced in turn by the capacity of firms and institutions within the region to develop and exploit new sources of knowledge and their existing knowledge infrastructure, as well as the talents and skills of the workforce (Wolfe 2010).) Todd Swanstrom draws our attention to this dimension and goes further in arguing that there are three different institutional spheres that contribute to regional resilience – the private (firms), public (governments), and civic (networks and associations) sectors (Swanstrom 2008).

Municipal and regional governments also play a central role in creating new development strategies for their local economy, but they rarely do so in a vacuum. As noted above, this involves the role of governments in multiple geographic scales, not just those operating at the local or metropolitan level. The ability of local and regional governments to draw upon the fiscal and policy resources available from more senior levels of government may be important in shaping their ability to frame appropriate policy responses to help their regional economies shift to new sectors of potential growth and move towards a new developmental pathway. But, in some respects, governments represent the slowest moving parts of the local or regional ecosystem and therefore may pose the greatest challenge in helping frame a resilient response to new challenges. Their ability to help their regions adapt is often reinforced by the presence of vibrant local civic associations.

Regions with strong and dynamic leadership from the civic sector, what Doug Henton and his colleagues term 'regional stewards', may prove more successful in working with the public sector to develop new strategies (Henton, Melville, and Parr 2006). Resilient regions are thus ones in which private market forces, a strong and flexible or dynamic civic sector, and local governments are capable of adapting to changing economic and environmental circumstances in order to respond to emerging threats and take advantage of emerging opportunities. Local civic associations also help develop new strategies to promote the growth of their local and regional economies and thus contribute to their potential resilience. Regions with a diverse cross-section of civic stakeholders can develop a set of innovative strategies that promote the future economic interests of the region. However, at the same time, local civic networks that have become excessively ingrown or self-replicating can be the source of an excessive degree of social rigidity that limits the potential for innovative solutions to emerge (Swanstrom 2008; Safford 2009).

It is important to recognize that none of these sectors act independently of each other. Much work has been devoted to explaining the emergence and growth of dynamic regions based on new technologies, as well as the challenge for older, industrial regions to break free of their locked-in paths of development. However, less attention has focused on the co-evolution of a region's industrial structure and institutional underpinnings. Rather, the path-dependent nature of development in regional economies involves the process by which these interdependent sectors co-evolve, as well as the process by which new institutional ensembles (composed of all elements of the three sectors outlined above) emerge in response to changing economic and environmental conditions. The question of how adaptable these institutional ensembles are to changes in the principal industries and technologies of the region's industrial structure lies at the heart of the question of regional resilience. Critical is the ability of firms, industries and institutions in a specific city or region to adapt their existing knowledge base and localized capabilities to the generation and exploitation of new commercially valuable sources of knowledge. 'New paths do not emerge in a vacuum, but always in the contexts of existing structures and paths of technology, industry and institutional arrangements' (Martin and Simmie 2008: 186).

Specialization versus diversity as sources of resilience

A key question, therefore, involves the underlying conditions that differentiate between a region's resilience in terms of its potential for adaptation versus adaptability. One important factor is the extent of economic diversity versus specialization that characterizes the regional economy. One perspective emphasizes the benefits for urban economic growth of specialization in similar or closely related industries, while the alternative focuses on the advantages that flow from a diverse and variegated urban environment. The first approach, associated most closely with the tradition that draws upon Alfred Marshall and the more recent work of Michael Porter, argues that the advantages created by a dense network of suppliers, a deep pool of skilled labour, and the knowledge spillovers that occur among geographically concentrated groups of firms in related industries make the most significant contribution to growth. These advantages are associated with a greater degree of specialization in an urban economy. The advantages are derived from factors that lie outside the boundaries of the individual firm, but are embedded in the industrial sector found in a particular city; they can include a common source of skilled labour for the firm, a network of specialized suppliers that provide intermediary products to the firm, local educational institutions that train the skilled workers the firm relies upon, and other local institutions that provide valuable support to the firm.

A diverse industrial structure provides greater resilience in that different economic sectors face differing changes in underlying production technology and international competitive conditions. A more diverse regional economy thus has a better chance of withstanding disturbances to its growth path, if not all its sectors need to adapt at the same time. A diverse economy is also important because of its potential for sectoral variety which, according to a long line of theorizing that draws its inspiration from Jane Jacobs, is more conducive to innovation because of the potential to generate new ideas that can lead to new technologies, new products and new markets at the intersection of existing economic sectors.

The contrasting perspective, frequently associated with the work of Jane Jacobs, suggests that new and innovative ideas often come from different industrial sectors. Therefore, city-regions that are endowed with a diverse range of different industries, rather than those that are specialized in a smaller number of industrial sectors, have the conditions that are most conducive to innovation and growth. Innovative ideas are derived by applying knowledge that may be considered standard in one sector to help solve problems or develop new products in another sector of the local economy. From this perspective, larger city-regions, with a broader cross-section of diverse industries, have a greater potential for generating innovative new ideas and, as a result, enjoy faster rates of growth and higher levels of innovation than do smaller ones. Knowledge flows between firms in different industries, where new ideas form by combining older ideas, or by applying knowledge that is routine in one sector to emerging problems in another sector, to drive innovation and growth. Large urban economies, with their mix of different industries and occupations, increase the potential for knowledge flows between industries, and therefore, exhibit faster growth and higher levels of innovative dynamism. The possibility of cross-fertilization arising from an economic structure with greater variety enhances the potential for the generation of new ideas and innovation within the local economy. The question of whether smaller and medium-sized cities can display the same degree of innovativeness across a range of sectors is open to further investigation (Jacobs 1969).

These competing views on the sources of urban economic growth have stimulated a considerable amount of academic research that has generated support for both sides of the argument, providing additional fuel for the ongoing debate. The extensive research in the field provides some evidence to support both perspectives: that the presence of both specialized *and* diversified urban economies contributes to the overall performance of city-regions, but the two factors may act in different ways in cities of different size. A recent survey of the literature suggests a possible explanation for the apparently contradictory results. The outcomes reported by different studies may be the result of the specific industries selected for examination. The results are also affected by the range of indicators selected as evidence of economic performance. Most significant, however, is the suggestion that part of the confusion may arise from the omission of time as a factor in determining whether the economic benefits associated with specialization or diversity exert a more important influence on the economic performance of firms in city-regions. In effect, ‘the role of externalities varies according to the maturity of the industry. Jacobs externalities predominate in the early stages of the industry life cycle, whereas Marshall externalities enter at a later point, and in the end, specialization will in fact hinder economic growth’ (Beaudry and Schiffauerova 2009: 334).

This conclusion is consistent with other contributions which suggest the introduction of an industry life cycle perspective, as well as a better appreciation of the relationship between city size and diversity or specialization, may provide a better understanding of the relative contribution made by industrial specialization and diversification to urban economic growth. The economic benefits associated with a more diversified local economy play different roles in the innovation process at various stages in the maturity of the industry, while differences in population also affect cities' ability to create and diffuse new knowledge. In an attempt to reconcile the contradictory findings described above, Gilles Duranton and Diego Puga have suggested that firms often develop new products in the diversified, creative environment found in larger urban centres, but as the technology and industry mature, there is a strong incentive for them to relocate to more specialized cities in the mass production phase of the industry's life cycle in order to exploit urban cost advantages. Larger city-regions tend to be more diversified and knowledge intensive than medium-sized and small cities. Where large cities tend to have multiple specializations, medium-sized cities have significantly fewer (Duranton and Puga 2000). Related findings reveal that levels of innovative activity are also strongly linked to city size, with R&D, patenting, and major product innovations much more concentrated in large urban areas (Audretsch 2002).

This insight is reinforced by an argument that links industrial activity, economic fortunes, and city size. Large cities with a diversified industrial base are more insulated from the impacts of economic change, while smaller ones with a narrower industrial base are more subject to a life cycle of growth and decline (Brezis and Krugman 1997). While a greater degree of specialization does stimulate the growth of some medium-sized cities, the outlook for those cities is linked to the economic prospects of the specific sectors in which they are specialized. Once the sectors lose their competitive edge, the cities may lack the knowledge assets or the quality of place to compete or diversify their local economy into newer and expanding industries. They are often confronted with the challenge of regenerating their local basis for economic development without the institutional capacity that can furnish a fresh supply of ideas and new sources of growth. This suggests that ultimately the source of innovation and economic growth for a city-region does not rest simply on the degree of specialization or diversification in its industrial structure but, more importantly, on the adaptability of the city-region in mobilizing its economic assets in the pursuit of a new basis for growth.

Variations in the ability of cities to create and diffuse new knowledge appear to be important for the cities' long-term growth prospects, as well as their ability to adjust to changing economic conditions and to recover from a decline in the economic fortunes of the industrial sectors in which they were specialized. Cities with a greater specialization in the kinds of knowledge-intensive service activities associated with the growing information economy tend to have stronger economies than places without any specialization. That is not particularly surprising, given that the globally focused information sector is the fastest growing part of the US economy and is concentrated in its largest metropolitan areas (Drennan 2002).

The growing centrality of knowledge-intensive activity to urban competitiveness suggests that the growth potential of cities increasingly depends on their ability to utilize their local knowledge assets to develop greater specialization in growing knowledge-intensive areas of economic activity. Indeed as John Montgomery argues, '[a]t the end of the day, there are only a handful of means by which city and urban regional economies can grow. One is the introduction of new production processes and services to create new work and new divisions of labour . . . More important than this even is the extension of new technologies to create new products and therefore economic sectors' (Montgomery 2007: 29). This introduces a distinctly Schumpeterian dimension into the analysis of urban economics that underlines the impact of the capacity to innovate. New economy sectors are sustained by the continuous pace of innovation and learning needed to keep abreast of the rapidly moving knowledge frontier in their industries.

This need for continuous innovation extends well beyond the manufacturing sector of the economy. In an innovative economy where the knowledge frontier is moving rapidly, dynamic cities are those able to draw on their local knowledge assets and research infrastructure to reinvent themselves by moving from one field of specialization to another. In this transition, existing industries may provide the essential building blocks for the emergence of a new innovative industry, because the skills and talents that have accumulated over time in the city may furnish critical inputs needed by the emerging industry. The successful development of these new industries and clusters, many of which involve information-intensive activities, is a path-dependent process, which builds on the distinctive knowledge and industrial bases of individual cities. As a result, the ability of individual city-regions to marshal their local knowledge assets and develop local concentrations of expertise in emerging technology areas may be a good indicator of their prospects for resurgence and growth.

The emphasis on growth driven by the virtuous interaction of skilled labour and firm preferences characterizes large metropolitan cities as environments where value chains underlying production, and the associated networks of economic actors, can adapt rapidly because of their efficiency at coordinating and managing the processes that are the basis of innovation and growth. In this sense, cities are acting like giant 'Schumpeterian hubs' of innovative activity, or 'switchboards which permit the constant creation and reshaping of the chains linking producers, consumers, and different kinds of indirect players of the economy' (Veltz 2004). Signs of this developmental dynamic are evident in large metropolitan areas, both in rapidly growing 'cognitive-cultural sectors' and in the formation of 'intra-urban industrial districts devoted to specialized facets of cognitive-cultural production,' such as high-tech and software in the San Francisco Bay area, movies in Hollywood, business and financial services in New York and London, and fashion in Paris and Milan (Scott 2007: 1470). These emerging areas of cognitive-cultural production tend to be located in, or close to, the central business district and often take advantage of low-cost space available in abandoned industrial warehouses or factories. The conversion of existing physical spaces associated with the older industrial economy to new uses for the emerging cognitive-cultural economy illustrates the critical way in which the spatial landscape of inner cities is reconfigured in dynamic urban regions (Hutton 2008: 11).

The key issue for cities and regions is the extent to which their industries are moving beyond the narrow confines of traditional areas of industrial specialization towards more advanced knowledge platforms and global knowledge networks. To be successful, dynamic and innovative firms must be grounded in a strong local economy capable of utilizing its local knowledge assets and research infrastructure, but they must also be globally networked. Coordinated approaches need to be devised to improve the capabilities of firms in the local economy as local governments simply lack the resources and funding to implement these strategies on their own. The effective resources available to support such strategies reside at the federal and provincial level. Local development initiatives must be able to tap into existing federal and provincial resources and put them to work in the local economy. Successful and effective policy has to be the responsibility of more than just one level of government – local, provincial or federal. Those cities and regions that are implementing a more coordinated approach to economic development have a strong, engaged civic community, capable of reaching a consensus around its future economic trajectory. Chapter 4 turns to a consideration of this process.

Specialization, diversity and knowledge platforms in Canadian cities

The past two decades have been a period of unusual economic challenges for Canadian cities, as even the economically strongest of them have undergone three major recessions and experienced dramatic fluctuations in the price for resource commodities. The impact of those external shocks, both positive and negative, have posed major challenges for many of Canada's cities, even the largest and most economically diversified. The Great Recession of the late 2000s has posed a particular challenge for the Toronto region, Canada's largest and most diversified urban economy. The Toronto region has experienced four major eras of growth over the course of the postwar period. The first, from the end of World War II to the mid-1960s, was characterized by the rapid influx of foreign subsidiaries into southern Ontario and the expansion of the aerospace, auto and telecommunication sectors, as well as by substantial government spending on educational, physical and social infrastructure. The second era, from the signing of the Auto Pact to the Free Trade Agreement with the US in 1988, was marked by an extension and deepening of those sectors which had taken hold in the earlier period, augmented by the flight of financial and business services from Montreal to Toronto. The third era witnessed a dramatic restructuring of the branch plant economy in southern Ontario generally, and the Toronto region more specifically, following the introduction of both the Canada–US and North American Free Trade Agreements. The impact of this restructuring compounded the wave of technological change that occurred from the mid-1980s onwards, leading to a dramatic loss of traditional manufacturing and clerical jobs and increasing income polarization in the city. The most striking indicator of the extent of change that occurred is the decline in the percentage of employment in manufacturing in the Toronto region, from 24 per cent in the 1981 Census to just 13.5 per cent in the 2006 Census. While some sectors, such as autos, aerospace and telecommunications, continued to expand in the late 1990s and early 2000s, the third era of postwar growth also saw the rapid expansion of the creative and cultural industries, including film, television, live theatre, music, fashion, design and publishing, along with the continued expansion of financial services (Boston Consulting Group 1995; Gertler 2000).

The period since the late 1990s has been labelled the Fourth Era in Toronto's postwar economic growth. Demarcated by the amalgamation of the municipal government into a unified structure in 1997 and the growing integration of the urban core within the broader regional economy, it marks the emergence of Toronto as a leading cognitive-cultural economy. With regard to financial and higher order business services, Toronto has a significant lead over other Canadian cities, with 28.2 per cent of its labour force employed in this sector. Other dynamic sectors include information and communications technology (including new media), biomedical and biotechnology, fashion and design, aerospace and automotive, tourism and the cultural-creative industries. Recent research has documented the dense concentration of both ICT and financial services in the regional economy and the growing linkages between the two sectors. The Toronto region has the third-largest ICT cluster in North America. In 2006, the Toronto regional ICT industry employed 240,000 persons in services and manufacturing, making the Toronto cluster three times larger than the clusters in Vancouver or Ottawa-Gatineau ICT (Lucas, Sands, and Wolfe 2009). In 2009 Toronto region ICT companies earned $52 billion in revenue, of which $22 billion was in manufacturing and $30 billion in services (City of Toronto 2010). The financial services industry is one of the largest consumers of information technologies and services, and these products and services are transforming the region's financial services sector. According to the Toronto Financial Services Alliance, the largest banks alone collectively spent $37.6 billion on technology between 1996 and 2006 with the bulk of this concentrated in the Toronto region. Conversely, the ICT industry in the Toronto region earns 16 per cent of its sales from financial and business services, which is reflected by the fact that almost one quarter of information and communications technology workers in the Toronto region are employed in the financial services sector (http://www.tfsa.ca/financial/industry.php).

The City of Toronto has long served as the cultural capital of English Canada and is home to a dense network of firms in the traditional cultural industries, as well as the burgeoning digital media industry. Toronto's diverse cultural, creative, and knowledge-based industries generate extraordinary potential for knowledge and innovation spillovers within the cultural and media cluster. In particular, creative industries, business services, and information and communication technology are notable as three sectors of specializations that are also leading in growth. As noted above, resilient cities are marked by instances where existing industries may provide the essential building blocks for the emergence of a new innovative industry because the skills and talents that have accumulated over time in the city may furnish critical inputs needed by the emerging industry, as has often been the case with the digital media industry. This is currently the case with the convergence of the cultural and media industries, where all subsectors of the media industry are being affected by convergence. The boundaries are blurring among the older media subsectors as both the content and methods of delivery are being digitized, and digital media is emerging as one of the high growth sectors in the industry. As Charles Davis and Nicholas Mills have recently noted, there are currently considerable spillovers between the information and communications technology sector, the traditional media clusters and the rapidly growing digital media sector which take the form of product spillovers where a growing number of firms are developing highly specialized capabilities to create cross-platform content for film, television, and mobile screens, as well as more diverse network spillovers where the co-location of a diverse range of cultural and media industries is creating the kind of milieu conducive to innovation and new product development anticipated by those who argue in favour of the importance of diversity (Davis and Mills forthcoming).

In stark contrast to Toronto, Calgary is one of the most distinctive cities in the country and in some respects, one of the most specialized. Since the discovery of oil at Leduc in 1947, followed by the construction of the Interprovincial and Trans-Canada pipelines in the 1950s to bring the oil and gas to Central Canada, Calgary has emerged as the centre of the oil and gas industry and one of the most dynamic and fast growing city-regions in the country. It is home to 87 per cent of the oil and gas producers. Despite the fact there is no actual oil and gas production within the boundaries of the city, mining and oil and gas extraction account for 6.5 per cent of the labour force of the Calgary CMA, with a location quotient of 4.6, which is substantially greater than the location quotient for any other industrial sector in the city. In the words of one interviewee in a case study, ‘in Calgary, you can’t do anything if it’s not linked to oil and gas’ (Langford, Li, and Ryan forthcoming).

Closely tied to oil and gas is a set of related industries whose prospects depend on those for oil and gas, particularly the construction industry, business, financial and ICT services. Knowledge is embodied in the people working in the sector and innovation within Calgary’s leading sectors is primarily based on local knowledge sources. Knowledge flows occur through the movement of personnel within specific sectors, but also occur through the assembly of networks of firms to meet the needs of individual clients, as well as through the broader social networks within the city. In spite of the high degree of specialization in Calgary, innovative ideas developed in one sector of the local economy, such as imaging technology developed in geophysical services, can be adopted and applied in other sectors, such as medical devices. Economic sectors that have grown up in close proximity to the dominant oil and gas industry, and have developed specialized knowledge and technological capabilities in that role, can apply their knowledge to other opportunities in new markets in different industries, such as software, global information systems and wireless communications. These new industries are thus drawing upon a platform of diverse related knowledge, including managerial, technical and financial knowledge, which emerged out of the primary resource-based economy and is now being applied to new commercial products and economic opportunities in a manner that suggests the possibility of moving beyond the confines of the specialization versus diversity model of innovation in urban city-regions. The result of this cross-sectoral application of the knowledge base developed for a highly concentrated and specialized industrial sector, such as oil and gas, suggests the possibility of a somewhat different form of innovation, labelled related-knowledge diversity, where the existing knowledge base is deployed to work on a related target problem, drawing upon a diversity of knowledge inputs from an existing sector. This development offers the possibility of an intermediate basis for innovation and growth situated between the conventional poles of specialization and diversity (Langford *et al*. forthcoming).

Hamilton provides another example of an older industrial city with a strong concentration in one particular sector. Hamilton's current economic situation has been adversely affected by the ongoing restructuring in the Canadian steel industry, which has long been the mainstay of the local economy. Innovation in the steel industry has historically been a sectoral phenomenon, largely occurring within communities of practice constituted by professional engineering organizations, such as the National Open Hearth Conference and later the technical committees of the American Iron and Steel Institute and the International Iron and Steel Institute. The takeover of virtually all of Canada's leading steel companies by major multinationals over the past decade has resulted in their integration into global supply chains and knowledge networks. Hamilton's leading steel company, Arcelor Mittal Hamilton (formerly Dofasco), is currently valued for its contribution to the knowledge base and technological capabilities of the parent company. The city of Hamilton, along with its leading university and a number of dynamic local civic organizations have devoted considerable effort over the past few years to developing new strategies to capitalize on the region's existing research strengths, as well as its traditional expertise in metallurgical science. Current innovation strategies are focused on deepening the research connections with McMaster University and the newly developed McMaster University Innovation Park (which will soon be home to the federal government's Canmet metallurgical laboratories), as well as the possibility of attracting one of Arcelor Mittal's global research centres to locate in Hamilton.

In somewhat surprising fashion, however, the other side of Hamilton's innovative economy is the network of emerging biomedical and health sciences firms based around the McMaster Health Sciences complex. Firms in this network tend to be oriented towards medical devices and the delivery of innovative medical services, often building on aspects of the unique teaching model at the McMaster Medical School, which has resulted in a significantly different pattern of innovation than the one traditionally associated with biomedical research. Research into the pattern of knowledge flows in the Hamilton economy reveals an unexpected linkage between the older industrial manufacturing sector that has traditionally dominated the urban economy and the emerging health sciences one. Steel company executives have traditionally played key leadership roles in the governance structures of the Health Sciences complex; and the well-endowed health benefit plans of the local unions have provided the financial basis for the new innovative firms in health services. This is a surprising twist on the conventional innovation model, where the cross-sectoral linkages, that are proving influential in stimulating the development of innovative products and services, lie within the consumer or demand side of the local economy, rather than the supply side (Warrian forthcoming).

The final illustration comes from another mid-size industrial centre in the heart of Canada's manufacturing belt – the three cities that comprise Waterloo region. Waterloo region has long been home to a number of traditional manufacturing industries, including the automotive industry. Since the 1980s, however, it has become notable globally for the emergence of its dynamic high-technology sector and currently boasts more than 700 companies involved in this sector. Regional organizations are also working with more than 200 early-stage start-ups, some of which are housed in the Accelerator Centre at the University of Waterloo Research Park, others in the new Communitech Hub in downtown Kitchener and others are located off-site (Communitech and Waterloo Region Record 2010). The companies are spread across four key subsectors: information and communication technology, scientific and engineering services, advanced manufacturing, and the life sciences biotech and environmental subsector. Unlike other concentrations of high-technology activity in Canada, the economy of the Waterloo region is not dominated by one particular sector, such as telecommunications or internet-based firms. This diversity has enabled the regional economy to weather economic shocks – such as the post-2000 dot-com meltdown – that devastated employment in other leading technology clusters across the country.

A key feature of Waterloo's adaptability has been the foresight of local firms in recognizing emerging technology trends and mobilizing key segments of the local business community, civic associations, and the post-secondary research infrastructure in support of new initiatives to capitalize on those trends. As the competitive dynamics of the information technology industry have shifted in recent years, with growing competition in the hardware products that Waterloo firms excel at, key civic and business leaders have recognized the growth potential of digital media and been quick to chart a new course for the region to expand in this direction. The cultural centre of Stratford, Ontario, located just a half an hour west of Waterloo, has traditionally not been considered part of the region, but the gap between the cultural and scientific sectors of the regional economy has been narrowed with a move by the University of Waterloo to establish a satellite campus in Stratford, followed closely by the creation of a new centre in digital media, linking Stratford directly into the Waterloo economy. This new branch of the University of Waterloo – the Stratford Institute, with a strong focus on the creation of content for digital media – is the centre of a national network to promote the growth of digital media across the country.

The Corridor for Advancing Canadian Digital Media (CACDM) is a collaborative initiative on the part of partners across the region and south-western Ontario to develop a Centre of Excellence in digital media. The goal of the Centre of Excellence is to create Canada's largest concentration of digital media R&D and commercialization expertise, and to develop internationally competitive and sustainable capacity in digital innovation. The vision of the Centre of Excellence is that arts and cultural content creation expertise can be combined with digital media in order to produce innovative ways to present and manipulate data and visualize processes. What is most innovative about the initiative is the inspiration to marry the well-established capabilities of the Waterloo region in digital technologies with the cultural and creative capabilities for which the city of Stratford had long been recognized.

The success of the region's civic and business leadership in attracting external funding from the federal and provincial governments has been a key to the early success of the CACDM and a related initiative, the Digital Media Hub and Mobile Accelerator. The two senior levels of government have underwritten nearly half of the total cost of creating the Hub. The Hub, which opened in October 2010, is a unique facility designed to support the growth and commercialization of Ontario's digital media industry. It provides an attractive location in the heart of the region for entrepreneurs, companies and academic institutions to interact under one, 30,000 square foot state-of-the-art, roof. In fact by mid-2011, the Hub had already filled its available space and there was a further expansion underway. Among the many features of the Hub are the immersive 3D HIVE (Hub Interactive Virtual Reality Environment) provided by Christie Digital, one of the key private sector partners, 3D-capable event space, and virtual conferencing facilities. In addition to Christie, the Hub has also representatives from some of the larger firms in the region, including RIM, Open Text and Agfa. Through a wide range of programmes administered by Communitech, the Hub helps build global digital media firms by mentoring tenant start-ups, creating linkages with more established companies in the region, and helping secure financing for digital media ideas. The facility has space to accommodate more than 100 digital media start-ups and, as noted above, Communitech is already working with more than 200 start-up firms in the region through its Executive in Residence programme and mentoring activities. The Hub also serves as the headquarters of the Canadian Digital Media Network and through the CDMN is the sponsor of the highly successful Canada 3.0 conferences held in Stratford for the past three years (Knowles 2011). While the mainstay of Waterloo's regional economy continues to be the better known technology firms, such as Open Text and RIM, the new focus on growing new strength in digital media and start-up firms, the region's leaders are anticipating future trends and not waiting to be adversely affected by external shocks before beginning to adapt.

Conclusion

The four cases discussed in this chapter indicate the ways in which some of Canada's largest cities, as well as its medium-sized ones, are adapting to the external economic shocks that have buffeted the global economy since 2000. The specific form of adaptation varies considerably across each of the cities, but they share in common the goal of building on some of the areas of traditional economic concentration by moving into new fields of the adjacent possible (see Chapter 1) through a process of cross-sectoral fertilization and related knowledge diversity. The largest and most diversified cities, in this case Toronto, clearly benefit from the presence of a wide range of diverse economic sectors and knowledge concentrations, and thus have the most extensive range of options in opening up new possibilities to exploit at the intersection of existing sectoral strengths. What is somewhat unexpected, and more interesting in some respects, is the way in which smaller cities, with traditional concentrations in a narrower range of industrial sectors, are also exploiting their existing knowledge bases or cross-sectoral knowledge linkages to develop new potential areas for growth through a process of diversifying into related sectors.

The degree of adaptability and resilience exhibited by each city-region is thus a result of both their underlying industrial structures shaped by a path-dependent process of economic development, as well as the strategic responses framed by both business and civic leaders working to develop and exploit opportunities with the potential to generate new areas of economic growth. As was noted at the outset, each region is a product of the particular way in which their industries and institutions have co-evolved over time. None is completely captive to the past trajectories of economic development, but neither do they get to wipe the slate clean and launch an entirely new strategy for future development. The most effective strategies for regional resilience rely on their ability to exploit the underlying knowledge bases and research capabilities by using their existing endowment of regional institutions to chart new paths forward. Path dependence will play a critical role in determining the outcomes of this process of urban economic diversification in each instance, but that role will remain contingent; it is framed by the strategic choices being made by a wide range of local actors and the degree to which they succeed in exploiting new areas of market opportunity as an effective basis for regional economic growth and development.

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4 Forms of emergence and the evolution of economic landscapes

Ron Martin and Peter Sunley

> Like alcohol, [the theory of emergence] is a stimulant only in proper doses; many who have used it have gotten drunk in the attempt to apply it to everything.
>
> (Reuben Ablowitz 1939)

> There is a glaring absence of bold social theories which uncompromisingly make 'emergence' their central tenet.
>
> (Margaret Archer 1995)

> The emergent properties of the entirety and the laws for its causal interactions are determined by the spacing and timing of the parts as well as by the properties of the parts themselves. The very essence of evolutionary progress is in the new timing and new spacing of the parts.
>
> (Roger W. Sperry 1986)

Introduction

Over the past two decades, the notion of 'emergence' has attracted increasing attention and controversy across the social sciences (see, for example, Bickhard 2000; Sawyer 2001, 2005; Kim 2006; Clayton and Davies 2006; Lawson 2003, 2010). This current wave of interest in fact marks a resurgence and revival of an earlier literature (for surveys, see Stephan 1992; Sawyer 2005), and particularly the debates on the meaning and significance of 'emergentism' that occurred during the 1920s and 1930s (see Alexander 1920; Morgan 1923; Lovejoy 1926; Pepper 1926; Ablowitz 1939). Two streams of literature appear to be driving this recent 'rediscovery' of emergence. On the one hand, the growth of the theory of complex adaptive systems, with its focus on how complex entities (including socio-economic systems) self-organise and adapt over time, has opened up considerable scope for exploring the part played by processes of 'emergence' in this evolutionary dynamic. On the other, and reflecting the early discussions on the topic, there has been renewed interest in, and debate over, emergentist hypotheses in philosophy, especially concerning the issue of ontology and the problems surrounding reductionism. These two sources of revived interest in emergence are related, inasmuch that each is concerned with how we conceptualise the world around us and how that world changes.

Within this context, as economic geographers, our concern in this chapter is with the usefulness of the idea of emergence for studying the economic landscape and its evolution. During the past few years, economic geographers have begun to explore a wide range of evolutionary ideas, metaphors and analogies in an attempt to assign a central role to history in explaining the formation and reformation of the spatial organisation of economic activity. Although the theoretical and empirical contours of this new paradigm are still unfolding, certain concepts and approaches have already assumed prominence. In particular, most of the work towards the construction of an evolutionary economic geography has drawn on ideas from Generalised Darwinism and path dependence theory (see Boschma and Martin 2007, 2010; Martin and Sunley 2006; Martin 2010). By comparison, evolutionary economic geography has thus far been much less influenced by complexity theory. Yet, as we have pointed out elsewhere (Martin and Sunley 2007), the theory of complex adaptive systems is, potentially, just as rich a source of concepts and metaphors for use in constructing an evolutionary account of the economic landscape as is Generalised Darwinism. Emergence, along with self-organisation and adaptation, is held to be one of the key defining features or characteristics of complex systems. Viewing the economic landscape and its evolution from a complexity-theoretic perspective thus directs our attention explicitly to the questions of what the concept of emergence means in this particular context, and what explanatory leverage it provides.

Writing a decade and a half ago on the idea of the economic landscape as a complex, self-organising system, Paul Krugman (1995) was quite emphatic about the importance and pervasiveness of emergent properties and structures. Examples of emergence, he argued, abound in the economic landscape. From cities, to spatial agglomerations of specialised economic activity, to central place systems, to centre-periphery patterns of economic development; these are all, he contends, the spatio-temporal manifestation of powerful self-organising tendencies driven by emergent properties and mechanisms. In his conceptualisation, the study of the economic landscape as a self-organising complex system is itself a study of emergence. The geographical forms that make up that landscape – cities, industrial districts, clusters, centre-periphery patterns of development, and the like – are not (usually) immanent in the motives of economic agents (firms, workers and consumers), but arise, that is 'emerge', as macro-features in an unplanned way from the myriad interactions of the micro-decisions and behaviours of such agents.[1] In this sense, Krugman sees emergence and self-organisation as central to his and others' work in the so-called 'new economic geography'.

Emergence, therefore, would seem to be one way of explaining how structure and form arises in the economic landscape, and why 'place matters' in processes of economic change and evolution. Contextual combinations of processes in particular places can be said to have emergent effects that produce particular spatial forms which then feedback to shape the operation of those same processes. The argument is undoubtedly intuitively appealing. But, in fact, it masks several questions about what emergence actually means and whether, and in what ways, it can be applied to economic spaces and systems at various scales. Our aim in this chapter is to scrutinise emergence and to examine its potential contribution to the analysis of economic geography.[2] The chapter considers in what sense geographical processes and places can legitimately be described as emergent, how such places themselves produce emergent effects, and how we should conceive of and study the 'emergent' space economy. It should be read as exploratory in nature, and selective in its coverage: our motive is to stimulate further discussion and debate around the potential contribution that an 'emergence perspective' might make to evolutionary economic geography, rather than lay claim to presenting a comprehensive statement. We begin by discussing the different types of emergence that have been identified by writers on this concept, and around which considerable debate exists.

The concept of emergence

As many commentators on emergence stress, the concept is used in diverse ways across diverse disciplines to denote diverse phenomena. This variety raises the question of what these phenomena have in common and whether a general conceptual framework can be formulated that allows a treatment of emergence without explicit reference to a specific underlying mechanism. One way of thinking about emergence is to contrast it with the minimalist claim that 'wholes are nothing but the sum of their parts'. This claim commits minimalists to believing that the properties of a system as a whole are simply fixed by the properties (including the relational properties) of its constituent parts or components: the whole can simply be described in terms of, that is, is reducible to, its lower-level parts. By contrast, the basic idea of emergence is conveyed by the claim that 'wholes are more than the sum of their parts'. More specifically, emergence is a process in which lower-level components of a system interact so as to produce effects (properties, patterns, functions) at higher levels of the system, so that latter are said to be 'supervenient' on the former, but are not simply reducible to those individual components (see Table 4.1). As de Haan (2008) puts it, 'some property or phenomenon is observed that somehow transcends the level of the objects that nevertheless produce it' (p. 293). According to Lawson (2003: 44) a stratum of reality can be said to be emergent, or as possessing emergent powers, if there is a sense in which it, (i) has arisen out of a lower stratum, being formed by principles operative at the lower level; (ii) remains dependent on the lower stratum for its existence; but (iii) contains causal powers of its own which are irreducible to those operating at the lower level and (perhaps) capable of acting back on the lower level.

According to ontological emergentism, such emergent properties or phenomena are real and distinct, and cannot be explicated purely in terms of, simply decomposed into, or reduced to, the properties of the constituent parts or components of the system in question. This conception of emergence is often described as 'strong emergence' because it implies that new classes of processes and properties come into existence at higher levels. It is contrasted with 'weak emergence' that does

Table 4.1 Emergence: key intersecting concepts

Concept	*Features*
Supervenience	Higher-level phenomena, patterns and properties emerge from the organisation and interactions of lower-level component parts, but are not simply the aggregations of those lower-level components and properties.
Irreducibility	A systemic (higher level) property or phenomenon is said to emergent if it is irreducible, that is it cannot be reductively explained in terms of the properties of the system's lower level constituent component parts.
Self-organisation	The spontaneous (non-planned or non-imposed) emergence and dynamic self-reproduction of spatio-temporal patterns, structures or functions in systems arising from the actions and interactions of their lower-level components or elements.
Downward causation	The idea that a higher level emergent property, pattern or phenomenon exerts causal powers over lower level properties and parts, either in those component entities or in their interactions.

not entail the introduction or emergence of new processes or principles which causally influence lower-level components. Further, the notion of emergence is intended to capture the idea that higher level irreducible properties or phenomena are produced spontaneously without the intervention of external modifications or interventions to a system, a feature that is often termed 'self-organisation'. And as Deacon (2006) stresses, throughout most uses of the emergence concept there is the implicit assumption that an effect is manifested at ascending levels of scale.[3] Indeed, scale is of special importance to the problem of emergence because an increase in the numbers of low-level (or micro) components increases iterative interaction possibilities. With every iterated interaction, relational properties are multiplied with respect to each other, so an increase in numbers of elements and chances for interactions increases the relative likelihood and importance of emergent properties and phenomena. Nor do scale effects work only upwards: many discussions and interpretations of emergence invoke the idea of downward causation, whereby an emergent higher-level property, pattern or element exerts causal powers over the lower-level components or elements that produced it.

This latter aspect can be used to distinguish between different types, categories or orders of emergence. Deacon (2006) for example, defines three types of emergent phenomena that can be arranged into a hierarchy of increasing complexity, each growing out of, and dependent on, emergent processes at lower levels: what he terms first-order, second-order and third-order emergence (Table 4.2). First-order emergence is the simplest form. Higher-level properties and forms emerge as amplified forms from – are 'supervenient' on – the interactions and properties of lower-level components, and there may be many different ways that different micro-details of structure and interaction can converge to produce the same higher-order properties ('multiple realizability'), but there are no top-down or downward causal effects that change the nature or properties of the lower-level components themselves.

Table 4.2 Three orders of emergence

Order	*Characteristics*
First order emergence	The most basic class of emergent phenomena. Interaction relationships between system components become amplified to produce aggregate system patterns and behaviours that emerge with ascent in scale. The same aggregate higher order properties can emerge out of different micro-level details of system micro-level composition and interaction, but there is no downward causation from those higher order properties on the micro-level components.
Second order (morphodynamic) emergence	Self-organising emergent structures and phenomena. Micro-level configurational particularities become amplified to determine macro-configurational particularities which in turn further constrain or amplify micro-level patterns and configurations. Specific recursive and recurrent architectures paramount.
Third order (developmental or evolutionary) emergence	Emergent phenomena and systems characterised by 'memory', where an amplification of higher-order influences on parts is combined with a selective sampling of these influences which reintroduces the parts into different realisations of the system over time, imparting both continuity with and divergence from prior states of the system.

Source: after Deacon, 2006.

In systems characterised by second-order emergence, the introduction of downward causal effects imparts an additional dynamic to the upward effects associated with supervenience. There is now cross-scale amplification arising from the concordances of micro- and macro-properties and patterns: the interaction dynamics at lower levels become strongly affected and biased by regularities, processes and constraints emerging at higher-order levels of organisation. Temporality assumes importance in second-order emergence, in that prior stages of emergence of macro-structures influence subsequent stages, and the macro-structural characteristics inherited from past states of the system constrain the future behaviours of its components. The system in this sense exhibits autocatalytic dynamics. So long as sufficient energy and other raw materials are available to keep reactions going (thatis, it must be an open system), this sort of system will continue to be 'autocatalytic'. Further, there is, we might say, a path dependence to this autocatalytic dynamic of second-order emergent phenomena and systems, a self-reinforcing lock-into a particular system architecture of macro-level form and micro-level interactions.

Third-order emergence extends second-order emergence in two important respects: selection processes and memory effects. Whereas second-order emergence is characterised by the emergence of self-organised macro-level morphology arising from the recursive amplifying interactions among the micro-components and between the latter and macro-level forms and properties, in third-order emergence memory and selection effects impart a developmental or evolutionary character to the system. Selection implies that second-order systems are given information that 'instructs' them to form adaptive traits in the context of the system's environment (Goodenough and Deacon 2003). Not all lower-level components need be equally adaptive, so how the macro-structure or system evolves will depend, among other things, on the heterogeneity of responses of the micro-elements. Some lower-level components may not survive at all, and any new ones added will also influence how the macro-level structure or system evolves over time.

In terms of memory, 'constraints derived from specific past higher-order states can get repeatedly re-entered into lower-order dynamics which lead to future states' (Deacon 2006, p. 137). This combination of selection and memory, according to Deacon, renders the temporal evolution of the system unpredictable on the one hand, but on the other hand also historically organised, with an unfolding quasi-directionality, or again what we might call a degree of path dependence. We take up this issue of emergence and path dependence in a little more detail later in the chapter.

Second-order emergence in the spatial economy

Our intention in what follows is to ask whether this identification of three types of emergence in physical and biological systems has implications for understanding emergence in economic geography, and in particular for regional economic development. Can we distinguish analogous forms of emergence in economic landscapes?

We are dubious whether examples of first-order emergence exist in the economic landscape. Or rather that, if they do, they are of relatively little interest. It would imply that the spatial structures of the economy are simple geographical aggregations of economic agents (firms, workers, and so on), and space and place do not matter other than being 'passive' containers within which firms and workers make location decisions. In contrast, a key claim by economic geographers is that space and place matter in a dual sense. The myriad decisions and activities of individual firms, workers, consumers and other economic agents, including their locational choices, shape the spatial organisation of the economy – the formation of cities, industrial clusters and districts, and broader patterns of regional development – and those spatial forms and patterns in turn shape and constrain the behaviours and decisions of the individual firms, workers and consumers of which they are composed. Economic agents produce economic spaces, and the spaces they produce in turn feed back to influence the behaviours and properties of those same agents:

> Spatial form as 'outcome' . . . has emergent powers which can have effects on subsequent events. Spatial form can alter the future course of the very histories that have produced it . . . One way of thinking about all this is to say that the spatial is integral to the production of history. . . . Just as the temporal is to geography.
>
> (Massey 1992: 84)

In other words, if the economic landscape is an emergent feature, it also exerts downward causation on the micro-economic components on which that landscape is supervenient: using Deacon's terminology, if the economic landscape is an emergent system, it would seem that it is of second or third order, not simply of first order.

As we have noted already, Krugman (1996) has provided one of the most lucid, if concise, discussions of spatial economic emergence and so we start with his exposition. Krugman begins with Philip Anderson's definition of complexity as the science of 'emergence': 'That is it is about how large scale interacting ensembles – where the units may be water molecules, neurons, magnetic dipoles, or consumers – exhibit collective behaviour that is very different from anything you might have expected from simply scaling up the behaviour of the individual units' (Krugman 1996: 3). On this basis he suggests that examples of emergence abound in economic theory. Thus, while he did not know it, Adam Smith recognised emergence: when Smith wrote of the way that markets lead their participants 'as if by an invisible hand' to outcomes that nobody intended, what, asks Krugman, was he describing but an emergent property? Turning to economic geography and location theory, Krugman subsequently argues that the classic Von Thünen model of concentric land use patterns around a town can be interpreted as a model of an emergent process. The concentric ring pattern is not intentionally produced by individual farmers and will emerge even if they are unaware of its existence. Yet he also argues that this model, while it incorporates a simple and weak form of emergence, is not self-organising, as the location of the town is assumed a priori and is not created by the endogenous dynamics of the model. In self-organising systems, spatial structure arises not from inherent differences among locations but from the internal logics of the system.

With this in mind, Krugman then goes on to build models of emergent self-organisation in the space economy. He offers several models of edge cities, polycentric metropolitan structures and central place agglomerations, in which the spatial concentration of firms in clusters and cities is created by the interdependent location decisions of businesses and workers. These models are based on a tension between centripetal forces, specifically a positive feedback effect in which the co-location of firms into clusters and other such agglomerations increases firms' access to customers, workers or suppliers, and a centrifugal force in which firms seek to avoid the negative competitive and congestion effects arising from the local presence of other rival firms. Assumptions about the spatial range of centripetal and centrifugal forces prove to be fundamental to the spatial structures that result. A polycentric structure requires that the geographical range or scope of centripetal forces must be shorter than that of the centrifugal forces. In these models any initial distribution of businesses across the landscape will evolve into a pattern in which business centres are roughly evenly spaced. This, he argues, shows a key property of self-organising systems: they tend to move towards highly ordered behaviour which exhibits surprisingly simple spatial regularities. Similarly, Beinhocker's (2006) recent treatise on evolutionary economics likewise argues that complex adaptive systems tend to have 'signature' emergent patterns – such as oscillations, punctuated equilibria and power laws – that are common across many different types of systems and help us better to understand the workings of those systems.

Krugman's models of self-organising emergent urban economies bear a strong family resemblance to the core regional models of the New Economic Geography (NEG), of which he has been the leading proponent. These models are also based on the outcomes of a tension between centrifugal and centripetal forces as they are mediated by the level of transport costs. Once again these models show that individual firms' decisions can produce endogenous dynamics that lead to self-reinforcing regional agglomerations of various kinds and geographical scales (see, for example, Fujita, Krugman and Venables 1999; Fujita and Thisse 2002; Baldwin *et al*. 2003; Combes, Mayer and Thisse 2008). For these reasons, we might also describe the NEG core model as a model of economic emergence. But this, of course, begs the question what type of emergence is represented in these models, and do they help us to understand the significance of emergence in actual regional economies?

The dynamics in these models of spatial economic emergence correspond with some of the characteristics of second-order emergence as perceived by Deacon (2006). The models show a type of recurrent or recursive architecture in which there is an interaction between the firm and its host agglomeration. That is, micro-level particularities, in this case the location decisions of individual firms, are amplified by the decisions of other firms and thereby determine the macro-configurational property, namely the agglomeration of firms in one or more centres. Furthermore, a form of downward causation occurs in these models either through positive increasing returns effects (Marshallian-type external 'economies of localisation' associated with the positive effects of locating near similar firms, such as the attraction of specialised labour and suppliers), on the one hand; and negative diseconomies of agglomeration such as competition with other firms for labour, land and capital which raises the costs of these and other inputs. Thus a temporal dynamic appears as initial micro-decisions influence macro-structures which in turn act to constrain or amplify micro-level interactions and shape future choices. The recognition of such feedbacks on firms opens the door, albeit narrowly, to forms of downward causation. The recursive and self-reinforcing morphogenesis of spatial forms such as cities and clusters depends on the dynamic balance between these different types of downward causation.

However, while these models demonstrate the importance of second-order emergence to regional and urban economies, and indicate some of the underlying economic mechanisms, at the same time they capture only limited forms of second-order emergence. In the first place, the models show that the spacing of firms is important but is this configuration merely aggregative rather than emergent? Aggregative properties are characterised by four conditions (see Sawyer 2005). First, the system property is not a product of the way the system is organised: the component parts are inter-substitutable without affecting the system property. Second, an aggregative property should remain qualitatively similar despite the addition or removal of a part of the system. Third, the composition function of the system remains invariant under processes of decomposition and re-aggregation of parts: there are no threshold effects. And fourth, there are no cooperative or inhibitory interactions among the parts: the relation between parts and whole is linear. Likewise a critical realist reading of emergence insists that emergence is defined by interactions between entities that affect the powers or capabilities and susceptibilities of those entities. Aggregative effects, in contrast, merely affect the conditions under which those powers are exercised and mediated, so that they shape eventual outcomes, but not the capabilities of the actors involved (see Sayer 2010).

On this basis, spatial agglomerations of firms – whether local clusters, industrial districts or cities – and regional economies more generally, are combinations of both aggregative and emergent effects. Firms, for example, are not identical, and not inter-substitutable, even within the same industry. Thus, the composition of an industrial cluster will influence its organisation, and changes in its population of firms will have some impact on the nature of the cluster and its functioning (see Martin and Sunley 2011). Further, changes in the number of firms in a cluster or regional agglomeration may well give rise to threshold effects in terms of the success and performance of the other firms in the cluster or agglomeration, precisely because of the emergence (or disappearance) of system-wide properties or processes. Certain system-wide (cluster-wide or region-wide) properties, processes and patterns – such as external localisation economies – may only emerge once the population of firms in the cluster or agglomeration reaches a certain size (threshold effects); and conversely, if the population of constituent firms falls below a certain size, those same properties (external economies) of clustering or agglomeration may disappear, leading to a vicious circle of further shrinkage and decline in the number of firms there. And, of course firms interact: they may cooperate and collaborate, or they may be able to inhibit, exclude or constrain other firms by means of monopolistic or similar behaviour. Clusters, agglomerations, regional production systems, and cities are not, therefore, simply aggregative phenomena, but emergent systems. In some cases they shape the capabilities of their constituent firms and actors.

But how far do NEG models move beyond the purely aggregative? In one sense, in these models it is simply the aggregation and lumping of (hypothetical) firms together in particular (hypothetical) sites that gives rise to increasing returns effects. The forms of downward causation pictured by these models are also highly restricted largely because the models incorporate a high degree of suspicion about non-pecuniary externalities and doubts about non-reductive, non-individualist forms of explanation – they are based on rather orthodox assumptions (profit maximising firms, perfect mobility of labour and capital, market clearing, iceberg transports costs, identical consumer tastes, and the like). In the large part, they deal only with pecuniary externalities that affect the costs of operation in a location. Further, these pecuniary externalities are envisaged as exerting a one-off influence on a firm's location decision, and the models have little else to say about the character of the firms, which in effect are treated in a black-box fashion. Thus these formal models of spatial economic emergence do not incorporate other forms of local and regional spillovers, such as learning effects, or networks and collective institutions, which may have a profound influence on the development of a firm. As Krugman (1996) himself notes, one of the key aims of this type of model is to identify ‘surprising and unpredictable’ emergent effects where individual agents do not intend to produce the outcomes, so that the emergence and role of deliberative and purposive actions by firms to create regional networks, share information and build synergies are also ruled out. There is little sense in these types of models that *relational* emergence may be fundamental to the capabilities of economic agents and that the locational configuration of those actually enables them to do things that would otherwise be impossible.

Fundamentally, therefore, while these models can be argued to resemble Deacon’s second-order type of emergence, the range of possible downward-causation effects associated with emergent spatial forms such clusters and agglomerations is a restricted one. And the models certainly do not capture the more complex dynamics of third order or evolutionary emergence.

Thus in these models there is no sense of selection and memory so that past development does not affect the development of local and regional economies. Admittedly these models claim to show that history is important in the sense that individual decisions can be amplified through autocatalytic reactions, but this is only one thread within the broader tapestry of real economic history. And while NEG theorists argue their models incorporate ‘history’, the latter is simply logical in nature: that is, which equilibrium economic landscape emerges from the self-reinforcing ‘dynamics’ in the model depends on the model’s ‘initial conditions’ (for a critique of the conceptions of both ‘geography’ and ‘history’ in NEG models see Martin 1999; Garretsen and Martin 2010; Martin 2011). Deacon (2006) argues third-order emergent systems can reintroduce influences over extensive historical and spatial scales so that a macro-regularity or even a micro-level effect may prove to have an unpredictable consequence for the trajectory of a particular system. While this provides a potentially more realistic perspective on how regional and local economies develop, it is very difficult to incorporate into formal mathematical spatial models and it is not surprising therefore that NEG has not approached this type of emergence. If we are to understand third-level evolutionary emergence, therefore, we might expect to find more appropriate theoretical tools in evolutionary economics and Generalised Darwinism. In the next section, therefore, we consider the degree to which evolutionary perspectives in economics and economic geography recognise and explain third-level emergence.

Evolutionary emergence and regional economies

If the increasing returns economics found in NEG models are able only to give rise to second-order emergence, then we might expect evolutionary economics to provide a basis for conceptualising third-order type of emergence in spatial economic systems. However, while evolutionary economists express strong agreement with the notion, (for example, see Dopfer and Potts 2004), evolutionary economics has lacked a substantive theory of emergence. Dopfer and Potts (2008), for example, illustrate this sense of unfulfilled promise. They offer a realist theory of economic evolution based on the role of cognitive, behavioural, technical and social rules that govern economic activity. Rules originate at a micro-level in human imagination and intention and are adopted by populations of carriers (individuals and firms). The adoption and combinations of rules creates clusters of rules at a meso-level, while macro-level analysis pertains to the co-ordination and coherence of these rule-sets. Dopfer and Potts (2008) argue that firms, organisations and meso-level entities, such as industries and regions, have emergent powers, precisely because of the ways in which they combine rules, but they say little about what these emergent powers mean or how downward causation operates. Indeed, for the most part their account is dominated by upward causation: 'Economic growth is what happens when a new idea that has been successfully trailed, adapted and embedded is able to provide the basis of an operational expansion of activities. Economic evolution is the ongoing supply of such generic opportunities' (ibid, p. 91). Their approach tracks rules through ascending scales: 'Economic systems evolve as a new idea becomes a micro, meso, and then macro trajectory' (ibid, p. 93). However, while they note that some rules allow the creation of other rules, there is little in their account how context and the form of relationships allow, bias and constrain the appearance of new rules.[4]

Partly as a result of this lack of explicit development of evolutionary emergence, evolutionary economic geography has not engaged with emergence in a sustained way. While emergence is argued to be a key focus of evolutionary economic geography (see for example Boschma and Martin 2007), the explanation of where and how emergence works has been fairly limited. It is typically used in a diachronic sense to mean the appearance of innovations and novelty. However, in some accounts, the term emergence is used simply to mean the appearance of novelty rather than to refer to any recursive interactions between micro- and macro-level phenomena. In such discussions, emergence tends to be conflated with the Darwinian principle of variation. Evolutionary economic geography has been primarily based on Generalised Darwinism and in this perspective all evolutionary processes consist of the operation of three principles: variation, selection, and retention or inheritance (usually after Nelson and Winter 1982). Thus it is argued that variation occurs as firms and individuals innovate and produce new products and routines; these are then 'selected' by competitive pressures and those that help firms to be more profitable and/or adaptable are retained and diffused (Esslëtzbichler and Rigby 2007). Furthermore, it is typically argued that successful routines are passed on by firms to their 'offspring' through the formation of spin-offs (see Boschma and Frenken 2006). In an analogous fashion to Deacon's third-order emergence, selection operates in these accounts to constrain lower-level systems by subjecting them to 'instructions' to show adaptive traits in order to survive. However, while third-order emergence reinforces the value of an evolutionary perspective it also implies that the understanding of how evolution works in the economic landscape needs to be revised.

In the process of third-order emergence, feedbacks between variables are not simply the products of accidental initial conditions but are also subject to processes of selection and memory. As Goodenough and Deacon write, 'The larger point, then, is that third-order systems, by being remembered/selected and not simply the episodic outcome of unspecified initial and boundary conditions, have the all-important property that they are subject to constructive influence'. In this view emergent cycles produce traits in behaviour, and those traits that aid adaptation to the environment are selected, represented and remembered. In this way there is an essential interdependence between self-organising and evolutionary processes. In Deacon's account the outcomes of self-organisation can feedback on their underlying resources via selection pressures.[5]

Consider the case, for example, of a business cluster, a strong candidate for the sort of third-order emergence proposed by Deacon, and a spatial form of key interest to economic geographers (see Figure 4.1). As defined by the originator of the notion, Michael Porter, clusters are 'geographical concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also cooperate' (Porter 1998: 197). Though not without problems in terms of their conceptualisation and empirical identification (see Martin and Sunley 2003), with some notable exceptions, clusters can be viewed as self-organising systems arising from the uncoordinated agglomeration of similar and related firms, workers and institutions in particular localities. Once a particular industrial/technological specialism begins to take root in a locality, and a process of clustering develops, this is believed to lead to, and be reinforced by, the emergence of localised externalities of various kinds – for example, a specialised labour market, and knowledge networks – that are sources of competitive advantage to the firms in the cluster. The more successful those firms, the more attractive the cluster becomes to other similar firms and workers. The emergence of the cluster is thus an evolutionary process: the cluster emerges as a result of the co-location of related and similar firms whose properties shape the nature of the cluster of which they are the micro-elements: in this sense the cluster is a feature or system that is supervenient on its firms. Properties of the firms become represented in the cluster. But the externalities that arise because of the clustering process then exert a 'downward' causal influence on the operation and dynamics of the firms concerned: that is cluster level properties then shape firm properties. The recursive nature of this process involves the two key features that Deacon suggests define third-order emergent systems, namely memory, or path dependence, and selection.

Memory, or path dependence, effects occur through several mechanisms and across scales (firm, cluster, and external environment). Firm properties shape cluster properties, which, in turn, shape subsequent firm properties. At the same time, the firms themselves carry over routines, practices, products and methods from one period to the next, whilst also embodying learning effects and knowledge spillovers arising from interactions with other firms in the cluster. And to the extent that the cluster firms compete or collaborate with networks of similar firms in other clusters, or embody knowledge from such competing or collaborating firms, the cluster influences its external 'environment', which in its turn feeds back to influence local cluster firm behaviour. Further, these processes will impact

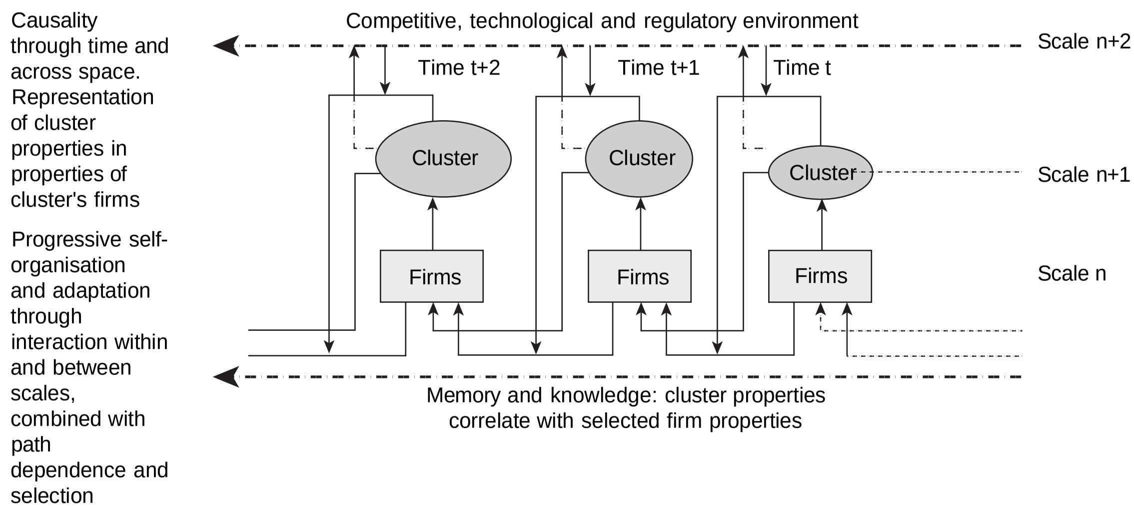

Figure 4.1 Stylised schematic of the emergent evolution of a local business cluster

Source: An adaption of Deacon's (2006) model of third-order emergence to the case of a cluster.

differently on different firms in the cluster such that selection effects will occur, and the population of cluster firms will change as some cease to compete and disappear, and others are created. In many ways, then, clusters would seem to embody the processes and traits that Deacon marks out as distinguishing third-order evolutionary emergence.

However, the centrality of traits and interactions between emergents at different scales – such as in clusters – raises an important set of questions for evolutionary economic approaches. First, this view of emergence implies that accounts of regional economic evolution that reduce the causes of change to one fundamental factor, such as rules of behaviour and routines, technological maturity, or knowledge networks, are unlikely to provide a wholly convincing account of how change occurs. Evolution is much more complex, multilevel and circuitous than a simple focus on the reproduction of economic routines implies. Instead, third-order emergence suggests that selection does not just operate on components but also on the emergent units produced by relational patterns. Thus, for example, a firm may prove economically adaptive and successful even if it includes some inefficient routines, as these may be offset by the positive interactions within the firm that aid learning and the accumulation of knowledge. As with social structure (see Elder-Vass 2010), the causal powers of an entity can arise from the relational organisation of its parts. Similarly, emergent outcomes at the level of, say, a cluster, for example, through high labour mobility, may overwhelm the negative effects of the presence of some inefficient and non-adaptive firms. Thus, it would seem that we have to take seriously the idea that organisational and relational patterns at different scales determine the ability of economic agents to respond to changes in the economic environment. It seems doubtful that such relational architectures can be condensed into an account of underlying economic routines and habituated behaviour. While routines can of course be relational and used to describe relationships between agents, they nevertheless lead towards a fairly reductionist and predictable understanding of what makes some firms successful. In fact, the outcomes of any routine economic behaviour may vary strongly depending on the context in which it is practised, and it may well be a combination and organisation of routines which produces an adaptive learning firm rather than a single set of routines inherited from a parent firm. This suggests that we need to know how relational interactions at different scales shape the adaptability of economic agents and whether there are traits in these patterns that support learning and the absorption of knowledge.

Second, third-order emergence implies that not only do emergent entities become objects of selection but that they also act as influences that constrain and bias what happens at smaller spatial scales. The contexts produced by self-organisation may create niches that shape how selection operates. Thus it suggests that the second-order emergent effects produced by various types of localised increasing returns will not only act to affect prices, wages and levels of costs but also shape and bias the selection of products and firms within those contexts. Emergence imparts a direction to the form of change. Thus selection might include both the development of specialised knowledge networks that shape the construction of particular innovations, as well as the creation of market niches and heightened demand for particular products. Third-order emergence is analogous to many situations in which markets are built through the construction of personal relationships and contacts. Competitive market selection often depends on the form of relationships, density and configuration of consumers and rival firms. We know, for example, that some regional contexts ('milieux') are much more conducive than others to the creation of new firms and start-ups. From an emergence perspective it might be expected that relational patterns that exist within a region are more supportive of the amplifying feedbacks surrounding the start-up of a company. Thus a set of regularities that has emerged between actors may be conducive to innovation in new sectors. Regional cultural contexts and shared practices shape individual cognition and decisions so that situated decision making reflects the context in which it occurs (Storper 2009).

Third, the concept of third-order emergence also implies that these relationships between regularities and micro-events and particularities will not always be easy to trace because of the degree of memory in practices and because of recursive interactions between phenomena at different scales. The circular relationships between emergent entities involve the reintroduction or 'sampling' of past regularities. The constraints and biases which shape the path of change in such a system are not only those in the immediate prior state. Instead, older elements and traces of emergent systems may be reintroduced over considerable time periods: path dependence may not always be straightforwardly sequential and predictable (Martin 2010). There are clearly analogies in regional economic change where elements from the history of particular regions enable and shape the ways in which they evolve. The trace of an older regularity may be re-entered into a self-amplifying cycle so that this provides an unexpected direction of change.

In fact, the relationship between emergence and path dependence is an issue that requires elaboration, not least because for evolutionary economic geographers, path dependence is held to be a fundamental feature shaping the evolution of the economic landscape: the spatial economy is a system whose outcome evolves as a consequence of its own history (Boschma and Frenken 2006; Martin and Sunley 2006; Martin 2010). Many of the basic mechanisms that make for path dependence in the economy – various forms of self-reinforcing increasing returns and external and network economies – have a quintessentially local dimension in their form and operation. In this way, path dependence can be seen as a process or effect that is locally contingent and locally emergent. Path dependence and the spatial form of the economic landscape are mutually constitutive: the emergence of clusters, industrial districts, regional industrial complexes, cities, and the like are both the outcome and the source of path dependence.

Path dependence, therefore, can itself be viewed as an emergent property of the economic landscape, whilst at the same time acting as a key mechanism by which the characteristic spatial forms of that landscape themselves emerge. Path dependence imparts 'memory' to the evolution of the space economy. The issue, however, is how 'strong' that memory is. Most discussions of path dependence – both in economic geography, and more generally across the social sciences – adopt

Paul David's (1985; also 2005, 2007) canonical model of path dependence as 'lock-in of outcomes by remote historical events', the idea that small, historically contingent 'accidents' or micro-level 'chance events' can have long-run effects on the future path of economic technologies, organisations and institutions, and hence on spatial economic structures. This view of path dependence actually leaves little scope for ongoing change and adaptation, and instead emphasises continuity – 'more of the same' and convergence to equilibrium (stasis) (Martin 2010). It would also seem to be close to the way in which Deacon (2006) discusses the role of memory in third-order evolutionary emergence, namely that:

> specific historical moments – either of higher-order regularity or of unique micro-causal configurations – can additionally exert a cumulative influence over the entire causal future of the system. In other words, thanks to memory, constraints derived from specific past higher-order states can get repeatedly re-entered into the lower-order dynamics which lead to future states. . . . Moreover, because there is a remembered trace of each prior 'self' state contributing to the dynamics of future states, such systems develop not merely with respect to the immediately prior state of the whole, but also with respect to their own remembered past states.
>
> (Deacon 2006: 137)

As in the case of the 'lock-in' interpretation of path dependence, the argument seems to be that a particular historical event establishes a path or pattern of emergent development which then becomes autocatalytic and cumulative. The view of 'memory' invoked here thus appears to be close to the 'strong history' or 'lock-in' interpretation of path dependence, whereby a remote historical event effectively 'selects' which of several possible multiple equilibria a system converges to over time: the eventual state of a system is conditioned not just by its immediately prior state, but the entire historical sequence of prior states (see also Setterfield 2010).

Now it is certainly true that the economic landscape is characterised by a significant degree of 'quasi-fixity': cities, clusters, industrial districts and the like, once established do not disappear overnight, but exhibit continuity: there is 'memory' or path dependence in the system. But, at the same time, we know that clusters and industrial districts do eventually decline and even disappear. And we also know that the economic landscape is also characterised by pervasive incremental mutation and adaptation. There is continuity but also constant change. Thus while there may 'a remembered trace of each prior "self" state contributing to the dynamics of future states', each 'self' state is also changed in ways which may give rise to departures from, or alter, the directional bias inherited from the past. Evolution occurs though two basic mechanisms: the additional of new (micro-level) entities with characteristics and properties that differ from those of the existing entities in the system; and changes in the properties of those existing entities (Endler and McLellan 1988). Further, these population dynamics involve selection processes. As a result, a system can exhibit memory or path dependence but also adaptation and continual evolution; and that adaptation will itself be path dependent.

These twin processes can be observed in cities, clusters, industrial agglomerations and the like. Such spatial forms consist of constantly changing populations of firms and agents, so that some degree of incremental change and adaptation is almost always present. In the cluster example outlined briefly above, for example, changes in the population of firms that make up the cluster – the appearance of new firms, the disappearance of others, and the product, market and technological re-orientation of still others – alter the composition of the cluster as a whole, and hence its higher-level properties and the nature of the 'downward causation' effects from the cluster back on the firms on which it is supervenient. This ongoing process involves memory, and is path dependent; but it need not involve any 'lock-in' to an equilibrium state or form (Martin 2010).

To our mind, there is a difference – possibly a fundamental difference – between the sort of path dependence implied by second-order emergence, essentially that of 'lock-in', and that implied by third-order evolutionary emergence, which allows for ongoing adaptation and mutation. Deacon's own discussion of memory effects – as indicated above – is somewhat unclear as to this difference. But in a spatial economic context, the difference is crucial. If processes of selection, heterogeneity, more or less continual mutation in the population of micro-level components – in our case, firms, workers, institutions and other economic agents – as well as learning, innovation and knowledge exchange amongst those components are allowed for, all of which are basic to how the economy works, then third-order emergence would be inconsistent with a 'lock-in' model of path dependence. Emergence in the economic landscape is a process in continual motion, of constant formation and reformation, not simply one of cumulative convergence to one (of several possible) historically selected equilibrium states.

While third-order emergence appears to provide a much more complex and circular view of how economic evolution may operates, we need to bear in mind that there are also important limits to the analogy between biological third-order emergence and emergence in economic systems. It is important to appreciate that in social and economic systems, emergence typically arises from relationships between individuals (Lawson 2010; Sayer 2010), and relationships are undoubtedly fundamental to many economic capabilities. In addition, social emergence is much more reflexive: agents are aware of the contexts in which they operate and continually modify their behaviour as a consequence. This suggests that economic emergence will be essentially knowledge based and that we should be especially concerned with processes that amplify and then sample past knowledge in particular locations. In some ways, third-order emergence, with its focus on semiotic systems and information from the past, looks highly relevant.

However, in another way Deacon's representation of emergence is itself too narrow and specific a framework to illuminate the many ways in which knowledge changes in economic activity. In particular, as we have seen, this theoretical approach to emergence rests on the importance of self-organisation in which non-intentional micro-interactions are often self-amplifying and have larger scale consequences. While this has some resonance with the emergence of cities and regions, it fails to recognise the ways in which inter-firm relationships and local business networks are often deliberate, intentional, and purposive constructions. While social organisations, such as firms, undoubtedly exercise types of downward causation in which they cause certain actions and practices, it is less than convincing to say that a firm is a self-organising entity created by inadvertent and non-intentional behaviour. Even in the case of local clusters and networks of firms many decisions are influenced by a reflexive awareness of how individual decisions will be reciprocated or how they will impact on particular interests and groups. In one sense then, economic emergence departs significantly from Deacon's perspective on biological emergence: his conception understandably prioritises vertical self-organising spirals, but does not explain how relational emergence operates across scales. The small-scale raw material of economic emergence is profoundly different in that it does not start with a simple first-order emergence, but it is in one sense even more complicated from the outset.

Conclusions

The appreciation of emergence in economic geography is quite paradoxical. On the one hand we have seen that emergence is often invoked or rather implied as a key principle underlying the formation and consequences of spatial patterns in the economy. A range of authors from different theoretical schools in economic geography are agreed that emergence needs to be taken seriously. On the other hand, we have seen that despite this, there is a striking shortage of research that tries to examine how and why emergence operates, and what sort of processes are involved. There are several reasons for this. In the first place, it is clear that while there is consensus about the core meanings of emergence there is little agreement about many of its implications, consequences and forms. It is easy to get lost in the philosophical thickets surrounding the concept of emergence. Second, emergence is frequently offered as a critique of reductionism, but many accounts do not move beyond this. Thus it often appears that the notion of emergence is simply another way of highlighting the presence of processes that are already known. Third, we have tried to show that the broad concept of emergence is in effect an umbrella term for a related but diverse set of processes. In order to start to explain and make sense of this diversity we have followed Deacon (2006) and distinguished between second- and third-order emergence. In doing so we have tried to argue that economic geographers need to move beyond a focus on second-order emergence, based on autocatalytic localisation and agglomeration processes, and should instead engage with an evolutionary concept of economic emergence. Second-order processes are undoubtedly important, but do not provide an adequate conceptualisation of temporal emergence in economic landscapes.

The concept of third-order emergence is important as it implies that evolutionary economic geography requires a less reductionist understanding of how economic evolution operates. While there have been recent developments in evolutionary economic geography that pay more attention to the co-evolution of firms, institutions and their spatial contexts (see some of the contributions to Boschma and Martin 2010, for example), evolutionary approaches have remained too infused by reductionism to adequately incorporate the significance of emergence. The value of third-order emergence may well be that it emphasises that we need a more interactive and multi-scale understanding of how economic evolution operates. At the same time, however, we have concluded that the biological origins of third-order emergence mean that it requires further elaboration within a socio-economic context to provide much insight into what has been called relational emergence. Emergence in economic evolution is far more relationship-driven than is suggested by many theories based solely on self-organisation. Currently, the greatest gap in our understanding of emergence in economic landscapes is our limited understanding of relational emergence. Indeed if an 'emergence perspective' in studying economic landscapes is to be taken forward and given more empirical content, then the detailed processes that give rise to relational emergence through time will need to be the key focus of research.

Notes

1 Arguably, Schelling's classic book *Micromotives and Macrobehaviour* (1978) is one of the most compelling accounts of how the economy can be conceptualised and analysed in terms of emergence. Krugman (1996) himself expresses his admiration for Schelling's work.

2 The paper can be regarded as a part of our ongoing exploration of different approaches to evolutionary economic geography. Other, earlier, contributions to this dramaturgy include our discussion of path dependence in regional economic evolution (Martin and Sunley 2006; Martin and Sunley 2010; Martin 2010), our examination of the scope and limits of complexity thinking as a basis for conceptualising the evolution of the economic landscape (Martin and Sunley, 2007), and our investigation of adaptive cycle ideas from panarchy and socio-ecology for the study of cluster evolution (Simmie and Martin 2010; Martin and Sunley 2011).

3 To our mind, Deacon provides one of the clearest and most suggestive discussions of emergence (albeit in biological and physical systems), and in what follows we draw mainly from his work.

4 The limitation appears similar to those evolutionary accounts that prioritise natural selection and provide only a weak account of how higher-order systemic processes constrain and bias the patterns of variations presented to the selection processes (Weber and Deacon 2000; Deacon 2003): "The challenge is in explaining how (other than by exceedingly unlikely accident) the higher-order dynamics of the ensembles came to regulate the dynamics of components' interactions" (Weber and Deacon 2000: 9–10).

5 In particular, Deacon's (1997) research on the evolution of human consciousness argues that the emergence of symbolic communication created a niche which altered the natural selection pressures shaping the development of cognition, so that language and the brain co-evolved.

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5 Strange attractors and policy emergence

Complex adaptive innovation

Philip Cooke

> By its nature, the metropolis provides what otherwise could be given only by travelling; namely, the strange.
>
> (Jane Jacobs, 1961, 238)

Introduction

This chapter builds on arguments developed in Cooke (2012) to the effect that, hitherto, policy making in general and innovation support policies in particular have been hamstrung by a vertical, linear narrative of what is to count as the 'policy field', a specialisationist perspective on the relevance of intervention, and a conservative posture on standard practice for proceeding with policy formulation. A condensation of the last part of the problem is presented in the 'Stacey Matrix' (Stacey 2002) which appears on p. 108. This represents 'close to certainty' and 'close to agreement' policy making as found in typical rational decision- making, classical project management and organisational development. Stacey contrasts this with a more innovative policy stance involving 'co-creating' methods that speak to enhanced management of knowledge resources, the use of creative energies and resources of passion and sense of responsibility ('taking ownership') found in 'appreciative inquiry' and 'open space' meetings. The latter are often found in 'design theory' exercises (Lester and Piore 2004; Martin 2009). These are particularly effective when a large, complex operation needs to be thoroughly reconceptualised and reorganised – when the task is too complex to be sorted out 'from the top'. This takes the decision process close to what complexity theorists call the 'edge of chaos'. But to find underlying order and avoid stakeholder disintegration requires the search and discovery of deeper than usual patterns and structures upon which action may be inscribed. This includes structures that are both broader and more nested in system hierarchies than prevail in traditional problem analysis. It will be shown in the third and penultimate sections of the chapter how the theory of 'emergence' comes to bear on this approach in both conceptual and practical terms, the latter based on primary research and empirics reported in the second half of the chapter.

However, while critique of the 'incrementalist' aspects of the conventional policy model has existed for many years (for example, Simon 1955; March 1978), the first two problems – linearity and specialisationism – have less so. Accordingly, space is devoted in the next section to a conceptual analysis of the key problems with the linear model. This prefaces a section that concludes that to conduct 'co-creative' policy requires that policy makers have a profound understanding of the processes – in this case primarily economic-geographic and creative-innovative – that underpin regional economic development. Both the regional *paradigm*, which is the particular combination of economic development trajectories found in the region, and the regional *regime* or the set of formal and informal organisations, institutions and conventions that influence policy, come into play in this regional system analysis. Since *innovation* is the engine of economic change (Schumpeter, 1934) understanding of pathways and obstacles to this is seen as imperative to regional economic development and policy. The chapter thus proceeds as follows. It begins with a comparison and contrast of vertical and horizontal conceptions of regional innovation processes as they affect linear and nonlinear approaches to analysis and policy. There follows a discussion of the virtues of a complex co-evolutionary framing of the regional economic development process for nonlinear regional innovation policy formulation, drawing on appropriate illustrative material. Finally, accounts are given of various transversal policy instruments by which innovation policy, including 'emergent' policy making have ensued in real world settings in Europe and Asia. There is then a brief concluding section.

At the crossroads: ontologies of reduction and diversity

Ontologies are ways of understanding the nature of *existence* while epistemologies concern the nature of *knowledge*. An interesting exemplification of this distinction of relevance to the interest of this chapter concerns the Bateson–Maturana debate in cybernetics, especially the 'concept of mind', that is, what is the mind? Gregory Bateson developed a theory of the mind as a biological version of a computer. Thus he conceived it as an aggregate of interacting parts that were triggered by 'difference' – which is likely to have been influenced by Claude Shannon's theory of *information*. The latter, somewhat reductively, eradicated 'meaning' from the definition of information. Although this appears massively to de-socialise the concept, four elements of interest remain: first, *uncertainty*, in the sense that the content of any particular message cannot be forecast; second, uncertainty means that information contains the unexpected, causing *surprise*. Third, it is complex and *difficult* to transmit and receive unproblematically; and fourth, it degrades and depletes over time, displaying *entropy*, as does everything else in the universe according to the second law of thermodynamics. For Bateson 'All receipt of information is necessarily the receipt of news of *difference* . . . ' (Bateson, 1979). In other words, it is received as an objective feature of the world (analogically, binary inputs to the computer). Next, the mind is stimulated by a receipt of energy which – and this is a separate point – works in complex but determinate (cause-and-effect ways). Fifth, the world is external and objective, being encoded by mind into an inner 'reality'. Finally, communication is via encoded and decoded receipt of messages and meta-messages or ways to encode and decode ('operating system' and 'software'). Maturana (for example, Maturana and Varela 1980) agreed with some, earlier parts of this schema but departed from the more physico-computational narrative on which it was irremediably based. Fundamentally, he rejected the 'mind as computer' metaphor that Bateson promoted so assiduously. Of course Bateson was not alone in this, as the largely disappointing results of a generation's research on artificial intelligence, which once also attracted evolutionary theorist Herbert Simon, testifies. A social scientific explanation of this is cited in Capra (1997):

> Bateson concentrated exclusively on epistemology (the nature of knowledge) at the expense of dealing with ontology (the nature of existence): 'Ontology is 'the road not taken' in Bateson's thinking . . . Bateson's epistemology has no ontology on which to found itself [but] Maturana's work contains the ontology that Bateson never developed'.
>
> (Dell 1985, cited in Capra 1997: 266)

This is an exemplary instance of the inappropriate application of a mechanical model to processes innate to living organisms. The physico-chemical and physico-computational epistemology owes its success in other fields to its reductionism, notably that atoms and molecules lie at the bottom of organic as well as inorganic matter, according to which biological explanation can be reduced to physico-chemical laws. For Maturana, a living system involves interaction and a relational 'knowing' involving bringing forth or creating the living world. Three key processes are entailed: first, this involves interaction patterns among agents and the physical world; such agents activate their agency through networks. System change and survivability is intimately dependent on the related variety ('richness') its networks display. Second, this enables living systems to 'self-organise' or to innovate, rather than simply produce and reproduce, involving change through development, learning and evolution that constitute the creation of novelty in system elements and trajectory. Finally, self-organisation is characterised by nonlinear relations between system entities represented by positive and negative feedback loops that respectively de-stabilise and re-stabilise both system elements and whole systems.

Thus evolutionary biology is clearly a more suitable ontology of living systems, including the socio-technical and regional innovation systems that are the subject of this chapter, than physico-chemical or physico-computational reductionism of the kind expressed in the 'mind as computer' epistemology that represents the core narrative of cybernetics and artificial intelligence. But this judgement has implications, some of which are ontologically and epistemologically de-stabilising even for evolutionary economic geographers let alone non-evolutionary social scientists. The prime one of these is that we cannot predict. At a commonsense level this is merely the Popperian scepticism to the effect that there can be no 'verification of truth' only 'falsification of truth claims' as the foundations of knowledge. But that remains a negative and fragile criterion for what is to count as truth, not least because it is unclear what rule measures what counts as 'falsification'. At an even more mundane level, it can be claimed that prediction is possible, albeit in a general rather than a specific way. Thus 'economies of scale,' whereby repeated production of a known good with proven means of mechanical reproduction (Benjamin 1973), can be relied upon to lower its cost of production – is predictable as a general rule of thumb. But is it any more than a highly constrained parametric relationship operative only under equilibrium conditions, that is, constant or declining costs of inputs? More importantly, is it a predictable guide to market success? By no means obviously, whether in relation to 'economies of scope' or, especially, non-price competition. At the far from mundane levels of international currency exchange, risk capital or stock market movements in economics or regime change in international politics, 'prediction' is either based on extrapolation models that become dangerously prone to debilitating positive feedback or what, with some irony, engineers call 'gain' effects when events outside model parameters occur, or no prediction at all (Davidow 2011). Indeed, Davidow more than once notes the observation of accident theorist Charles Perrow (1999) to the effect that, in highly complex and tightly networked systems, accidents are normal and unavoidable. Adding controls or safeguards will most likely exacerbate accident conditions. The Three Mile Island nuclear reactor 'chaos-event' began with a cup-size water leak. This, in turn, led to a control system malfunction causing the reactor core to overheat. Operator panic led to the reserve cooling system being shut down which caused valve failure and the loss of further coolant. By now klaxons were blaring and some sixteen-hundred warning lights flashing. Each standard operator action contributed to further loss of coolant. Meltdown was averted by overriding standard operating procedure and replenishing the plant's cooling system. Davidow (2011: 189–90) draws the parallel between Three Mile Island and the 2008 financial crisis, where multiple interacting failures caused mortgage, institutional and credit defaults to amplify demand for even more of the same reckless sub-prime inputs to keep the securitisation bubble expanding, resulting in massive system failures at the corporate and sovereign levels of indebtedness. According to Lewis (2010) even those who benefited by 'shorting' the market didn't *predict* such a state of affairs, merely taking out insurance against occurrence of the event in question.

The second implication of an evolutionary biology ontology, which is plainly more appropriate to analysing living systems than the current alternatives, is that if we cannot predict *ex ante* we cannot explain *ex ante* only *ex post*. This seems to undermine the rationale for human and social agency, relegating the mind to that of 'sweeper up' after the fact. But even this is more difficult than it seems, one of the reasons why engineering complexity theorists, untutored in historical or social scientific methods often fall back on 'chance explanations'. Linear epistemology presumes, perhaps partly under a suffocatingly narrow interpretation of Simon's (1955) insight into 'bounded rationality', that 'planning' is impossible. Neoliberal ideology asserted that markets operating as 'self-organising' systems ('the market knows best') compensate for human frailty by incentivising human agency to exploit 'market inefficiencies' in ways that produce benign effects (Fama 1970). We learn from these failures that, sadly, nearly two hundred years of social science was informed by the wrong epistemology and a feeble ontology. The task for the future is to develop a superior understanding of the operations of living systems and a suitable methodology for overcoming the absurdities that accompanied our delusional 'framing' of ourselves as social physicists and social engineers.

Strange attractors: complexity, relatedness and regional innovation

Despite the unsatisfactory nature of such complexity theorists as Arthur's (1994) earlier reliance upon 'chance events' to account for innovations, his more recent work shuns randomness in recognition of the usually researchable paper-trails that occur in what he terms the 'combinative evolution' of (technological, engineering) innovation (Arthur 2009). However, this has the effect of bringing him more into line with evolutionary economic geography than moving the debate forward a great deal.

The first important 'reframing' thing to do is to lower the 'gain' on the accompanying vertical and linear 'framing' of socio-economic life and institutions (otherwise our prevailing 'silo' mentality or ontology and epistemology) and substantially increase the 'gain' on a more horizontal, relational and nonlinear 'framing' of socio-economic life. This is particularly appropriate to a perspective upon systemic innovation, the founding father of which, Joseph Schumpeter (1934) noticed with great clarity that innovation occurred through the recombination of knowledge, often already existing knowledge. Recombinant knowledge supports lateral thinking and a relational or interactive model of change (Mead 1934; see also Balland, Boschma and Frenken's chapter in this volume; also Frenken 2006). Cross-pollination of knowledge at industry or activity interfaces lies at the heart of a grander process of path interdependence. Both evolutionary economic theory and complexity theory agree that the sources of novelty in socio-economic life occur at these knowledge intersections. It is here that what complexity scientists call 'attractors' in complex adaptive systems meet. In a remarkably geographic or spatially informed discourse, authors like Kauffman (2008) write of attraction between 'clusters' (here meaning points of energy) in complex adaptive systems occurring in 'basins' that exist in a 'fitness landscape' that may be rugged or smooth. In the smoother fitness landscapes path dependent entities (for example, industries) are not abundant and the system is stable and un-innovative, although where it is not quite in this torpid state normal attraction between or among 'clusters' that are sectorally as well as geographically neighbouring (for example, agriculture and food processing) will occur and may entail innovation. By contrast, in more rugged fitness landscapes with steeper slopes, path interdependence may occur for two different reasons. First, ruggedness denotes greater abundance of energy points or 'clusters' meaning there is a greater chance of, albeit system de-stabilising innovation at interfaces. Second, it denotes a greater energy and even 'lawlessness' by means of which 'strange attractor' path dependences may converge. It is the 'strange attractor' convergences that are the most fruitful for recombinant knowledge exchange, which means such landscapes have, accordingly, more innovation potential. Finally, development in such landscapes, with more abundant cluster opportunities, allows exponential growth of novelty or innovation from a more complex living system or ‘economic web’.

The final element of the theoretical design of a complex evolutionary economic geography of regional development is the related concept of ‘emergence’. This subject is tackled in the accompanying chapter by Martin and Sunley (this volume) but here we propose to stress the horizontal rather than the more familiar and classically ‘vertical’ framing of ‘emergence’. Think of inorganic chemistry’s ‘model’ of the composition of matter for a single moment, temporarily overlooking the earlier judgement that it is an inappropriate discourse for regional evolution. It states that the power to form compounds is forced upon the lowest molecular or atomic levels by the superior content of the upper, more complex levels in what can look very much like a three-level governance or ‘resilience’ (Folke 2006) model of vertical system integration. Think next of a sponge-cake, occupying the uppermost level of complexity, human utility and chemical refinement, overlooking for the moment its worryingly high calorific and associated embodied energy content. Two of its ingredients, at the meso-level of physico-chemistry are sugar and flour, another is water. This level experiences value-added from its specific recombination synergies (for example, sugar’s taste and energy properties; flour, different taste and culinary properties). At the lowest atomic level in this elegant confection (the conceptual model, not the cake) lie atoms of carbon, hydrogen and oxygen. Some of these recombine (Schumpeter-style) to become sugar, others for reasons that are not entirely clear ‘decide’ to form flour from the self-same carbon, hydrogen and oxygen atoms. Yet others ‘decide’ to form water, carbon dropping out of this particular recombination, being replaced by two hydrogen atoms. This is chemistry’s curious and intriguing narrative of the composition of basically everything. Of course we can see human agency being involved at two levels, whereas physico-chemistry sees atomic and molecular interactions. There is no space to explore the even more interesting spatial recombinations that yield sugar and flour from the same atomic ingredients, or that which confects sponge-cake rather than, for example, Welsh cakes. But we get a useful insight, not of top-down but of both ground-up and top-down creative interactions, on the one hand, and spatial interactions at the different levels, on the other, when we transfer the ‘emergence’ discourse to evolutionary policy making in the penultimate section of the present chapter.

Evolutionary regional innovation and growth theory

Recent theoretical analysis of regional evolution has highlighted the concept of path dependence for regional analysis. From a regional innovation and growth perspective, in particular, this has enabled progress to be made on the spatial *process* (or regional paradigm) dimension of spatial evolution (Martin 2010; 2011; Martin and Sunley 2006; 2011; Cooke *et al*., 2012). Here the regional paradigm comprises regional composition of economic activity, its path dependencies and technological vintages and its related and unrelated variety potential. Resonating with this, Sunley's (2011) and Tödtling and Trippl's (2011) further reflections on the roles of 'conventions' in understanding the 'soft institutional' dimension of regional *regime* formation and change add considerably to the analytical content of the notion of the regional regime in regional analysis. In a complementary manner, Cooke and Rehfeld (2011) further analysed the relations between such conventions – meaning relational 'soft institutions' – and firmer *structural* institutions and organisations that comprise regional regimes. Here a set of comparative and contrastive 'frames' were drawn up to capture different densities of regime narrative. These could be seen ranging culturally to denote dimensions relating to ethnicity, urban, rural, political, labour and business 'framings' in accounting for variety in the intersections of regional and corporate cultures. Clearly such dimensions are broader than a concern with questions of innovation capability alone. Accordingly, at the macro-regional level, the integrated regional *paradigm* and *regime* may be referred to as the *regional socio-technical system* (as, for example, in the work of Geels 2007). When expressed in terms of a more complex, dynamic set of interactions highlighting knowledge *exploitation* and *exploration* practices pinpointing innovation and growth, we may speak of a region having characteristics of a *regional innovation system.*

Two recurring themes in this co-evolutionary spatial analysis are *relatedness* of industry, by means of which regional growth is assisted, and *path dependence*, by means of which it can be constrained. Exploration of the first is a relatively recent phenomenon, pioneered by Frenken *et al*. (2007), but already it is a core body of theory and empirical research in evolutionary economic geography (Boschma 2005; Boschma and Frenken 2003; Boschma and Wenting 2007). The main mechanism by which relatedness influences regional growth is through knowledge transfer between firms, one result of which can be innovation. The key agents of such transfer are employees developing their careers by changing jobs in neighbouring areas and new companies being formed by the spin-off process that may also be a vehicle for innovations. Path dependence is a more established concept arising in economic history, particularly the branch interested in the history of innovation (David 1985). It has been analysed fruitfully in the context of evolutionary economic geography and particularly regional development, adaptation and change.

The champions of 'relatedness' indicate the pivotal position occupied by the idea of 'related variety' in evolutionary economic geography. Comparable to 'proximity', it has numerous dimensions, notably the cognitive, social, organisational, institutional and the geographical. Much research effort is exercised in relation to both concepts seeking to assess the relative importance of each in understanding the evolution of agglomerations or clusters, the core problematic of economic geography. In doing this, light is cast on the role of numerous other of the key process elements of interest to evolutionary economic geography, such as: innovation, technology, knowledge spillovers, learning and the creation of new regional developmental pathways. Foremost, authors take the two most frequently identified types of relatedness; geographical and cognitive as their main focus. Not a new idea, this distinguishes the base meaning of 'proximity' as 'shared space' from a distortion of that meaning, which allows a spaceless ‘community of interest’ kind of cultural closeness or ‘proximity’ to evolve (Webber 1963). They then apply these perspectives to issues of externalities and regional growth, on the one hand, and technological change in new path creation, on the other.

With respect to externalities and regional growth Boschma (2005) and Frenken *et al*. (2007) note that a key research question has been the extent to which firms in agglomerations benefit from ‘Romer externalities’ of *localisation* or ‘Jacobs externalities’ of *urbanisation* (see also Vatne 2011). Specialisation and diversification are the key differentiating dynamics in respect of these two perspectives on growth and agglomeration. Specialisation has been a mantra of the supply-side, clustering and cluster policy era, to which, as ‘Smart Specialisation’ European Union regional policy makers remain wedded. Even as key neoliberal proponents abandoned ship after the financial crisis of 2008, there was little policy recognition of the perils of unreflective advocacy of ‘regional specialisation’ (Porter and Kramer 2010; Davidow 2011). This was doubly ironic since every policy body from the International Monetary Fund and European Union on down was calling for post-crisis economic re-balancing away from specialisation in financial ‘securitisation’ towards meeting ‘Grand Challenges’, such as climate change. This was to be achieved by supporting greater economic *variety* in diverse forms of ‘Sustainable Economic Development’ of the kind facilitated by ‘urbanisation’ processes of knowledge cross-fertilisation. According to textbook ‘perfect market’ conditions, specialisation would logically require low inter-industry knowledge transfer effort. This is because similar specialist technologies being utilised mean lateral absorptive capacity among incumbents would be accordingly high, requiring little policy intervention. However, because of market failure, especially in inter-sectoral knowledge transfer, this is seldom the case. Therefore, the gains from efforts by intermediary agencies to assist knowledge transfer among similar *and* different industries might yield a greater regional reward than awaiting intermittent market signals for firms to react to. Beyond sectoral relatedness, evolutionists also place strong emphasis on *technological* relatedness, even among diverse industries, as being a necessary but not sufficient condition for cognitive proximity, meaning clarity of understanding of the other’s business model, processes and potential, possibly leading to innovation-led profitability (Kaplan 2008). The empirical research of Frenken *et al*. (2007) shows advantage accrues through the absorption of knowledge spillovers from regional (and extra-regional) industry that is cognitively relatively proximate in some way (technological, inputs, skills) whereas gains from Romer externalities (specialisation) perform less impressively. These processes are sufficiently nonlinear to require business intermediation to exploit relatedness potential by promoting ‘transversality’ at firm or cluster interfaces.

These early analyses were static so attention turned to the dynamics of technological relatedness and regional branching (new path creation). This invited discussion of relatedness in the short and long term, one hypothesis being that constructing advantage from related variety only brings short-term advantage. Long term, some wholly new branches are needed to sustain regional growth.

This is clearly an open question, warranting deep thought because at the heart of spatial evolution is a notion of an industrial ecosystem, which means complementarities foster growth while unrelatedness destroys it. As noted in 'transversality' analysis of regional innovation and growth, keeping industry conscious of regional relatedness is one of the key tasks of the advanced regional development agency (Cooke 2012). This raises a key question about the strength and longevity of radical innovation. Many authors use the term 'radical innovation' in undefined and unreflective ways (for example, Dahl Fitjar and Rodriguez-Pose 2011) or to denote relatively short-term but regime shifting change, for example in fashion markets (Verganti 2006). More typically it has been utilised to signify a major, long-lasting waveform transition in the dominant technological paradigm (eras of mechanisation, motorisation, informatisation, and so on). Path dependence applies to the period of 'normal science' (Kuhn 1962) or unpunctuated regional equilibrium, which *is* the short-term in 'episodic' or short-term radical innovation. But multilevel interaction between regime elements and paradigm elements is far more diffuse and complex during long-term, more 'epochal' periods. Because the 'relatedness' perspective can appear 'dis-embedded' from neo-Schumpeterian concerns about innovation and policy, it can also appear to be vulnerable to randomness in its predictive qualities. However, this aspect improves with the introduction of a dynamic element into the analysis represented in such historical branching processes as entrepreneurship, merger and acquisition, and exploitation of industrial density. These are also mechanisms that contribute to regional path dependence, which impose a heavy effect on regional evolution such that new path creation is generally influenced by the industrial legacy. This makes the Silicon Valley phenomenon really an extreme exception rather than the rule of regional development, which is one reason why it has never been replicated.

The idea of the regional economy as a path dependent system is the subject of research by Martin (2010; 2011a) and Sunley (2011). Among the conceptual issues raised are questions such as the extent the regional paradigm and its 'regime' are uniform, or composed of elements on different paths; to what extent are paths articulated even if they are on different paths; indeed, can regional evolution be characterised as systemic at all? Clearly these are salient questions because articulation would suggest relatedness but disarticulation the opposite, namely chaos. Hypothetically, therefore, the disarticulated region would be expected to be weaker in economic terms than the systemically articulated one. Much depends on refinements of conceptual degree and intensity. Thus it may be unnecessarily misleading to inquire whether regions display path dependence in certain industries or not. Many are 'externally controlled', some are endogenously so. As Cooke and Rehfeld (2011) show, this makes a real difference in regional paradigm embeddedness. Thus Westphalia-Lippe in Germany remains endogenously path dependent on strong, internationally competitive, quality products produced in endogenous family firms. Wales, by contrast. is path inter-dependent on both legacies and opportunities in more exogenous engineering, energy and agro-food. This helps illuminate important aspects of what qualifies an economic region to be differentiated between displaying path dependent and path inter-dependent socio-technical system characteristics at the regional level. One element is clearly ‘agglomeration’, another may be ‘origins’, ownership or ‘embeddedness’ meaning when and why key events first occurred, evolved and diversified or ‘branched’ in a particular region. Martin (2011b) suggests the predominant way in which regional path dependence has been conceived is either in terms of industry ‘selection’ of one from a number of candidate regions, or in terms of why regional ‘specialisation’ occurs in a specific industry.

However, a second approach involves the conscious quest for regional path-interdependence between industries; in other words its entire ‘paradigm’ and ‘regime’ evolution such as would allow profiling systemic regional articulation. This question is also asked in investigations of ‘regional varieties of capitalism’ and ‘regional corporate cultures’. Regional path interdependence introduces the historical dimension quite profoundly. Cooke (2011b) advances evidence for this in small, Nordic regions. Here early path dependence (for example, ship’s propellers; milk coolers; plough design) remains embedded in later path dependent industry (wind turbine blades) in north Jutland. Forestry explains early path dependence on, for example, pulp and paper specialisation while evolved capabilities in flexography (packaging; flexible printing; graphic design, film scripts) are later emanations of that initial resource endowment in Värmland, Sweden. Connecting to the earlier discussion of ‘epochal’ and ‘episodic’ radical innovation, both transitions described above have ‘origins’ in ‘epochal’ (long wave) exploitation of natural resources such as Schumpeterian ‘mechanisation’. But paradigms have been ‘episodically’ innovated according to opportunities arising from intersections of epochs (for example, ‘mechanisation’ and ‘electrification’ for windmills; ‘mechanisation’ and ‘informatisation’ for flexographics). Of course, path dependence with renewal also applies to epochal long waves and their after-shocks. This seems more satisfying than the ‘randomness’ that some path dependence analyses share with some ‘relatedness’ perspectives (David 1985; Arthur 1994)

Evolutionary complexity geography and some key questions arising for policy

In considering matters germane to Regional Innovation Strategy by taking a *transversality* perspective, a number of key questions arise. These concepts are originated in evolutionary complexity science, after Kauffman (2008). Of importance here are two ideas about the origins of innovation: the first involves ‘preadaptation’ or ‘innovation twists’ that take an innovation from one context (industry or use) and apply it in a completely different one. The second refers to the ‘adjacent possible’ which is *terra incognita* or a *tabula rasa* but not too far away from what is known *ex ante*. The first concerns what expectations one might have about the outcomes of ‘preadaptation’ versus the ‘adjacent possible’ in relation to the standard classification of innovations in terms of incremental versus radical. These are two mental moves towards two innovation outcomes. Broadly speaking, the preadaptation move introduces mostly incremental but could be radical innovation to the ‘other’ industry to which it is introduced. Meanwhile,

Table 5.1 Preadaptation and the adjacent possible in incremental and radical innovation

	Preadaptation	*Adjacent possible*
Incremental	Extend engine block to form tractor chassis (Ford/Farkas innovation for *Fordson* Tractor)	Combine very hardwearing polypropylene from textile machinery to medical technology (Hip replacement therapy, Charnley, Nobel prize)
Radical	Transfer nanotechnology innovation in clean 'smart textile' from automotive to medical clothing industry (Bayern Innovativ)	Combine static pumping engine with wheels and rails. This allowed steam engine to radically innovate railway transportation (Trevithick). Later, a similar combustion engine recombination introduced 'motorisation' as the fourth 'Kondratieff' wave (Maybach)

Source: Centre for Advanced Studies, Cardiff University

exploration of the 'adjacent possible' could be more radical than 'preadaptation' but will also imply quite a bit of more normal, incremental innovation. Table 5.1 gives an indication of this, with examples.

A further sub-question refers to the relationship of preadaptation and the adjacent possible to 'White Spaces' namely empty spaces in a topology of existing innovative clusters. These are bridged as knowledge from one (or more) clusters (or other industry or public agents) recombines to produce an innovation new to a different industry or – a possibility with the 'adjacent possible' – a wholly new firm, its imitators/competitors, hence a new industry cluster. So the relationship with White Spaces can be, to simplify, either incremental and *engineered* or radical and *architectural* (Henderson and Clark 1990).

A second question arising, concerns the importance of (possibly small) firms as *system integrators* in or among innovative clusters. In an industrial world characterised by lean production, open innovation and modular clusters (as Andy Grove 1996, former CEO of Intel refers) such 'hub firms' or *'firmes pivots'* as they are referred to in France (Gilly *et al*. 2010) become crucial actors. They play major roles in aggregating 'relatedness' of knowledge, business model and industry interfaces. We may understand how transformative their role became in ICT even in the 1990s by referring to Grove's diagram explaining that historic shift in industry organisation from 'vertical silos' to 'modular clusters' in Figure 11.1 (Chapter 11).

Clearly, the question of how there might be an interface or complementarity between what firms do regarding orchestration of a value chain changes over time. For example, what was beginning to be called the ICT 'global value chain' had changed by the end of the 1990s into the 'global production network' (GPN). This had changed again by the end of the 2000s from the GPN to the GIN (Global Innovation Network; Chen and Wen 2011). In this, systems integration for major 'smartphone' brands (for example, *Apple*, *Android*) could be managed by a software firm like Cambridge-based *Ubisense*, implemented by DHL or a competitor logistics company. The role of such an SME, floated on the AIM tech-market in London in June, 2011 is to assess production metrics, track consignments, personnel and vehicles as orchestrator of a decentralised system such as production of the *Airbus* A380, tracking parts brought together from different countries (Ubisense 2011).

This kind of systems integration represents the ‘modular tracking’ capability of the company. Another division (‘geospatial networks’), tracks fixed assets for utilities, telecom companies and so on, mapping and making sense of their vast networks. Although far too ‘granular’ in nature for policy purposes, such tracking competences are what RDAs may be expected to do in the early phases of a transversal platform innovation process when orchestration deals with cognitive, problem finding or framing issues. Back in the corporate world such ‘geospatial networks’ capabilities have attracted large customers such as *General Electric*, *Deutsche Telekom* and *BMW* to *Ubisense*. Regarding *BMW*, the production line at Oxford uses ‘scope’ (not only ‘scale’) economies in an assembly line that assembles different kinds of *Mini* one after another. Every car has custom fittings so such variety of options needs to be carefully managed to ensure smooth flowing production: in this *Ubisense* orchestrates what could be compared to ‘indoor radar’ where sensors keep track of the various moving parts, sending signals to a central system allowing managers to observe the process ‘panoptically’.

The new re-balancing imperative for intermediaries in Europe involves EU-branded ‘Grand Challenges’. To transfer panoptic thinking to that of an RDA managing the components of an ‘emergent’ policy system such as the Grand Challenges hubs, consisting of possibly six clusters or initiatives for each of two current Grand Challenge missions (for example, West Gotland or Region Skåne’s ‘Sustainable Cities’ and ‘Personal Healthcare’ hubs) means the region has to develop such measuring, tracking, positioning and system integrating capabilities – especially focused upon the *innovation projects* they manage. These are the core of the innovation platform since they are the means by which guidance of innovation within and among (‘White Spaces’) clusters that are to a large degree elements of a ‘self-organising system’ will occur. A key part of this relates, for example, to occasions when potentially preadaptive ‘innovation twists’ are picked up by the RDA in the ‘outdoor radar’ of ‘innovative project’ monitoring and learning. Processes and activities described in sections that follow relate to what was earlier elaborated under the label of ‘design thinking’ as one element of policy orchestration (Lester and Piore 2004; Martin 2009).

This is also discussed regarding exploratory projects referred to in the sub-section on regional system–integrator knowledge below. Experimentation is necessary to identify (or ‘filter’) those project ideas that are capable of ‘translation’ into products or services. This occurs through a meticulous project review process. We can talk of ‘innovative projects’ as being composed of two types: ‘exploration’ and ‘exploitation’ projects. But at issue must always be if it is sufficient to enable firms, networks of firms and Grand Challenge ‘Hubs’ to create new niches since we know that there is often a need for supporting innovations (‘strategic niche management’). This goes back to the rationale for and design and governance of a relevant policy mix. When it is noted below that there is a need for 'fashion shows' where attractors can meet, it is important to determine if it is 'entrepreneurial' qualities that identify a project, product or service as an attractor or whether it is more likely or typically identified by the innovator or manager of the 'translating' firm. Where practised elsewhere it seems the RDA 'intermediary' plays an important 'third party' role, as in *Bayern Innovativ*. This is relevant for regions which tend to frame innovation as an entrepreneurial effort. This directly addresses Verganti's (2006) interactionist idea of including interpreters in the 'design discourse'. His interpreters are bearers of different perspectives – entrepreneurs, innovators, intermediaries (for example, from technical or design schools) – and their communication is crucial to changing 'socio-cultural meanings.' The collective capability (for example, Region Skåne's interactionist 'Sounding Board') of being able to make sense of weak signals can make contributions in terms of pattern formation and collective framing of shared challenges and issues. That is, the key idea is that forming a community of interest about a collectively defined issue is important for addressing both Grand Challenges and opportunities for transversal innovation.

Learning from your industry (and citizens): some considered answers about regional innovation strategy

To implement a 'White Spaces' innovation strategy, a regional innovation policy must first recognise it is encouraging firms to step outside of their comfort zones according to Stacey Matrices (Figures 5.1 and 5.2; Stacey 2002). The preferred way for policy making – as shown by approaches like New Public Management and Evidence Based policy making – is to rely on complexity reduction which works in the zone closest to the bottom left in Figures 5.1 and 5.2.

The Stacey Matrix in Figure 5.1 is a guide for navigating complexity concepts and a method to select appropriate management actions in a complex adaptive system based on the degree of certainty and level of agreement on the issue in question (Stacey 2001; 2002). As indicated above, close to certainty and close to agreement regarding policy development is the commonest assumption for policy design and its implementation. However, such assumptions are not fulfilled for complex policy issues, for example, regarding Grand Challenges and innovation. These can be or are 'wicked' issues. Zones 2 and 3 require some changes in work process not least in terms of understanding the environment but do not fundamentally change the policy 'landscape'.

However, this changes significantly in zones 4 and 5. In the chaotic zone, the major achievement may be to understand and translate the environment into actionable patterns which is a kind of 'order' that moves issues from chaos to the complexity zone where action still has to be characterised by co-creation, applying design thinking and similar approaches. This important point resonates with comparable points broached in the chapters by Melkas and Uotila, and Uyarra and Flanagan in this volume. As the former see it, the absorptive capacity, learning, application of design thinking and co-creation involved in implementing the

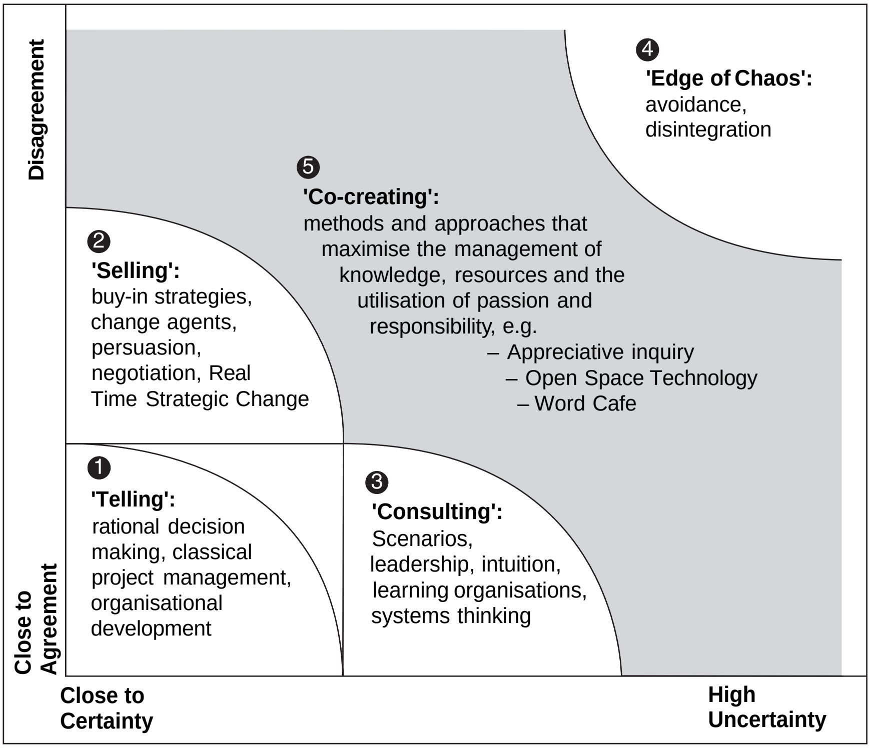

Figure 5.1 The Stacey Matrix

Source: Stacey (2002).

'platform' model of path creation in a region bereft of its familiar path dependence is tantamount to the innovation process in a firm, possibly even more complex in its transversality. For the latter, policy making is a variety of complex innovation process, because it involves recombination of knowledge, articulation of a process of co-creation, design of instruments and appeal to the policy community which are indistinguishable from the 'commercialisation of new knowledge' typically taken as the core definition in the systems view of innovation (for example, Tödtling and Trippl 2005).

In this interesting 'reframing', innovative production and innovation policy are two dimensions of the design perspective. Both clearly have the intent of changing socio-cultural meanings, the one at paradigm level the other at regime level. Problematic hitherto is that policy is not seen, and policy makers do not see, the innovative nature of their task. For too long, focus has remained in the bottom left corner of the Stacey Matrices. The rise of transversality, in general, and of Grand Challenges, more specifically, as innovation motivators in an 'emergent' policy process, means that recognition of the innovative content of accomplished policy is now unavoidable. However, it must be adaptive,

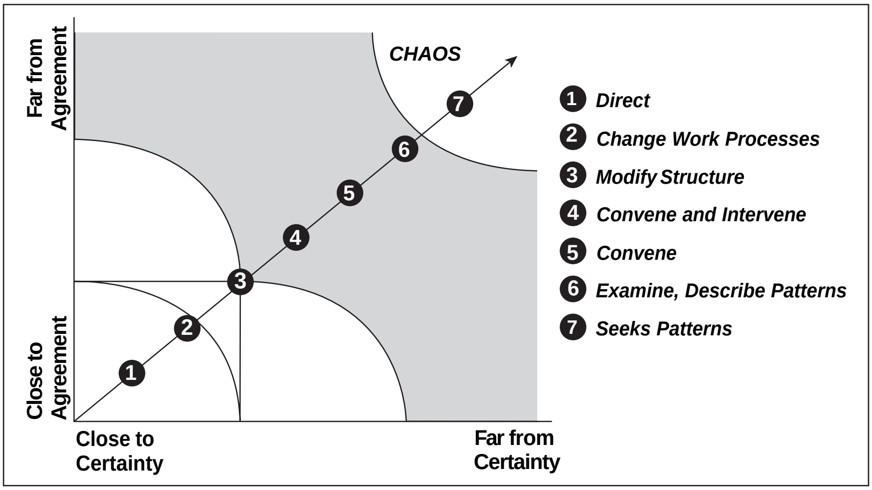

Figure 5.2 Policy design using the Stacey Matrix

Source: Stacey (2002).

continuous and influential rather than seek to be determinative. Thus innovative platform policy has to be catalytic in assembling knowledge agents in ways it has seldom been before.

In summary, therefore, the mix of policy rationales – market and systemic failure – leads to a mix of policy that covers a broad spectrum from issues of meaning and sensemaking to knowledge creation and, finally, directly influencing market or governance transactions.

Grand challenges as forms of emergence

There are two different approaches to Grand Challenges. The first is to try to deal with them within the prevailing paradigm of 'science push'. That means a strong focus on research and technology. The second is to see Grand Challenges as types of social problems that require not only new technologies but also social innovation and a systemic approach in addressing them. The difference between the science and technology push approach and the society pull approach is illustrated in Figure 5. 3 with the case of transition to 'home-based healthcare' in Halmstad, one of the Swedish transversality exemplars. The key point is that there has, for fifty or more years, been a path-dependent socio-cultural regime favouring elderly healthcare in medically clean and well-serviced environments. However, that system logic is undermined by the 'Grand Challenge' of demographic population ageing and the unaffordability of the old model. This required a more complex shift of path dependences into a *path interdependence*, whereby societal innovations both technical and relational allow the problem to be solved in a wholly different way. The arrows in Figure 5.3 represent change within regimes – staying in the same

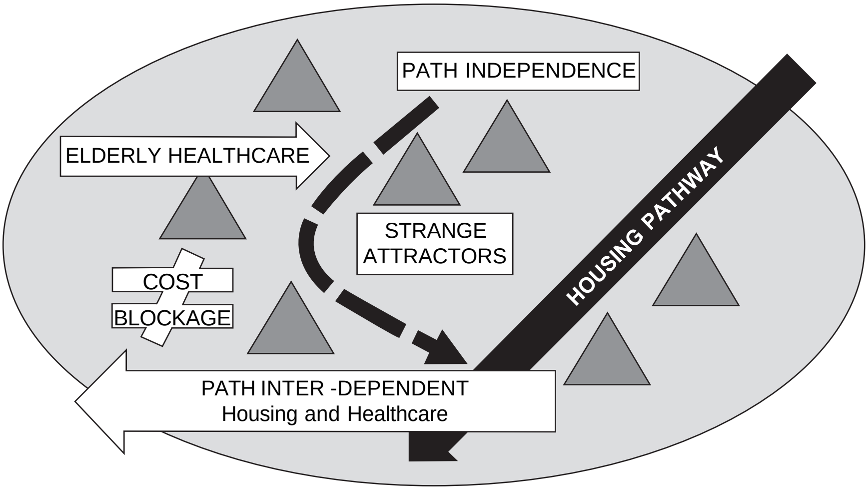

Figure 5.3 Healthcare Technology Alliance: societal innovation by system optimisation

Source: Centre for Advanced Studies, Cardiff University.

valley in terms of topological 'landscape', namely system optimisation constrained by the regime´s attractor.

Healthcare Technology Alliance

Funded projects concerning elderly person needs are the means of achieving the key objective of this initiative: identifying innovation to meet technological or organisational needs in the healthcare and social care sectors. So, first, the alliance's perspective has broadened somewhat from its initial focus upon elderly care alone. Accordingly, second, and at the firm level, *Famulok*, a company now employing 35 persons accomplished transversality as a start-up associated with the Healthcare Technology Alliance (HTA) making mobile security locking devices combined with mobile billing capability. Finally, a recent phase-change in a key technology involved 'preadaptation' of *dating agency* software. This new application was evaluated by cost-benefit analysis and found to be faster, more secure, more flexible and sustainable (in reducing CO2s) than prevailing security practices for the elderly. *Katrell* is another associated start-up that sells a mobile pen system for registration and documentation purposes. Some social care solutions are not so high-tech as with a 'conversation' started in 2011 on 'elevatorisation' in apartment buildings of four to five storeys designed and constructed widely in Sweden in the 1960s and 1970s. Many elderly persons live in such accommodation. Their most emphasised healthcare difficulty is in climbing the stairs to these apartments. Inability to do this traps many in their flats, making them more dependent and isolated than they need be. In fact this 'social care' problem belongs to the municipal *buildings* department rather than the *healthcare* authorities. Such *transversal* problem appreciation of a systems-design issue facilitated co-creation of an innovative solution. Reinforcing this design element, a majority of surveyed elderly persons given the choice, expressed a preference to live downtown rather than in the suburbs for reasons of both accessibility and sociability. Accordingly, a programme of elevatorising downtown apartments brought triple benefits in terms of personal mobility, accessibility to central facilities like shops, and sociability with fellow elderly persons and other age-groups. To try to achieve such transversal aims, HTA developed an innovative governance model. Its legitimacy was embedded in the existence of an HTA stakeholder network, through which innovative knowledge and ideas were then infiltrated into the political system for whom healthcare is a growth sector (‘Grand Challenge’) in regional economic development strategy. Elsewhere, Verganti (2006) talks about innovation in terms of changing socio-cultural meaning, including new types of instruments that affect the policy mix, such as demand side programmes that may influence the conditional probabilities of establishing new pathways between regimes – path-interdependence – which by stimulating demand can influence what turns out to be the adjacent possible. Accordingly – a second important point – the RDA or its cluster agents must separate innovative intentions between, on the one hand, ‘innovation twists’ (preadaptations) and real ‘White Spaces’ or ‘adjacent possibles’, on the other. This is because, after search and selection has been done, ‘innovation twists’ are relatively straightforward technological solutions that may be left largely – once evaluated – to individual firms unless their complexity requires ‘system integration’ functions. In the case of ‘White Spaces’ such as the second ‘elevatorisation’ part of the HTA – the far more sophisticated part of their achievement – social innovation must be ‘emerged’ to a higher, political level involving regime change of ‘socio-cultural meanings’ involving many and more powerful actors, some of whom can make or break honourable efforts working ‘at the edge of chaos’. Second, the ‘adjacent possible’ here is a higher-order ‘emergent’ decision-making process flavouring national and even international policy with a completely new taste. So, third, there need to be specific ‘Business Intervention Models’ (BIMs) implemented by RDA innovators – which may be forms of ‘innovative procurement’ – required of firms, clusters and ‘emergent’ macro-policies like ‘Grand Challenges’ (see Morgan, Chapter 15 in this volume).

Innovation Policy Business Intervention Models (BIMs)

Innovation twists (preadaptations)

These require innovation ‘fashion shows’ where ‘attractors’ including both ‘natural attractors’ who are near to predictable, coming from neighbouring industries in the technical sense, and ‘strange attractors’ coming from largely unconnected industries, can meet and absorb knowledge spillovers from sectoral ‘others’. These settings should include stages (theatre-style) or ‘living labs’ with ‘red thread’ narratives, ‘storytelling’ discourses and dramaturgies, as practised in Finland’s ‘Regional Platform Development Methodology’ (see Melkas and Uotila, Chapter 10 in this volume). Fundamentally, firms in one industry or cluster are presented with accounts of useful innovations developed in a different industry. If this process sparks off some inspiration to adapt it in a new field, firms begin ‘conversations’. These may be brokered by a third party from the RDA to provide ‘neutral territory’ and ‘trusted third party’ facilitation, which also serve learning and policy co-creation purposes from an ‘innovation platform’ point of view.

Reverse innovation

There may also be ‘reverse innovation’ business models like that discussed by Immelt *et al*. (2009) regarding General Electric’s ECG machines for LDCs – targeting Prahalad’s ‘bottom of the pyramid’ markets - in BRICs and elsewhere (Prahalad 2005). This was pioneered in Taiwan where key ‘hub’ system integrator in ICT is *Mediatek*. In 2004, *Mediatek* expanded into the territory of mobile phones by making ‘chipsets’, a total solution incorporating processor-, radio- and other sorts of chips in ‘stacks’ with the necessary software. It is now widely perceived that *Mediatek*’s solutions and business model have revolutionised the handset industry, at least in China (Chen and Wen 2011). Before *Mediatek*’s entry, leading handset chip makers, such as *Texas Instruments* (*TI*), *Broadcom*, and *Qualcomm* worked closely with global oligopolistic brand lead marketers of handsets. *Mediatek*’s total solutions, which shortened the lead time to market from nine months to three months, made it much easier for handset makers to design and produce a wide variety of mobile phones. Together with its extensive technical supports in China, *Mediatek* facilitated the explosive development of Shanzhai (informal economy) handsets in China. It was estimated that about 150 million Shanzhai handsets were produced in 2007, with 40 per cent of them exported to countries such as India, Russia and Brazil. By coincidence, Taiwan has a comparable ‘Grand Challenges’ Innovation Strategy to that being developed as two inter-linked hubs in Region Skåne (Figure 5.4, i236 Innovation Strategy).

In addition, the initiative promotes cross-strait cooperation in industrial standards which coincides with widely publicised strategies to promote indigenous innovation and industrial standards in China. A few areas have been identified as the priority themes for cross-strait cooperation in industrial standards, with mutual consensus on advancing beyond dialogue and standard harmonisation. To a certain extent, these initiatives are relevant to the future development of Taiwan’s ICT industry. For example, for cross-strait cooperation in industrial standards, both sides have reached agreements to work together on the fields of TD-SCDMA (frequency band), LCD, LED and solar cells. As far as Taiwan is concerned, cross-strait cooperation in industrial standards is meant to come to terms with the rise of China and promote cross-strait economic relationships beyond the current typical form of Taiwan-based firms’ relocation of industrial

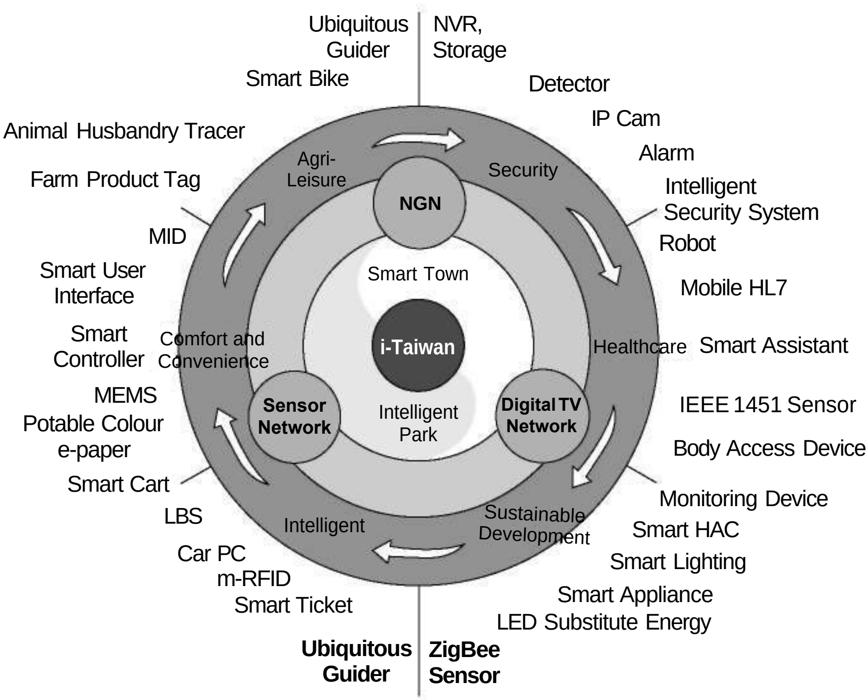

Figure 5.4 Profile of the i236 innovation strategy in Taiwan

Source: Chen and Wen (2011).

value chain to China. This represents the transition of a global production network (GPN) to a global innovation network (GIN).

User-driven innovation

There may also be user-driven as well as reverse innovation or innovation 'twists' (preadaptations). Here twists can occur in supply chains depending upon the aforementioned shift from global production networks (GPNs) to global innovation networks (GINs). Such twists must be understood by RDA intermediaries working with and learning from cluster expertise in technological and business model transitions occurring worldwide. One such twist affecting Nordic former ICT leaders like *Nokia* and *Sony Ericsson* is that they pursued endogenous systems applications long after Asian competitors like *Samsung*, *HTC* and *Huawei* were pursuing *Apple* into the 'smartphone market'. As the Nordics have had to downsize due to the Asian and US competitive surge, firms like China's *Huawei* have begun snapping up redundant telecom engineers by locating in their former strongholds, especially in Sweden. *Huawei* is a threat to the infrastructure as well as systems and handsets aspects of the mobile telephony market. But, basically, Nordic mobile telephony firms had low absorptive capacity towards such competition and remained locked-in to their proprietary technological path dependency for too long.

A further example from Taiwan of alertness to user-driven innovation shows the close involvement in 'transitioning' Taiwan's Flat Panel Display industry of the country's national Innovation Agency (ITRI) during the twenty-five years since 1986 (Figure 5.5). This has involved ITRI on numerous occasions brokering ICT cluster shifts in terms of indigenous technology development, technology adoption and technology transfer, including merger and acquisition activities with divisions of foreign multinationals like Philips, IBM, Toshiba, Sharp and Mitsubishi.

Real 'White Spaces'

Learning from your industry

If the former three points refer mainly to 'innovative twists', the next three refer mainly to 'White Spaces' adjacent possible explorations. First we may refer to Baldwin and Von Hippel's (2009) notion of 'Learning from your Industry' in a context of 'From Producer Innovation to User and Open Collaborative Innovation'. They say:

> our approach is modelled after Williamson's analysis of different forms of transactional governance and especially the account of how agency costs affect the allocation of residual claims. However, in contrast to this prior work, we will not attempt to determine which model is most efficient in minimizing transaction or agency costs [for example, returns on project investments] but will establish bounds on the viability of each model. When one form is viable, we do not expect to see one form driving out the other (as is the common assumption) but rather expect to see creative combinations of the forms to take advantage of what each one does best.
>
> (p. 42)

Innovation development, production, distribution and consumption networks can be built up horizontally – with actors consisting only of innovation users (more precisely, 'user/self-manufacturers'). Some open source software projects are examples of such networks, and examples can be found in the case of physical products as well. It may be concluded that conditions favourable to horizontal user innovation networks are often present in the economy. In these circumstances, the BIM demands that the regional agency, minimally, keeps a knowledge management system (KMS) of its large and SME 'system integrator' firms. Each year all are asked what solutions they need and these become the regional system's initial innovation market for 'exploration' and 'exploitation' innovation projects. Thus, the 'system' learns through the RDA of the innovation needs and functioning or projected innovation projects in demand from specific types of large firm users, system integrators and the knowledge capabilities of regional start-ups and research laboratories. In this way, existing path dependences are exploited and renewed with the possibility that new paths may open up in consequence.

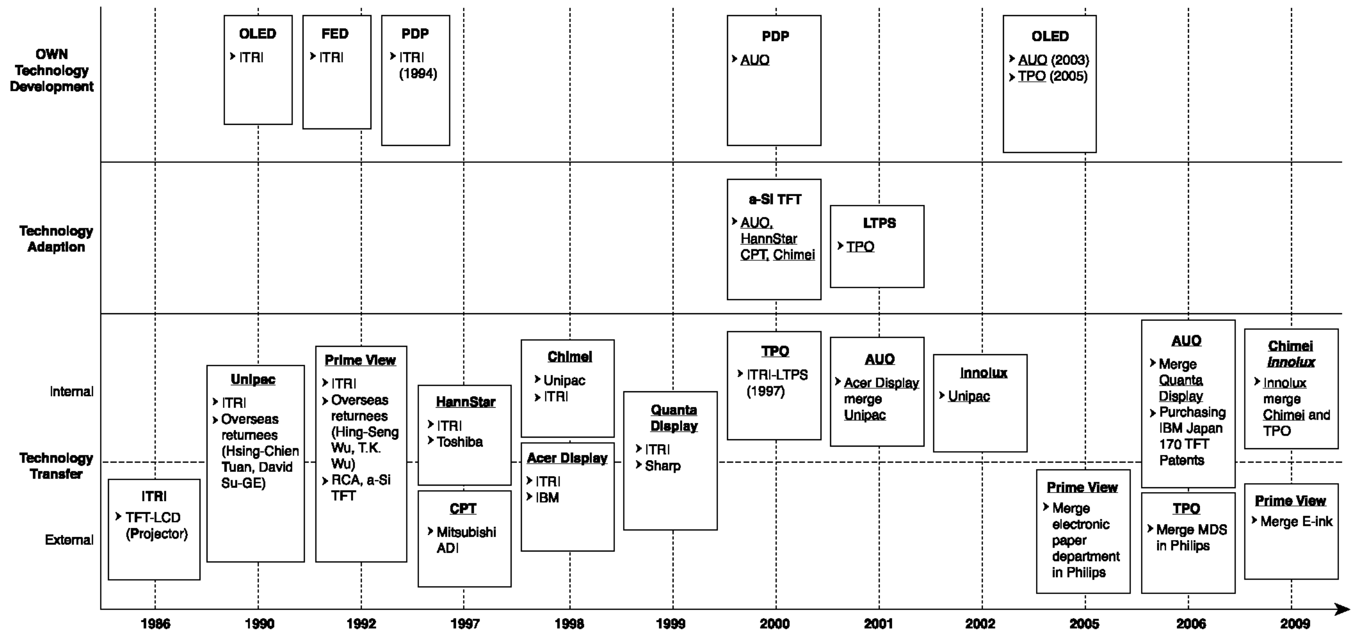

Figure 5.5 A chronology of flat panel display industrial development in Taiwan

Source: Chen and Wen (2011).

The transversality in this process is shown in research conducted for this chapter in two further Swedish clusters. The first is the *ProcessIT* initiative to supply innovative services to heavy industry (pulp and paper, mineral mining, energy) where the 'cluster' promotes innovation projects that are now typically on 'visualisation', positioning', automation and 'simulation' using serious digital gaming technology. This marks a change in these industries towards driverless mining and timber harvesting vehicles, the need for outsourcing and open innovation in Mark 2 'lean management' production systems and the rise of sensor-embedded control technologies more generally. Hitherto projects were far less 'systemic' requiring more one-off problem solutions. Convergence with another initiative, a 'cluster' of fibre optics firms ('Fibre Optics Valley') has simultaneously been moving from its origins, close to *Ericsson* in telecom cabling, towards cross-fertilisation of expertise in sensors, simulation and digital services to meet similar user-demand for advanced digital control services in similar heavy industries (Cooke, Eickelpasch and Williams 2011).

Regional system–integrator knowledge

Among suppliers of software and systems-based services of the kind in demand from users in industries such as those just discussed – mining, metallurgy, forest products, energy, and so on, are mainly regional but some national and international firms that are precisely those 'hub' or 'pivotal' innovative systems-integrator firms discussed earlier in this chapter. In this knowledge distribution system, knowledge from regional research and system integrators is presented to regional firms individually or in partnership with one or two others. Theoretically, this is a process involving 'learning about confidentiality', aiming to move gradually towards more 'open kimono' postures on the part of firms that are even today hyper-secretive. Eventually, a collective or sub-group 'showcasing' business model may be designed by the regional innovation agency but a major trust-building process has first to be implemented. This filters into customer minds new business practices, new technical solutions, new opportunities for exploring 'White Spaces' according to those who occupy positions as the 'internal radar' of global innovation networks (GINs). These are firms seeing, thinking about, understanding and proposing to move, if partners can be found, into new strategic niches. Here the role of the RDA as innovation broker of solutions to final users in and beyond the region is also crucial – as 'orchestrator' of shared interests and relatedness 'storyteller'.

Exploratory projects

These are especially important for 'White Spaces' and Grand Challenges investigations as more strategic action lines than typical 'innovation twist' projects, discourses or narratives. They are, accordingly, funded across cluster interfaces within and between clusters either within Grand Challenge' 'emergents' or among clusters interfacing outside Grand Challenges involvement. This evolves as a collaborative business model and 'exploratory' innovation projects may later mutate into 'exploitative' ones. A further case in point from Swedish regional experience of the virtues of transversality is another healthcare 'Grand Challenge' initiative to which HTA, discussed above, is affiliated. It is known as New Tools for Health (NTH) in ÖstraGötaland (Linköping/Norrköping region). Although the regions with special powers regarding regional economic development (West Gotland and Scania) also propose healthcare as a Grand Challenge, the healthcare landscape is extremely broad and NTH began conceptualising how to deliver health and social care in a distributed and personalised way (domestically, not in hospitals and care-homes until necessary) long before it became, in many countries, a live issue from both healthcare and public expenditure perspectives, as it is today. Accordingly, this is a 'White Space' of major proportions and much experimental thinking and work have already been conducted. One of the primary issues over the initiating and middle years of the scheme (2005–11) was convincing powerful interests in regional governance, regional healthcare services and regional academe that the idea of 'personalised healthcare' was valid. All were wedded to a vertical 'separation of powers' path dependence on established certitudes mainly that the economy, in the first place, and the national government in the form of tax revenue, in the second, would provide the necessary resources to continue unchanged *ad infinitum.* But authoritative government statements on demographics, rising costs and declining public budgets finally 'shocked' holders of these presumptions into a condition of serious incertitude. At this point NTH gained sufficient legitimacy and institutional support to facilitate assembly of a regional healthcare 'stakeholder system' for procurement of innovations in personalised healthcare (Figure 5.6).

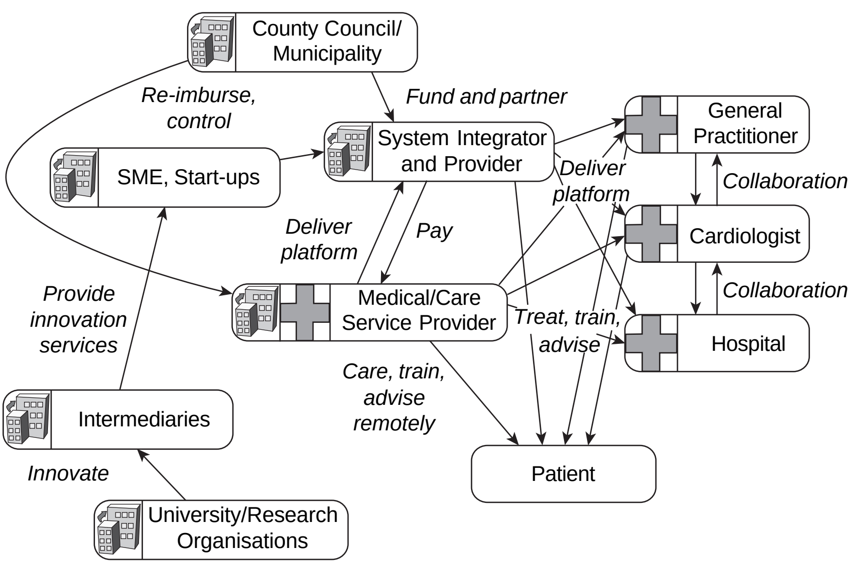

Figure 5.6 Regional healthcare stakeholder system for innovative procurement

Source: Cooke *et al*. (2011) drawn by Jörg Habetha, Philips Research.

In this case, because the regional healthcare system is inordinately complex but lacking large firm providers of innovative solutions while start-up businesses are too small and specialised, the system initiator NTH must take on the catalysing and co-ordinating functions of regional healthcare system integrator. It commissions innovative solutions through innovation projects between hospitals, healthcare research and existing or start-up SMEs while building relational capital with large, external firms with some relevant competence areas. However, so new is this mission that relatively few large-scale personalised healthcare providers of the kind required are to be found anywhere. Accordingly, experimentation through exploratory projects, building alliances, as with HTA and absorbing its experience, and articulating hitherto unconceived innovation demands are the drivers of this initiative.

Conclusions

In this chapter, regional development and, more particularly, the innovation and growth aspects of that complex process, has been 'reframed' as a problem amenable to analysis and practical improvement according to key principles of evolutionary complexity theory. Such reframing moves a step further into the 'adjacent possible' from the launchpad provided by its intellectual near neighbour of evolutionary economic geography (EEG). Evolutionary complexity theory (ECT) contains many overlaps with EEG: amongst them are core interests in matters of *variety*, notably related variety and its fascinating obverse in unrelated variety – together, the principal elements of *relatedness* – which, in turn, gives the policy key known as a series of Business Intervention Models (BIMs) that comprise 'transversality' (for fuller discussion, see Cooke, 2012b). Further interesting avenues of research in connection with this are raised in the chapter by Balland, Boschma and Frenken (this volume) around *asymmetrical* related variety. This is important because it brings the question of centrality, influence and power back in to the intellectual and practical agenda. Put simply, some nodal individuals, firms, and clusters have more dimensions of relatedness than others. This shifts the focus in network thinking from networks to nodes; clearly, in policy terms regions need to optimise their *nodality*, not simply their networks. Furthermore, intermediary agencies need to have the best intelligence on *nodal* targets for incumbents to further optimise their knowledge recombination and interactive innovation capabilities.

A second area of overlap between ECT and EEG relates to the evolution of industry trajectories, particularly concerning path dependence and the prospects for path-interdependence. Creating new paths is the main way in which regional economies grow in an increasingly internationalised and competitive world. However, as we have seen, ECT is secure in the understanding that:

> In her famous book *The Growth of Cities*, Jane Jacobs notes that in postwar Milan and its hinterland, and in Tokyo and its hinterland, a web of complementary technologies mutually spurred growth. Jose Scheinkman [also]

> found a positive correlation between diversity and growth. Thus there are some demonstrated grounds to believe that the economic web autocatalytically drives its own growth into the economic adjacent possible, generating ever new economic niches and evolving future wealth.
>
> (Kauffman, 2008: 160–1)

This occurs by means of intersecting path dependencies among regional industries according to EEG, while the same processes are caused by *strange attractors* according to ECT. Recombinations of knowledge, most of which already exists, some of which may be new, are the core vehicles of interactive innovation, the key source of productivity and growth. But because firms are myopic rather than omniscient, most innovation opportunities have tended to be missed. Accordingly, animating what ECT tends over-optimistically to conceive of as autocatalysis is the new prime support task of the regional innovation system regime. Many of the tools for doing this were outlined in the second half of this chapter. But there will be others. For example, at the broader level, the contributions to this volume of Uyarra and Flanagan, on the one hand, and Melkas and Uotila, on the other, point to the need for complex policy making to move beyond the local and myopic, to experiment in 'living lab' settings and, above all, that policy informed by the evolutionary perspective can only ever be 'adaptive'. This resonates with the inference that path dependence is both a constraining but also a facilitating process. Most previous readings have emphasised the negative 'lock-in' implications rather than the positive 'path creation' attributes of evolutionary 'skunkworks,' as Morgan refers to them (in this volume).

Finally, we come to the issue of 'emergence' in the understanding of regional paradigm and regime evolution. It was shown in this chapter how analysis of path interdependence or 'strange attractors' moving across a 'fitness landscape' can produce innovative understandings of socio-economic processes. This was revealed in the economics of healthcare exemplars, which in turn were expressed in innovative policy solutions at the regional regime level (as Simmie also shows in his chapter on renewable energy, in this volume). The illustration of the molecular structure of a sponge-cake was presented in this chapter as a direct parallel with the 'emergence' of the capabilities of innovative local clusters (molecular level) to comprise integrated elements of a transversal regional innovation strategy recombining those capabilities (ingredients level) to fulfil national and supranational level ambitions to meet today's 'Grand Challenges', such as affordable healthcare or climate change mitigation (outcome level). But, it has to be admitted that this and similar examples described in Cooke (2012b) are pioneering and as yet by no means widely followed.

The discussion point here is that, as ECT sees it in most cases the 'relevant world' for the molecules and ingredients to address has not been, and maybe cannot be (bounded rationality problem) prestated. But in the case of the Grand Challenges they were prestated both from ground-up and (later) top-down by EU and national governments. Accordingly, policy emergence was one result (for example, Sweden's 'Challenge-driven Innovation Programme', VINNOVA 2011). Kauffman

(2008) sees this as the LegoWorld problem, in which an actor is surrounded by Lego bricks, with an infinite number of functionalities, but no specific purpose at hand. So, having a clear purpose at hand is, in a way, the hard part. For example, he notes how the Wright brothers' workshop contained, *inter alia*, a boat propeller, a box kite, a lightweight petrol engine, bicycle chains and bicycle wheels, which they successfully recombined to fulfil their purpose of achieving powered flight. From an innovation policy point of view, the LegoWorld problem is solved by creating 'theatres' that mimic the Wright brothers' workshop. Audience members may be stimulated, inspired or rendered apathetic by what they learn. For the first two categories, they directly interact (network) with their selected *nodal* individual or firm, or the innovation agency brokers such interaction as a third party. In either case the agency then follows up with its portfolio of Business Intervention Models (BIMs) as and when needed. Furthermore, innovation increasingly takes place in open or semi-open ecosystems with strong international linkages. This offers new perspectives for intermediary agencies. As the configuration of capabilities within the ecosystem has to be mutually agreed upon, the innovation agency, as a proactive co-creator, can complement nodal individuals, firms or clusters with not only operational capabilities but also orchestration capabilities for the participants that are important to the regional ecosystem (Wallin 2006).

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Part II

Innovation and diversity

6 The health technologies sector in Oxfordshire

Evolution or optimism in regional development?[1]

Helen Lawton Smith

Introduction

This chapter's theme is how regions are positioned in processes of change by key agents and the possibilities of intervention designed to shape technological and innovation trajectories through a co-opted alignment of stakeholders at regional and international scales. It is about 'picking winners' – optimism tempered with reality. It reports on a three-year FP7 project: HealthTIES, which commenced in October 2010. Partners are Leiden, Oxford, Barcelona and Zurich, chosen because each region has a strong presence in biomedical research and the biotech sector. The chapter presents evidence from Oxfordshire, which for biotechnology and biomedical research is the dominant part of the UK study region, the Thames Valley, in South East England. For this study the Thames Valley comprises the three geographical areas of the counties of Berkshire, Buckinghamshire and Oxfordshire. It includes unitary authorities of Milton Keynes and those in Berkshire (for example Reading and Slough).

In this case study, key agents are a subset of the Oxfordshire project team partners. The team is led by a Professor of Medical Oncology at Oxford University, the 'convenor' of this particular stakeholder network. The project represents the co-option of other actors into regional development processes by a scientific elite. It intends to do this by, 'translating research through innovation partnerships and cross-sector networking' (Academy of Medical Sciences 2010). The FP7 project is a response to current opportunities and challenges presented by advances in medical research, changes in the healthcare industry more broadly internationally and nationally, as well as changing competitive conditions for example in market opportunities (for example, in targets for public health improvements). Other challenges are increasing cost-per-unit of drug development, a diminishing research and development pipeline (Academy of Medical Sciences 2010), plus the effects of new legislation of various kinds.

This case study brings into focus the various geographical scales at which those challenges and opportunities occur, hence providing possibilities for intervention by various stakeholders in each region. Conceptually the theme is design (Cooke 2011). It is about constructing regional advantage and interrupting path interdependences from the perspective of stakeholder theory (Freeman 1984; Freeman and McVea 2001) applied at a regional level. Design relates to the ability of lead actors or convenors (Svendsen and Laberge 2005) to co-opt and influence firm-level activity in a multi-jurisdictional environment with multiple rationalities (Clark *et al*. 2002). The chapter considers the spectrum of primacy through to minor influence exerted by various stakeholders whence their varying ability to influence paths of regional development.

This is not just a regional approach because this sector is one element within a regional economy, it is not a firm-based sectoral approach (firms as system agents, Cooke 2011) because it takes into account non-sector actors because of the co-option by the scientific convenors of other stakeholders into the health technologies innovation cycle. Although it is impossible to predict the regional and non-regional outcomes of 'design', possible scenarios of what might be outcomes of coordinated intervention are suggested in the concluding section.

System relatedness and stakeholder theory

In this chapter, three different ways of looking at how targeted intervention towards a sector could change paths of regional development are explored. These are, (i) path dependence (Arthur 1989, 1994; Martin and Sunley 2006), (ii) constructed regional advantage (Cooke and Leydesdorff 2006) and the associated idea of constructing regional advantage (Asheim, Boschma and Cooke 2009) and (iii) stakeholder theory (Freeman 1984; Freeman and McVea 2001) applied at the regional level which draws on both of the above. What each have in common is the idea of system inter-relatedness, but the last like 'constructing regional advantage' (Asheim *et al*. 2009) is less concerned with self-organising processes than organised processes. It is argued here that the advantage of stakeholder theory applied at the regional (and inter-regional) level is that it more clearly focuses on agency and attributes of power within interdependent systems.

Path dependence

The focus in path-dependent theories is the firm and the industry. Path dependence is a function of two inter-related and reinforcing processes: positive feedback represented by increasing returns to scale, and lock-in whereby economic agents remain within particular paths of accumulation (Clark *et al*. 2002). Boschma (2007) summarising Arthur (1989, 1994) distinguishes the (1) spin-off model, region grows firm by firm through spin-off dynamics, and (2) the agglomeration-model – the more start-ups enter a region, the stronger the growth. As Boschma points out, citing Martin and Sunley (2006), 'path dependence should not only produce space (industries creating space), but places also impact on path dependence processes (making it a place-dependent process)'. This is place-specific knowledge embodied in particular customs and practices (Clark *et al*. 2002). Moreover, Boschma points to the importance of networks suggesting that 'the evolution of networks may be described as a path-dependent process, based on the principle of preferential attachment' (Barabasi and Albert 1999; Andersson *et al*. 2003): each new node joining the network may have a preference for linking with a node that is already highly connected, in order to get access to many other nodes through this one node.'

Regions can also be vulnerable or can benefit from externally driven events which can also contribute to their resilience (Simmie and Martin 2010). Firms can be merged or acquired (M&A). While merger theory assumes that the consequences for large firms are negative, Weitzel and McCarthy (2009) argue that it needs to be modified for SME M&A, as the behaviour and financial success differs from larger public firms. They find that SMEs are more likely to rely on M&A as an external growth option. Agency costs are significantly reduced for smaller firms, and boundedly rational value destroying actions are less prevalent as smaller firms are more flexible and able to withdraw from unsuccessful M&A activity. Hence M&A activity may bring benefits to small high-tech firms, where they perform better post merger or acquisition. If their operations are closed or transferred to other locations, then the effects are negative.

In this chapter, the question is not just why some regions are more favourable than others (Boschma 2007) but whether intervention by stakeholders can make that region more effective than if left to chance under either model 1 spin-offs, or model 2 agglomeration economies. In other words, efforts are targeted at enhancing particular places' specific sets of knowledge and ability to recombine knowledge from outside the region.

Constructed advantage

Cooke and Leydesdorff (2006) consider whether regions provide the relevant system of reference for knowledge-based economic development. They suggest that knowledge-based construction requires interfacing developments in various directions, building on notions of comparative and competitive advantage as summarised below:

- Economy – regionalisation of economic development; 'open systems' inter-firm interactions; integration of knowledge generation and commercialisation; smart infrastructures; strong local and global business networks.
- Governance – multi-level governance of associational and stakeholder interests; strong policy-support for innovators; enhanced budgets for research; vision-led policy leadership; global positioning of local assets.
- Knowledge infrastructure – universities, public sector research, mediating agencies, professional consultancy, etc. have to be actively involved as structural puzzle-solving capacities.
- Community and culture – cosmopolitanism; sustainability; talented human capital; creative cultural environments; social tolerance. This public factor provides a background for the dynamics in a Triple Helix of university–industry–government relations.

(Leydesdorff and Etzkowitz 2003)

Cooke and Leydesdorff argue that constructed advantage is both a means of understanding transformations in economic growth activity and provides a strategic policy perspective of practical use to business firms, associations, academics, and policy makers. In Cooke and Leydesdorff's concept of 'constructed advantage', stakeholders appear under governance.

Next the concept of stakeholders is explored in more detail. Here stakeholders are the agents which tie partners together.

A regional stakeholder approach

The stakeholder theory of strategic management emphasises the active management of the business environment, relationships and the promotion of shared interests. It is also a systems theory which focuses on interdependencies: the development of collective strategies that optimize the network (Freeman and McVea 2001). It can be used for 'understanding a system by identifying the key actors or stakeholders in the system, and assessing their respective interest in that system' (Grimble *et al*. 1995: 3–4).

In stakeholder theory, the firm is at the centre of the stakeholder map or system. Freeman's (1984) stakeholder theory incorporates other parties, including governmental bodies, political groups, trade associations, trade unions, communities, associated corporations, prospective employees, prospective customers, and the public at large. Sometimes competitors are counted as stakeholders. The stakeholder view of strategy is an instrumental theory of the corporation, integrating both the resource-based view as well as the market-based view, and adding a socio-political level.

The thesis is that the firm can affect the environment, as well as the environment affecting the firm, by investing in relationships that will ensure long-term success. Stakeholder analysis is used to differentiate and study stakeholders on the basis of their attributes, the criteria of the analyst or convenor appropriate to the specific situation and the opportunities from the perspective of each stakeholder. These may include the relative power and interests of each stakeholder (Freeman 1984), the importance and influence they have (Grimble and Wellard 1996) and the networks and coalitions to which they belong (Freeman and Gilbert 1987). Mitchell *et al*. (1997) derive a typology of stakeholders based on the attributes of power (the extent a party has the means to impose its will in a relationship). This can also be interpreted as the extent to which they add value to a regional system.

The idea of conveners, introduced by Svendsen and Laberge (2005), helps to focus on relative power relationships within and external to a region through the use of their networks. This concept relates to the relative influence of different stakeholders – the primacy of some agents – and to communication issues. Stakeholder networks have been defined as, 'a web of groups, organizations and/or individuals who come together to address a complex and shared cross-boundary problem, issue or opportunity' (Svendsen and Laberge 2005: 92). Allen (1997) earlier described influence through such networks as 'associational power'.

Convenors are the centre of networks. It is their task to help a multi-stakeholder network to tap its latent energy, resources and intelligence to generate novel solutions and whole-system innovations that no single member could achieve on its own. Of key importance, which relates to agency, is the observation that 'anyone can convene a network if they have the legitimacy and social capital needed to bring the key people together around a particular issue' (Svendsen and Laberge 2005: 92). Agency as a process relates to the role and status of economic agents in relation to other agents and relevant institutions, and social circumstances (Clark 2002). Legitimacy is based on reputation effects and the perception that specific organisations and agents have the power to effect or influence change in economic and policy processes. They are legitimate in that there is a generalised perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions (Suchman 1995: 574). Examples of convenors might include the UK's Confederation of British Industry which markets itself as 'the UK's top business lobbying organisation'.[2] At a local level, the Oxfordshire BioScience Network (OBN) (see below) has lobbying as a function. In both cases legitimacy is derived from their position of speaking on behalf of their constituent members. Social capital is crucial as it is the quality of partnerships within and between organisations that underpin the possibility of bringing about change.

At the regional level, different maps for each of the stakeholders can be used to show where they overlap, in their perspectives on the regional economic environment on the basis of their own interests, their relative influence and where there are gaps in the system. This idea is not entirely new. Cooke (2001) drew attention to the policy agenda of engaging stakeholders (industry, academic, education, research, government and other institutions) in the Scottish biotechnology sector. Similarly, as referred to above, Cooke and Leydesdorff (2006) highlighted the role of stakeholders in multi-level governance in knowledge-based systems, requiring interfacing developments in various directions.

Influence at the regional level is also dependent on the special interests of participants for influence, information and financial resources (Storper and Salais 1997). Feldman (2003) introduced the concept of 'anchor firms' to explore the locational concentration and specialisation of the emerging biotech industry. She suggests that established anchor firms who use a new technology may create knowledge externalities that benefit smaller firms and increase overall innovative output in the region. These include breeding grounds for managerial skills. Stam and Martin (2011) suggest that one of the factors which may have contributed to the problems of the recent decline of the Cambridgeshire high-tech economy is the lack of anchor firms. Moreover, key stakeholders such as the head offices of multinational companies and convenors (public policy makers) might not be based in the region, which means that not all challenges can be addressed though regionally based stakeholder networks.

From the above, it is argued that path dependencies need to be understood as a series of power relationships as an issue of structure and agency: the ability of stakeholders to co-opt membership on the basis of common interests, and money.

This argument relates to one of Martin and Sunley's (2006: 13) unresolved issues associated with path dependence, that of a theory of human agency: 'How do agents interact with, reproduce and transform the path dependence structures within which they are embedded? How do agents produce new paths?' Next the HealthTIES study is used to examine these issues.

HealthTIES: the Thames Valley and Oxfordshire case study

Introduction

The HealthTIES study combines four of Europe's top regions in biosciences, medical technology and health entrepreneurship: Medical Delta (West of the Netherlands), Oxford and Thames Valley, Canton of Zurich, Biocat (Catalonia), and the mentoring region Észak-Alföld in Hungary. The Healthcare Technology Specialization Matrix, framing the thematic focus of HealthTIES, integrates three technology platforms and four major disease areas. Recent scientific and technological breakthroughs in molecular technology, imaging, as well as drug design, development and delivery have opened up exciting new opportunities for primary prevention through risk-factor identification and secondary prevention through early and accurate diagnosis, as well as more appropriate and effective treatments. HealthTIES will apply these technologies to four major disease areas: Cardiovascular, Cancer, Neurodegenerative, and Immunology and Infectious diseases.

The HealthTIES strategic focus is to accelerate the Healthcare Technology Innovation Cycle. The Healthcare Technology Innovation Cycle connects engineers and medical professionals, scientists and entrepreneurs, developers and end-users (medical doctors and patients), geared towards the needs of European citizens. Missing from the table are other regional stakeholders such as representatives of employees, other labour market structures, the regional and local authorities and big pharma. Society and the national government are general stakeholders. Thus networks have the feature of not being inclusive. They do not necessarily convene relationships with organisations that might legitimately be expected to have an interest in the outcomes of interplay between various actors. The motivation for the study is summarised in Table 6.1.

The first stage of the project is designed to assess the strengths and weaknesses of the region by data collection and, on the basis of this analyse, the hurdles and best-practices for all aspects of innovation (for example, policies, legal aspects, IP system). The next stages involve designing and implementing action plans for each region and across regions.

The Thames Valley and Oxfordshire

The Thames Valley's local endowments (Clark *et al*. 2002), and Oxfordshire's in particular, in principle make it an already favourable region for this kind of intervention. Martin and Sunley's (2006: 23) 'possible sources of regional path

Table 6.1 Regional innovation by design in health technologies

Region dimension	*Thames Valley*
Focus	Healthcare Technology Innovation Cycle
Shocks	Increasing ageing populations and sustainability of healthcare system
Responses	European inter-regional collaboration, biomedical scientists, firms and policy-makers
Linkage	FP7
	Key convenors: Professor of Medical Oncology, Oxfordshire Bioscience Network (OBN)
	Intermediaries – OEO, Said Business School etc.
Technologies	Life sciences
	Medical technologies

Source: adapted from Cooke 2011.

dependence' are used here to identify where the region's particular strengths and weaknesses lie. Its primary strength lies in its, 'local external economies of industrial specialisation'. It has approximately 600 healthcare companies, nearly a quarter of the UK's pharmaceutical manufacturing companies – some 300 pharmaceutical companies (R&D and manufacturing), over a quarter of the UK biomedical sector and 14 per cent of the UK's diagnostic sector.[3]

Oxfordshire specialises in biotechnology, with a limited presence of big pharma. OBN (2011) has estimated that there are around 163 biotech firms in the county, up 14 per cent since the start of 2008. Of the new ones, the majority (86 per cent), were local start-ups or spin-offs and four were either new branches of larger companies or companies which had moved into the county. The trend has been for more start-ups and fewer relocations or new branches. The strength of the sector is increased venture capital investment: $450 million over three years (up 50 per cent from 2005–7); attraction of a stream of R&D companies, and maturing and developing product pipelines, with some 292 pipeline products. Drug discovery and development is the largest sector (22 per cent), followed by medical technology (19 per cent), the fastest growing sector, diagnostics (15 per cent) and laboratory supply (15 per cent). In the period 2005–9, Oxford University produced the most university spin-offs in the sector of all UK universities (Mobius Life Sciences Fund 2010).

Oxfordshire, although it is the dominant location for biomedical research in the region, does not have a distinctive technological regime or innovation system. Instead it has 'dedicated technology and research organisations'. The county has a world leading university (University of Oxford), plus Oxford Brookes University and a dense concentration of research institutions specialising in biomedical research. Some are attached to the university in the form of charity-funded institutes, some are free-standing institutes based in Oxford, while the others are located in the south of the county on the Harwell Science and Innovation Campus. Associated with these is a very highly skilled labour force, in part related to dominance of the public sector, which, when higher education is included, is the highest in the UK. Oxfordshire has the fifth highest proportion of residents employed in managerial, professional and technical occupations at 51.3 per cent, compared to 44.0 per cent across Great Britain. For professionals alone, Oxfordshire ranks second behind Cambridge (Lawton Smith and Waters 2011).

The Oxfordshire BioScience Network (OBN) is a region-specific sectorally focused institution. It is through OBN[4] acting as a convenor of firms, investors and suppliers that the HeathTIES project most immediately is making a difference through inter-regional, inter-firm linkages. It does this by networking, holding events and coordinating elements in the supply chain.

Between 1999 and 2010, OBN hosted around 150 networking events for bioscience industry in and around Oxfordshire, including networking events in London and elsewhere in the Thames Valley. These OBN argues (OBN 2011) have contributed to the Oxfordshire Life Sciences cluster's development as a social entity, thus as a fully functioning cluster. Networking outcomes include gaining new business, obtaining funding, acquiring competitor intelligence and scientific knowledge. Clustering around Oxford has also led to the OBN Purchasing Scheme. Agreements have been made by OBN with 25 suppliers to reduce margins to gain a larger share of available business, for example, in couriers, recruitment, IT services and financial services. This Scheme has now been extended to OBN members elsewhere in the UK.

Its major event, BioTrinity, is an annual trade fair. The event brings together SMEs with big pharma and their corporate venturers. In 2011, OBN targeted companies from HeathTIES partner regions. Participant firms included Novartis, AstraZeneca, Shire, Merck, GSK, Pfizer, Sanofi Aventis, Boehringer, Baxter, Takeda, Teva, Lilly, Abbott, Smith & Nephew, Fosun Pharma, Ironwood Pharma, Merck Serono, Novo A/S, J&J and Lundbeckfund. Over 450 companies from 19 countries across Europe, Asia and North America and 75 investment firms that specialise in funding emerging biotechnology companies took part.[5]

A further plus for Oxfordshire is the reinforcing role of national public policy towards the healthcare sector which has a disproportionate impact on favoured regions (see Martin and Sunley 2006, on nation-level, system-wide arena), and also contributes to the resilience of the region in this sector. Moreover, in a sector such as the life sciences/healthcare sector, the organisation of the production system (from research through to healthcare deliver) takes place within an international context. Big Pharma are global players and developments in any country and any region have to be seen in that context. Hence 'lock-in' is not such a straightforward idea since 'high inter-relatedness and embeddedness' is less likely to be the cause of a decline of activity of that sector in a region. Instead, examining stakeholder/convenor behaviour might be more productive, and, as Martin and Sunley (2006) suggest, the extent of multiple related path dependence across and between regional economies considered. Possible mechanisms include new knowledge being brought into a region directly by inter-firm collaborations, by inward migration of firms, or by merger or acquisition. Firms can also leave. Pfizer closing its R&D operations in Kent in 2011 is an example of a negative impact of an external event on a region.[6]

Where the UK and the Oxfordshire Life Sciences system is weak is in a financing gap in 'innovation capital' for early-stage companies. This restricts the progression of companies that are creating the innovations which big pharma will develop through in-licensing and acquisition, and is a particular problem in the UK compared with the rest of Europe (OBN 2011). In order to overcome this gap, OBN has started its own fundraising advisory service, OBN Capital Advisors. It also organises match-making meetings with investors at BioTrinity, and at regular networking meetings to which investors are invited.

It also lacks dedicated incubators. Its one small incubator (Diagnox) (12 tenants, 279 m^2 letable space) is full. Although there are other incubators in the county, bioincubators do not form a significant element for support in the life science sector as in other regions (Mobius Life Sciences Fund 2010).

The trajectory of the healthcare sector in Oxfordshire

The data on the healthcare sector used to present an overview of the sector's local trajectory are explored from two perspectives. The first is a longitudinal study of the sector going back to data collected in the 1980s (Lawton Smith 1990) supplemented by data from OBN and Isis Innovation, Oxford University's technology transfer company, and publicly available databases such as FAME, which holds financial and activity data on firms in the UK and Ireland.[7] The second is exploration of the degree of interconnectivity between firms and research institutes as measured by patent citations. This is a reasonable proxy, given that the healthcare sector is characterised by analytical knowledge bases where scientific knowledge is highly codified but where university industry links are important (Asheim *et al*. 2011).

Preliminary data on 84 biotechnology and pharmaceuticals spin-off companies in Oxfordshire is presented here. The general state of the sector is used as a base point for comparisons with spin-offs from Oxford University. Although there are some positive signs of growth in the cluster and in the performance of Oxford University spin-offs, there are also some negative ones. The first is the decline in employment of some of the larger firms, the second is the relatively poor recent performance of Oxford University spin-offs, and the third is the lack of connectedness of the sector as indicated by Oxford University life science patents.

The trajectory of the sector based on the 84 firms shows an upward trend. Firm formation rates, however, slowed down in 2009–10. This trend is matched by a decrease in turnover and employment. Figure 6.1 shows that the large majority of the companies were established between 1995 and 2010. The oldest company is Penlon, which was established in 1943. The youngest company is IXO Therapeutics, established in 2010. 2002 was a good year for university spin-offs: seven were formed of which four survive. Of these, 70 companies (83 per cent) are still active, either independently or as part of other companies and groups. Figure 6.2 shows the split of the companies based on their status in February 2010. This trend is matched with that of the life sciences cluster as a whole, suggesting an improving stability and resilience in the sector. The proportion of companies of

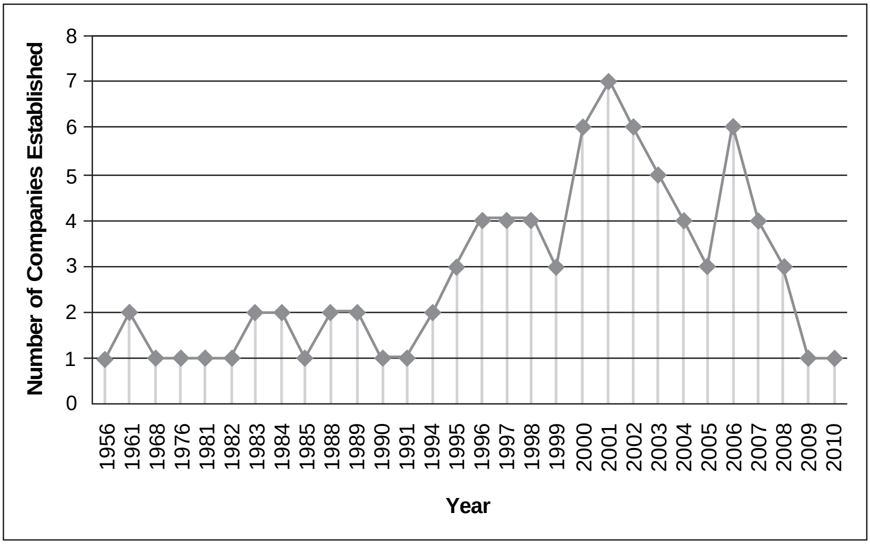

Figure 6.1 History of the group of companies by date of formation

six or more years in 2010 was considerably larger than in 2007 (70 per cent compared to 50 per cent) (OBN 2011).

Trade sales as well as IPO are indicators of the health of a cluster's firms as they are indicators of investment opportunities. Overall in the Oxfordshire bioscience cluster, M&A has been slow since 2008 and concentrated into fewer but larger activities. For example, the acquisition of OSI Pharmaceuticals by Astellas for

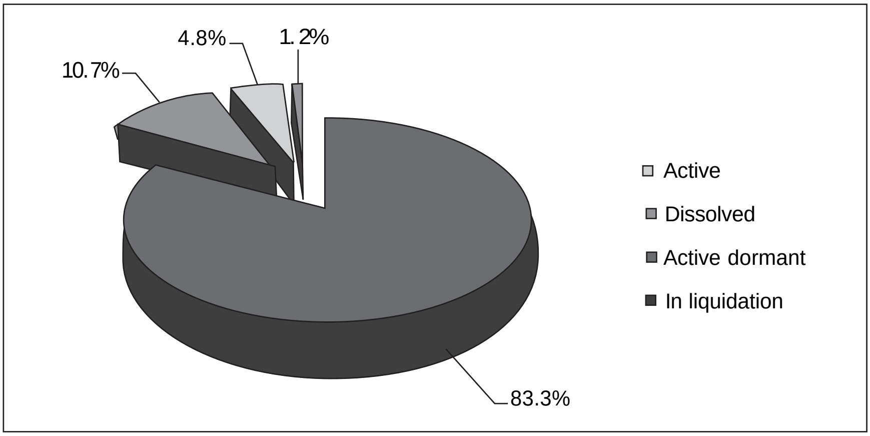

Figure 6.2 Status of the Oxfordshire healthcare companies

Source: OEO.

$4m included the Oxford-based Prosidian subsidiary. However, a significant proportion of its intellectual property (IP) and clinical assets were subsequently sold off in 2011. Acquisition of Oxfordshire companies in the past three years has led to an increase in job creation and investment facilities, even in some of the university spin-offs, in line with predictions by Weitzel and McCarthy (2009). Other university spin-offs have been bought out by US investors. For example, BioAnaLab formed in 2002 was acquired by Millipore Corporation in 2009 and Surface Therapeutics, formed in 2004, was acquired by Serentis Inc in 2007. Hence a problem for stakeholders is how to help companies grow and keep the benefits in the region, or at least the UK, without making them even more vulnerable to take over. Other M&A activity has been through Oxfordshire companies buying other companies, for example, Oxford BioMedica's acquisition of RecipharmCobraBiologics in 2011.

Using HealthTIES classification of companies by size (which is not the standard classification of SMEs employing less than 250), the group is largely formed by small companies. Figure 6.3 shows the classification of companies by size in 2009. There are no very large companies, hence no examples of very large anchor firms (Feldman 2003) which would contribute to county's bioscience cluster through providing a source of experience professionals and know-how and so on.

Survival is not matched by either a growth in the number of employees or in turnover. The total number of employees dropped in 2009 after growing from 2006 (Figure 6.4). This data has to be analysed taking into consideration that employment data was available for 48 companies in 2005, 63 companies in 2006, 23 in 2007, 21 in 2008 and 18 in 2009. Biomedical spin-offs from Oxford University have been relatively under performing in the last 20 years, especially the last 10 years. There have been a small number of exceptions, for

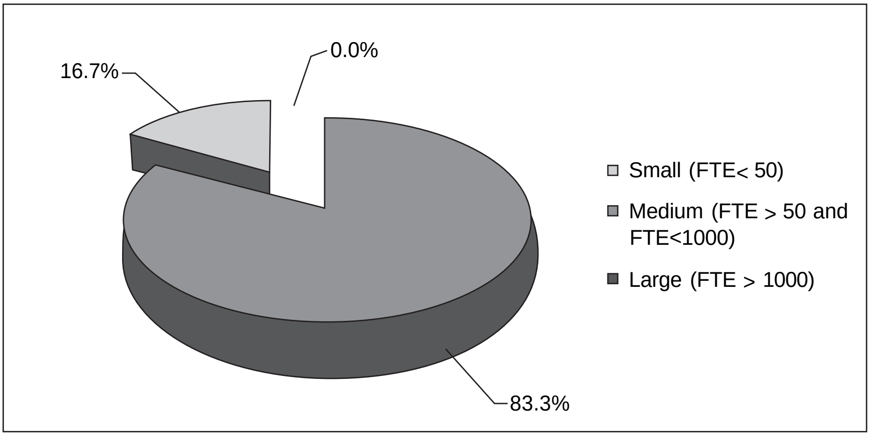

Figure 6.3 Classification of companies by size in 2009

Source: FAME/OEO.

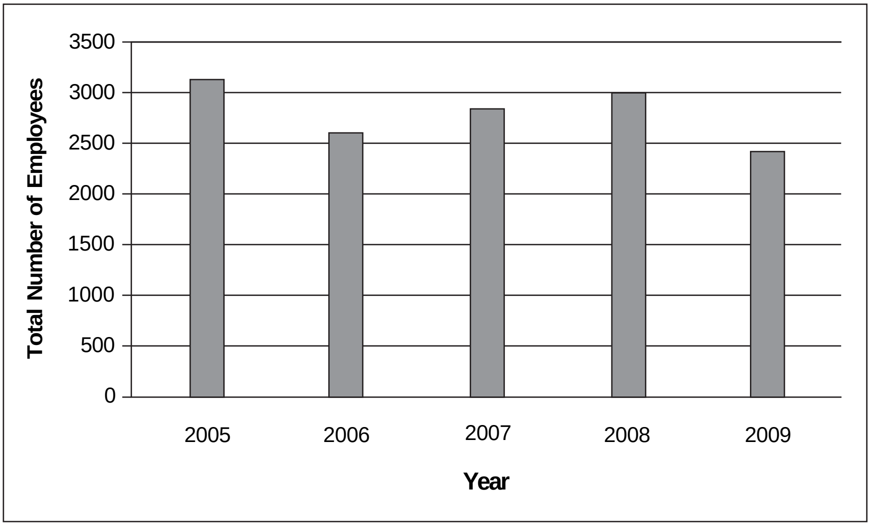

Figure 6.4 Total number of employees for the period 2005–9

Source: FAME with OEO elaboration.

example, Oxford Immunotec, which is not one of the largest companies and Oxitec. Table 6.2 shows the size of the most successful Oxford University spin-offs. Overall, employment levels are relatively constant, with some firms losing employmen, for example, Medisense, the largest.

The financial performance of the group as a whole also experienced a substantial decrease in 2009. Total turnover dropped by 20.4 per cent between 2008 and 2009 (Figure 6.5). However, Figure 6.5 should interpreted with care taking into consideration that in 2005 and 2009 turnover data was available for 59 companies, for 29 companies in 2007, 26 in 2008 and 2003 in 2009.

Table 6.3 shows turnover of the Oxford University biomedical spin-offs. The whole pattern is one of stability, with some notable increases, for example, Cellmark Diagnostics, and the Evolutec group, with declining fortunes for Oxford Biomedica and Summit.

Since 2005, five companies out of 84 have been publicly quoted. These companies are: Oxford Biomedica PLC, Summit Corporations PLC (formerly VastOX PLC), Evolutec Group PLC, Haemocell PLC and Physiomics PLC. The total market capitalisation of these five companies has moved from a minimum of £61 million to a peak of £280 million. These have not been very recent. OBN (2011) found that there had been no bioscience IPO since 2006.

Figure 6.6 shows the total market capitalisation for the publicly quoted companies from 2005 to 2009, which indicates a sharp dip in 2008. OBN (2011) noted that of 14 South East Region firms that floated between 2004 and 2007, five have effectively failed, eight are still trading, and one has been delisted and is still

Table 6.2 Oxford University spin-offs employment ranking

Company name	*Year of incorporation*	*1996*	*2001*	*2005*	*2006*	*2007*	*2008*	*2009*
Medisense (Owned by Abott Labs)	1990	448	1297	1175	885	897	848	640
Penlon Ltd	1996*	—	261	268	277	277	290	292
Harlan Laboratories UK Ltd	1976	—	—	218	213	232	281	269
CMED Ltd	1999		25	86	133	188	210	251
Orchid Cellmark Ltd	2000			161	181	188	196	238
Evotec OAI UK	1991	71	289	358	359	243	211	205
Serotec Ltd	1981	38	42	60	78	77	80	83
Oxford Immunotec Ltd	2002			26	42	35	65	75
Summit Corporation PLC (was VastOX PLC)	2003			19	48	135	142	73
Oxford Nanopore Technologies	2005					17	28	70
Oxford Biomedica PLC	1996	20	110	69	72	80	85	69
Haemocell Ltd (part of Surgical Innovation PLC)	1988	22	21	44	47	48	45	63
Evolutec Group PLC	1998		2	11	12	6	26	39
Oxagen	1996		98	30	18	18	18	17
Oxford Ancestors Ltd	2001			10			11	12
Physiomics Plc	2001		2	6	6	6	6	5
Oxford BioInnovation Ltd (now Diagnostics Systems Laboratories Inc)	1997		6	10	11	8	8	2

* Penlon, an Oxford University spin-off, was founded in 1943.

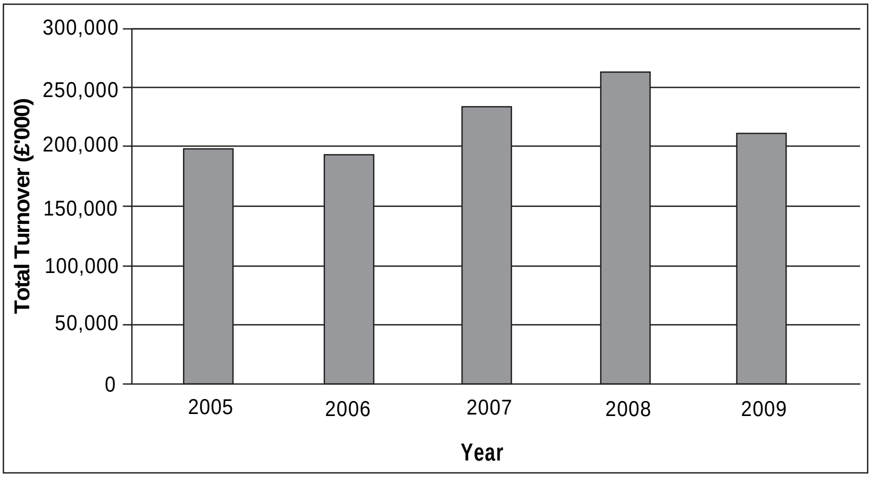

Figure 6.5 Total turnover of the companies between 2005 and 2009

Source: FAME – OEO Elaboration.

trading. Many of those still trading are valued between 2 per cent and 15 per centof their share price in 2007, with only two faring better. The small cap Physiomics plc, an Oxford University spin-off, appears to be the only one for which the share price has remained broadly stable.

With respect to raising finance, some of the Oxford University spin-offs have been among the top ten fund raisers in the county, which collectively raised $313 million between 2008 and 2010. This is approximately one sixth of the total investment in the UK bioscience sector over the same period. This was up on the previous years, when the effects of the recession were noticeable on investor confidence. The Oxford BioCluster is therefore performing well compared to the rest of the UK, particularly since 2008. Top were Oxford Nanopore technologies, (formed in 2005), Summit, Oxford Immunotec (2002) and (Oxagen 2007). Therapeutics attracts the most investment, and most UK investment is in the Golden Triangle, with Oxford and the South East attracting half the total (OBN 2011).

However, it is later-stage bioscience companies, which are closer to the market rather than early-stage R&D ones, that have been most favoured by investors. Investors have tended to be more risk averse. Hence the picture is one of an investment divide in the UK. This divide is probably a crucial factor in the poorer performance of some of the recent Oxford University spin-offs. What seems to be happening is that failure to raise finance, combined with weak progress between pre-clinical and clinical stages, leaves firms open to acquisition by US and other investors.

Table 6.3 Oxford University turnover (£'000) ranking

Name	*Year of incorporation*	*1996*	*2001*	*2005*	*2006*	*2007*	*2008*	*2009*
Medisense (Owned by Abott Labs)	1990	18622	65362	70729	53728	56592	57573	52319
Penlon Ltd	1996		18845	22413	27364	28509	32008	32704
Evotec OAI UK	1991			33927	34669	32829	26154	25455
Harlan Laboratories UK Ltd	1976			13782	16073	19401	19859	21354
Orchid Cellmark Ltd	2000			16086	14900	14994	14296	18840
CMED Ltd	1999		2000	6541	9815	10230	11615	13533
Serotec Ltd	1981	3315	3197	5372	6851	8616	8950	9427
Haemocell Limited	1988			4018	4460	4770	4312	4541
BioAnalab Ltd	2002			655				3634
Evolutec Group PLC	1998			14	14	82	1994	2937
Oxford Immunotec Ltd	2002			290	636	1156	2001	2746
Oxford Biomedica PLC	1996			824	760	7219	18394	1912
Pharminox Ltd	2001				405	1113	1326	1115
Oxford BioSignals Ltd	2000			955	670	977	1411	1073
Aurox Ltd	2006				17	80	83	726
Physiomics Plc	2001			159	164	153	275	306
G-Nostics	2003				54	19	55	240
Oxitec Ltd	2002			137	41	75	105	196
Summit Corporations PLC (was VastOX PLC)	2003			531	1034	3030	1831	189
Oxford Nanopore Technologies	2005					182	361	125
Inhibox Ltd	2001			85	282	216	69	65
TDELTAS	2006				99	67	79	62
Oxford Medistress	2006				8	16	17	10

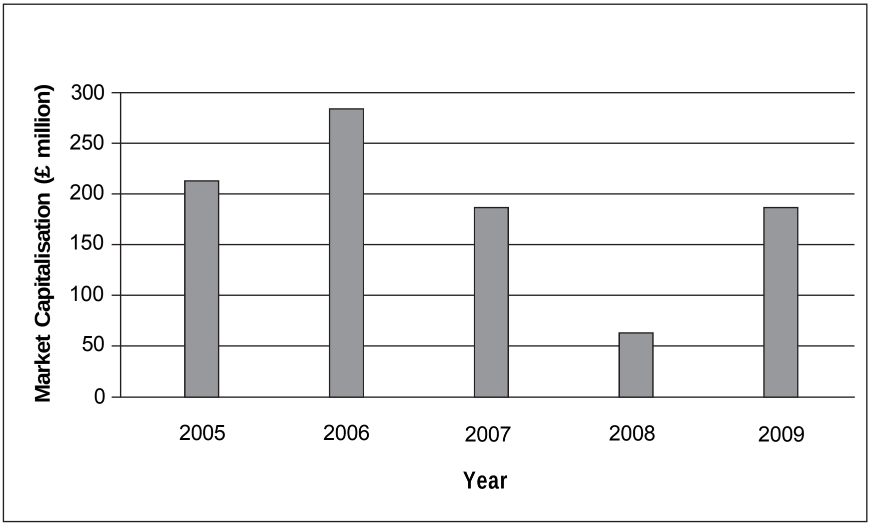

Figure 6.6 Total market capitalisation for the publicly quoted companies between 2005 and 2009

Source: FAME.

Patenting and connectedness

A lack of interconnectedness between the science base and industry in Oxfordshire is shown by patent data. Isis Innovation, Oxford University's wholly owned subsidiary responsible for technology transfer, is the most prolific patenter in the Thames Valley region over the study period 2001–10. It has had 369 medical and life science patents granted (21 per cent of total) excluding 45 University of Oxford patents (3 per cent), 77 of which are US patents (21 per cent). It has created 65 companies since 1997 and filed, on average, one patent application each week: there was a marked acceleration in patenting rate since 2007. While many technology fields are represented, medical and life science are increasingly dominant.

The important point to note, however, is the small number of citations for those patents within the region. Figure 6.7 shows the Oxford Region Patents Map for USPC435: molecular biology and microbiology. This is not what would be expected in a more networked cluster such as in Silicon Valley. There is therefore a role for the regional stakeholders to overcome such fragmentation.

Moreover, patenting itself is not a guarantee of business growth. Table 6.4 shows that even the most successful patent holders do not make money out of them. The evidence shows that the region has the ability to invent in the medical/ life science sectors. However, small patent-intensive firms are lacking local investment and commercial know-how to innovate (that is, successful commercialisation of inventions). Patent maps show little evidence of commercial networking and synergies between academia and industry or universities and government.

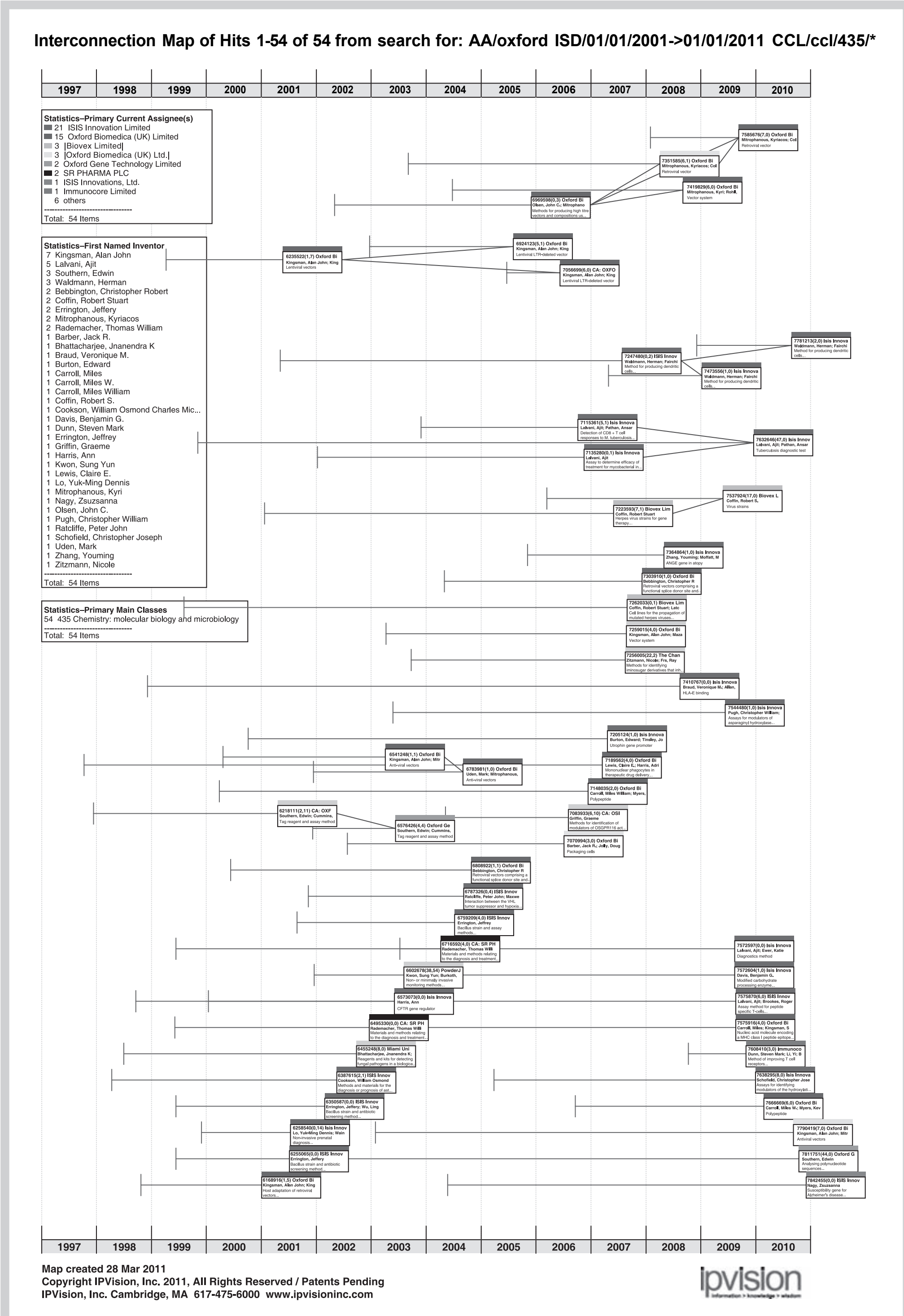

Figure 6.7 Oxford Region Patents Map

Table 6.4 Commercialisation of patented inventions in the Thames Valley

Company name	*Date of incorporation*	*Patents granted (2001–10)*	*Income (2009) patents (2001–10) in £million*
Vernalis plc	1988	141	0.1
Syntaxin Ltd	2005	27	0.1
Summit plc	2004	33	0.0
Chroma Therapeutics	2000	50	0.0
Biovex Ltd	1997	23	0.0
Oxagen Ltd	1996	30	0.0
Sense Proteomic Ltd	1996	22	0.0
Proimmune Ltd	1999	14	0.0
Surface Innovations Ltd	2001	13	0.0
Circassia Pharma Ltd	2006	14	0.0

Note: All companies except Vernalis plc are based in Oxfordshire.

In line with the argument made earlier, the region is lacking local/large institutional venture capital investor(s) to provide the guidance/networking required to rapidly/globally scale up. Only a handful of small firms have had the benefit of more substantial investment and commercial support from US VC investors, for example, Archimedes Pharma ($95m, 2010), Syntaxin, Oxford Immunotec, Chroma Therapeutics and Circassia Pharma. Patented inventions, whilst desirable, are not a sufficient condition to create sustainable business. Exits remain scarce and the track record of successful investment and commercialisation is limited.

Conclusions: path dependence, constructing advantage, stakeholders and possible outcomes

This chapter has suggested that the impact on path dependence from attempts to construct regional advantage is inevitably variable. It will depend on path interdependencies, engagement by key stakeholders and convenors, and absence of others. It brings into focus the role of human agency (Martin and Sunley 2006). The vision of a super-cluster for life sciences in the Golden Triangle region will require UK and local stakeholders to adopt bold plans (OBN 2011). Taking the HealthTIES project, possible constructed advantages which could contribute to that intent include the following possible scenarios.

The first is that the stock of firms will be strengthened as a result of intervention by key stakeholder convenors in the region. This could be through SME collaboration across the partner regions. OBN appears to have a key role as a convenor of business-facing networks, which include companies, investors, supplier, and so on. The challenge for the HealthTIES project convenors is to link those activities to the other sections of the HealthTIES cycle, particularly medical and engineering sciences within the regions.

The second is that the range of knowledge developed in the science community will increase scientific cross-regional interactivity. Science community interactivity with the hospitals and SMEs might also produce a quicker to market set of applications. As is intended, SMEs will be supported by Said Business School in taking forward these applications to market by training to improve management skills. It is possible, however, that inter-regional scientific interactivity may run in parallel to the other activity, as there is an easier match of interests, and the applications output will be less significant.

Third, the region seems to be vulnerable to changes in the performance of existing firms and the relatively weak university spin-offs that have been established in recent years. It is possible that HealthTIES will produce a constructive response in Isis Innovation because of the leverage power of Oxford University's scientific elite represented in the study. From a negative regional perspective both of above, that is, 'strong path dependence in a particular industry attracts agents to it' (Cooke 2011: 5) may increase attractiveness of the assets of the Oxford/TV region – to American investors – who are more active than UK investors. The outcome is that the firms' activities are transferred to the US (external de-stabilisation, Cooke 2011). It is therefore necessary that all of the elements in the healthcare technology innovation cycle are strengthened.

This vulnerability of the system is shown by the absence of necessary stakeholders, such as UK venture capitalists represented in the region. Venture capitalists are also convenors through the use of their networks to bring market access, management skills, as well as finance, to the firms in which they invest. Smaller seed funding is less of a problem. This, however, is a chicken and egg problem – the scientific developments may not be robust enough to attract sufficient venture capital. Moreover, the project also lacks other critical stakeholders in the form of big pharma. Larger firms are yet to be incorporated into the project strategy. Both of these will be addressed in the Joint Action Plan at a later stage in the project.

Notes

1 The author acknowledges the contributions to the paper by Saverio Romeo and Pierre Nadeau on the data collection and analysis, and to Jon Rees, CEO OBN for his kind support and insights.
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7 Reframing regional innovation systems

Evolution, complexity and public policy[1]

Elvira Uyarra and Kieron Flanagan

Introduction

Understanding the dynamics of innovation at the regional level is a growing concern both for scholars trying to understand uneven regional development and for practitioners seeking to improve the economy prosperity of places. The centrality of the region not only as a repository but especially as a source of new knowledge has led to a rich literature linking innovation dynamics with regional development. Heterodox approaches in economic geography (many of them subsumed under the label of 'territorial innovation models' (Moulaert and Sekia 2003) have, for instance, stressed the importance of local institutional dynamics for inter-firm networking and industrial development. The literature on Regional Systems of Innovation (RSI), in particular, has been influential in conveying the idea that firms interacting locally, with adequate institutional support, are able to achieve higher rates of innovation, and ultimately generate quality jobs and growth in the region. The RSI literature (see for example, Cooke *et al*. 1997; Braczyk *et al*. 1998; Howells 1999; Doloreux and Parto 2005) has over time developed into an extensive body of work (Carlsson 2005), and has been influential as a framework for the design, implementation, justification and evaluation of policies in a variety of regional and national settings. Reservations have, however, been expressed about RSI research adopting a narrow regional focus and an implicitly static analysis. Other concerns relate to the normative uses of the concept, which paradoxically risk devaluing its policy relevance in the longer term (see for example, Uyarra 2010).

These critiques provide a starting point from which to revisit the debates over regional systems of innovation and examine the core arguments in the light of recent contributions from evolutionary and complex systems perspectives. The adoption of more explicit evolutionary and complex systems approaches promises an improved understanding of the evolution, transition and resilience of regional systems whilst, at the same time, raising new conceptual and methodological challenges. One such challenge relates to the relatively underexplored implications of evolutionary thinking for public policy.

This chapter briefly reviews the key insights of regional systems of innovation (part one) and discusses the implications of evolutionary and complexity approaches for our understanding of localised path dependent trajectories, institutional change and regional resilience (part two). Part three explores the issue of evolutionary policy dynamics and suggests some directions for future research and part four presents some final remarks.

Regional systems of innovation: networks, institutions and policy

The term 'regional system of innovation' came into use in the early 1990s, informed by in-depth research on a number of European industrial regions (for a detailed review of the origins of the concept see Cooke 2008). These regions were seen to be operating as innovation systems, namely a 'geographically defined, administratively supported arrangement of innovative networks and institutions that interact regularly and strongly to enhance the innovative outputs of firms in the region (Cooke and Schienstock 2000: 273–4). Given such a definition, not all regions (probably very few of them) could fulfil the characteristics of a functioning RSI (Cooke 2001). Attempts at replicating such systems would therefore always be 'a difficult and hazardous venture' (Iammarino 2005: 504).

According to Doloreux and Parto (2005) three dimensions underpin the use of the RSI concept, namely: the interactions between different actors in the innovation process, the role of institutions, and the use of regional systems analysis to inform policy decisions. We discuss each in turn. First, implicit in the definition of RSI is an emphasis on *innovation as an interactive and dynamic process* reliant on learning in networks of related actors (Lundvall 1992) and on the *localised nature* of such networks (Cooke *et al*. 1997; Howells 1999; Koschatzky and Sternberg 2000; Freel 2002). According to Howells (1999), RSI are characterised by bottom-up features including localised patterns of communication, search and scanning processes, localised invention and learning patterns, knowledge sharing and localised innovation capabilities and performance. The symbiotic relationship between innovation, networks, and proximity has long been a focus of interest for economic geographers and innovation scholars. For instance 'knowledge spillover' studies have sought to gauge the impact for firms (especially 'knowledge intensive' SMEs) of locating in close proximity to private and public R&D activities (Audretsch and Feldman, 1996). With the assumption that knowledge is either codified (and thus readily transferred) or tacit (and thus potentially harder to transfer), such studies suggested a 'typical distance decay function in communication' (Howells 1999). Other accounts such as the 'innovative milieu' (Aydalot 1986), the 'learning region' approach (Asheim 1996; Morgan 1997), the 'network paradigm' (Cooke and Morgan 1993), and localised learning and 'collective learning' (Keeble and Wilkinson 1999) also stressed the relational and cultural underpinning (or embeddedness) of such networks.

This emphasis on localised knowledge networks has led commentators to critique what they perceive as an 'overterritorialised' (Hess 2004) view, namely a tendency to underplay the importance of non-local links while potentially overstating the incidence and benefits of lasting proximate relationships (Bunnell and Coe 2001; Lagendijk 2002; MacKinnon *et al*. 2002; Bathelt *et al*. 2004). Cooke (2005) however maintains that the term 'regional' in RSI is used in a relational not containerised sense. Other considerations have been put forward from the point of view of network theory. Grabher (2006), for instance, suggests that economic geographers have tended to emphasise strong, locally embedded, cohesive networks whilst neglecting weak, extra-local networks. Yet cooperative, trust-based relations in local inter-firm networks may be the exception rather than the rule and, even where they are strong, they may lead to cognitive lock-ins and may reduce the adaptability of regions (Grabher 1993; Oinas 2002). Further, the influence of knowledge networks on innovation are likely to differ across firms according to differences in 'network centrality'. As will be elaborated in the next section, of recent interest to economic geographers is not only the density of inter-firm networks but also the emergence, types and structural characteristics of such networks (Cantner *et al*. 2010; Ter Wal and Boschma 2009).

Second, the *institutional context* in which actors are embedded is part and parcel of discussions on inter-firm relationships and therefore of RSI. Localised innovation networks are considered to be nurtured by a 'number of institutions of a private, semi-public, and public nature which act as a "life-support" system, especially for SMEs' (Cooke and Morgan 1993: 555). The so-called 'institutional turn' within economic geography emphasises the role of institutions in influencing firms' behaviour, particularly in relation to inter-firm networking and industrial relations. In this view, the presence of a RSI is associated with a strong regional institutional density or 'thickness' (Amin and Thrift 1995). Howells (1999) lists a number of top-down (macro-to-micro) dimensions of RSI, such as the role of policy, institutional set-up and industrial structure, whereas Asheim and Gertler (2005: 299) define RSI as 'the institutional infrastructure supporting innovation within the production structure of a region'.

Despite the importance attached to institutions in explaining uneven regional development, the roles they may play remain poorly understood (Gertler 2010; Doloreux and Parto 2005). One point of concern is a tendency to take an ahistorical view of actors and institutions, potentially downplaying or underexploring their emergence, evolution, restructuring and disappearance over time. 'Supportive' institutions are time and context specific, and may change or even contribute towards inertia and lock-in over time. Reference to institutions and other system components is all too easily reduced to a list of functions or activities (such as knowledge production, knowledge use, knowledge intermediation) that are expected to be present in an idealised 'system'. An unfortunate unintentional implication of this kind of approach is that institutions and actors exist to fulfil an explicit function within the system (Flanagan *et al*. 2011). Yet as Pierson (2000b: 477) notes, 'it is one thing to demonstrate (or, more often, speculate) that an institution is "doing" something for social actors. It is quite another thing to jump to the conclusion that this accounts for the institution's presence'. Clearly not all innovation systems will consist of the same actors (or institutions) performing the same function (Cooke 2003). More research is needed to understand actors and the roles they play over time, and across different systems, recognising that the roles actors may play are not always those analysts or policy makers may expect or intend them to play (Flanagan *et al*. 2011).

It has also been argued that, whilst economic development is clearly rooted in region-specific institutional settings, the impact of institutions may sometimes be overstated: they are likely to condition rather than to determine economic behaviour (Boschma and Frenken 2009). An over-emphasis on networks and institutions supportive of innovation risks downplaying the agency of individual and collective actors. Actors are seldom simply the passive targets of policy intervention; they are often directly or less directly able to shape policy and influence outcomes (Flanagan *et al*. 2011). Related to this, Gertler (2010) proposes a reconstituted institutional economic geography incorporating individual agency, institutional evolution and change over time (see also Parto 2005; Christopherson and Clark 2007; Sotarauta and Pulkkinen 2011).

The idea of RSI has, over time, become widely adopted by policy makers across and beyond EU and OECD member states, as part of a wider process of regionalisation of industrial policy and economic development policies.[2] This link between theory and policy has led some scholars to criticise RSI research as policy-led (Lovering 1999), whilst others have urged caution about the growing use of RSI as a normative concept (De Bruijn and Lagendijk 2005; Moulaert and Mehmood 2010; Uyarra and Flanagan 2010). Fløysand and Jakobsen (2011: 2) argue that 'with the development of strong linkages between research and policy, the [system] approach has been reconstructed as a standardized model for best innovation practice and used instrumentally for adjusting system failures within national, regional and even local innovation systems'. Iammarino (2005: 504) suggests that when a normative interpretation is adopted, 'then the question becomes one of what an RSI ought to be, and drawing implications (particularly those for public policy) from stylised constructs should be done with caution'. A lack of caution may lead to an uncritical translation of insights informed by very specific and unique regional realities into an all-purpose formula for development (Storper 1997). For instance, a normative account of the 'functions' a system should deliver might promote unrealistic expectations about the feasibility of reproducing all the relevant elements within a territory, whilst downplaying bottom-up processes and initial conditions. Normative accounts may involve prescriptions for the creation of new organisations to fulfil new roles (or roles that are perceived to be lacking in the system), neglecting existing organisations and the roles that they could and do play. Introducing new actors may often seem easier to policy makers than reforming established ones (Boschma 2005). Radosevic (2002) identifies this tendency in discussing attempts to build regional systems of innovation in Central and Eastern Europe, noting that policy sponsors were more likely to establish 'greenfield' organisations rather than to 'deal with the messy and complicated world of existing institutions'.

A further risk is that normative assumptions about the extent to which systems are unproblematically amenable to regional policy intervention downplay policy complexity and uncertainty (Uyarra and Flanagan 2010). Moulaert and Mehmood's (2010) 'localist trap' refers to an unrealistic view of the strategic leeway of local policy makers, or in other words a belief that 'they can act effectively regardless of the political and economic realities operating on them' (Christopherson and Clark 2007: 11). Falling into this 'trap' is to assume that innovation and competitiveness strategies constitute the main driving force of actual regional development (Moulaert and Mehmood 2010). When the performance of the system is seen as the result of regional innovation policy, we can assess the impact of the latter by measuring the former, replacing a difficult and frustrating challenge of dealing with a complex and unpredictable system by a seductively simpler one of applying and improving measurement, benchmarking and evaluation tools.

Finally, despite the allure of system approaches in informing policy, missing in most discussions is a view of the state and of public policy that is grounded in evolutionary thinking (Boschma and Martin 2010).[3] Reference to policy is generally restricted to normative views about how policies should look like, based on systemic or evolutionary views (*inter alia* that they should be adaptive and bottom-up, target specific systemic failures and avoid 'one-size-fits-all' solutions). Generally absent is a positive account of policy-making processes taking in policy emergence and change, the agency of actors in relation to policy and outcomes and their influence on institutionalisation processes. We return to this discussion in the final section of this chapter, after a short discussion of evolutionary and complexity thinking and its implications for understanding regional evolution, resilience and path dependence.

Revisiting RSI: networks, diversity and path dependence

Recent contributions from evolutionary economic geographers have sought a dynamic explanation of the evolution of regional systems (see for example, Boschma and Frenken 2006; *Journal of Economic Geography* 2007; *Economic Geography* 2009; Boschma and Martin 2010). Considering the economy as a dynamic, irreversible and self-transformational system, evolutionary approaches are less concerned with how systems should look than with the *adaptation*, *resilience* and *change* of system configurations. Despite lacking a unified, coherent framework and drawing instead from diverse contributions in evolutionary biology, complexity theory, and network science, these approaches have the common feature of trying to link the micro-economic behaviour of agents (firms, individuals) that operate in territorial contexts with the spatial evolution of industries and networks at the meso-level of the economy (Boschma and Frenken 2006; Boschma and Martin 2007). They therefore potentially provide an integrative, micro to macro, view of regional systems of innovation (Dopfer *et al*. 2004; Iammarino 2005). Characteristic features of evolutionary approaches include a consideration of boundedly rational actors and their routines as the unit of analysis; the role of diversity in development processes; the non-linear, dynamic and path-dependent nature of economic development; and the dynamics of adaptation and co-evolution of economic, technological and institutional environments. Evolutionary economic geographers seek to demonstrate how place matters in such evolutionary processes.

Localised, path-dependent trajectories

Evolutionary approaches reject the idea of the 'representative' firm, viewing differences in firm behaviour as the driver of economic change (Metcalfe 1995). In the presence of bounded rationality, firm behaviour is guided by routines through which they create, and adapt to, novelty through learning. Routines can be understood as decision rules, or regular and predictable behavioural patterns (Nelson and Winter 1982). Generation of novelty occurs as a consequence of search activities and, given the complexity and uncertainty of innovation processes, firms are likely to draw on acquired knowledge and routines and search locally for markets and technologies with which they have become familiar in the past (Boschma 2004). It has been shown that, given a set of assets and capabilities, firms are more likely to diversify into related products (Hidalgo *et al*. 2007). This proximate, partly myopic, search behaviour has a corresponding spatial aspect, one hinted at in accounts of localised interactive learning processes and the path-dependent formation of clusters (Maskell and Malmberg 2007). Initial myopic decisions by entrepreneurs may lead to others deciding to co-locate similar or complementary activities, in turn attracting similar kinds of competencies and setting in motion a cumulative causation process. The result is regional branching effects through related activities and greater spatial heterogeneity.

The way these evolutionary trajectories unfold would therefore be path dependent. Geography and path dependence are thus clearly linked; As Boschma and Martin (2007: 545) note, 'path-dependent processes have a quintessential "place-dependent" character, so that it is not simply a case of arguing that path dependence produces places, but equally that places produce path dependence'. However ideas of path dependence (and 'lock-in') are not unproblematic (see Martin and Sunley 2006; Martin 2010). Indeed to some extent, the wide application of the concept has come at the expense of diminishing analytical leverage, one common misunderstanding involving the consideration of a canonical example of path dependence based on the distribution of events but not the sequencing of such events (Page 2006). Martin (2010) similarly argues that the 'canonical' form of path dependence (derived from the work of Paul David and Brian Arthur) is 'equilibrium dependent' rather than 'outcome dependent' and stresses inertia over change. Particularly problematic in Martin's view are, first, the implication that the origin of new paths is 'accidental' and, second, the notion of 'lock-in' (and a consequent tendency to see 'de-locking' as exogenous). Over-emphasis on initial random events can draw attention away from the influence of pre-existing industrial structure on the development of new industries. At the same time, treating 'path de-locking' as largely exogenous and random appears to all but rule out the possibility of endogenously initiated change. Thus an emphasis on exogenously-driven or 'accidental' path creation is at odds with evolutionary views of capitalism as an economic system that transforms itself from within (Metcalfe and Ramlogan 2008). The undoubted significance of unintended emergence and random events does not rule out deliberate agency – rather path creation is likely to be a complex admixture of the two (Martin and Sunley 2010).

Yet deliberate agency is not perfectly rational but the product of 'imagined conjectures' by entrepreneurs about different courses of action and their consequences (Metcalfe 2011). Ultimately, received ideas about path dependence overlook a richer repertoire of options in the evolution of technologies, industries, and local and regional economies, including the possibility of on-path evolution or even 'path inter-dependence' resulting from overlapping sets of inter-related industries (Martin and Sunley 2006).

Moving on to the meso and macro level, Maskell and Malmberg (2007) suggest that there is a theoretical blind spot in relation to the processes that connect micro behaviour to institutional change. Concentration of activities would be accompanied by the (conscious or unintended) formation of dedicated supporting institutions, in a co-evolutionary process of development of technology, market and institutional environments. Institutional variations are likely to deepen over time in response to requirements of existing economic configurations, and would, in turn, generate a favourable environment for attracting those firms and individuals more compatible with them, making certain activities and behaviour more likely whilst limiting the exploration of certain other possibilities (Maskell and Malmberg 2007, see also North 1990).

Innovation systems as complex systems

Systems of innovation are perhaps best defined as complex systems (Metcalfe and Ramlogan 2008), for they are characterised by 'dynamic, non-linear system change, instability and disequilibrium, not the stability and equilibrium assumed in traditional mechanistic models' (Sanderson 2009). Complex systems emerge when dependencies among constituent elements become important such that removing one such element can completely alter system behaviour. This is because interactions are not random or independent, but characterised by positive and negative feedback.

The characteristics of complex systems include a dynamic structure with interdependent constituents that interact in non-linear ways. The implication is that the network becomes the meaningful unit of analysis, inasmuch as the added value is generated by the connections, and not the elements themselves, and that aggregation from micro to macro becomes virtually impossible (Foster 2005). This 'limited functional decomposability' in turn entails that the macro-level functioning of systems cannot be deduced from knowledge about the system components. In contrast to the 'operational closeness' implicit in many system approaches (Martin and Sunley 2007), complex systems are open, with boundaries that are difficult to identify and structures that may span many scales. Another characteristic is that micro-level interactions result in emergent properties or behaviour, which cannot be predicted by the properties of the system constituents or the system itself. Finally, complex systems are able to self-organise, that is, emergent properties may change structures or create new ones.

Principles from the study of complex systems could be helpful focusing devices to understand RSI. We acknowledge concerns that have been raised in terms of the limitations of selectively importing theoretical frameworks and concepts from physical sciences (Grabher 2006; Martin and Sunley 2007), although the study of complex biological, physical and economic systems can also be considered as sub-categories of a broader general class of complex adaptive systems (Beinhocker 2006). Foster (2005) suggests a four-fold distinction based on degrees of complexity. As one moves up these orders of system complexity, the role of connections and knowledge becomes increasingly significant, and the primary driver of change shifts from imposed energy to natural selection and increasingly to the novelty and selection of ideas. Fourth-order complex systems exhibit interconnected knowledge, a feature that is characteristic of modern economies. Economic development is perceived to be triggered by the emergence and exchange of knowledge, which evolves across multiple network connections (Martin and Sunley 2007; Metcalfe and Ramlogan 2005; Potts 2001). Knowledge (or rather ignorance) is fragmented and distributed, specific, local, and tacit (Metcalfe and Ramlogan 2005; Metcalfe 2011).

Martin and Sunley (2007) consider discussions about knowledge and connectivity in networks and interactions as a point of connection between economic geography, evolutionary and complexity theory, while Grabher (2006) suggests a re-examination of the properties of complex networks and their link with geography. Indeed, the properties of certain network configurations have important implications for the creation and diffusion of knowledge as well as for the vulnerability or robustness of networks. For instance, research by Albert and Barabási (2002) revealed that many networks have scale-free properties, with significant implications for network dynamics. The distribution of links in such networks follows a power law, the majority of nodes being relatively poorly connected whilst a few show extremely high connectivity. This reflects a particular pattern of network growth based on ‘preferential attachment’, whereby new nodes prefer to connect with nodes that have greater connectivity. Such configurations are found to be common in the internet, in citation networks among scientists, and in some innovation networks (Barabási 2003; Powell *et al*. 2005). Scale-free networks, characterised by high connectivity and short average path length, influence performance in terms of knowledge diffusion, generating so-called ‘small world’ effects (Watts and Strogatz 1998).

Geography influences network trajectories and, in turn, localised network evolution influences regional innovation dynamics. According to Glückler (2007), the combination of preferential attachment, local embedding and multiconnectivity constitute cumulative retention mechanisms that induce path dependence in networks, mechanisms that are themselves often mediated by geography. Frenken (2006) notes how geography may play a role in the emergence of ‘small world’ network effects. Since geography acts as a constraint on search behaviour, its influence would counteract the effect of preferential attachment, as companies may connect to proximate companies rather than the ones that have the most connections. The degrees of local connectivity, and the benefits of these connections, differ among local firms in clusters and along the life cycles of clusters (Giuliani 2007; Menzel and Fornahl 2009). For instance Giuliani’s (2007) study of the Chilean wine cluster demonstrated how firms differ in their centrality in the local network and how a number of firms in the cluster can act in a way completely isolated from the network. This interplay between network topologies and geography implies a diverse landscape of spatial network typologies rather than to a dichotomous one of local clusters on the one hand, and global links on the other (Glückler 2007).

The properties of some networks may make them more resilient and robust. In network theory, a scale-free topology implies that a significant fraction of nodes can be randomly removed from the network without it breaking apart. However, despite such apparent robustness, they also present vulnerability around key positions, as external shocks affecting key hubs, that is, highly connected actors, can lead to cascading failures due to their high degree of interconnectivity. The formation of scale-free networks is associated with greater unevenness of network configurations, in contrast to more homogeneous views of networks.

The rather topical idea of *resilience* is increasingly used in connection with the adaptability of regions to external shocks (Hassink 2010a,b,c; Pike *et al*. 2010; Martin 2012). Martin (2012) contrasts the ‘adaptive’ interpretation of resilience, based on the capacity of the system to adapt so as to minimise the effect of a destabilising shock, with other related interpretations of the term, including: an ‘engineering’ interpretation, that is the ability of a system to return to, or resume, its assumed stable equilibrium state; and an ‘ecological’ interpretation, i.e. the scale of shock or disturbance a system can absorb before it is destabilised and its configuration changes. In contrast, the ‘adaptive’ view of resilience is not a static but an evolutionary feature, and can therefore change, influenced by the impact of shocks but also by ‘the ongoing restlessness of structural economic change and adaptation’ (Martin 2012: 15). Adaptive resilience is therefore linked to the structure of regional network configurations. Grabher (1993) has already noted that regions can suffer from lock-in due to too much local connectivity. Grabher and Stark (1997) emphasise the importance of a rich diversity of organisational forms, and of strong and weak ties between social actors within social networks. Loose couplings that indirectly connect social agents, often bridging structural holes between relatively isolated groups of actors (Burt 1992) are crucial for the adaptability of networks. Work on ‘related variety’ (Frenken *et al*. 2007) also suggests that diversified regions, presenting a variety of generic competences and open to extra-local links, may be more likely to adapt to changing conditions and less susceptible to lock-in effects. As Pike *et al*. argue (2010: 65), ‘diversified economies are more adaptable because they act as a “shock absorber”, dissipating negative effects across an array of economic activities and places rather than concentrating and reinforcing them’. It seems therefore that relatedness is both an outcome of evolutionary search processes and also a dependent variable shaping opportunities for further adaptation and renewal (Boschma and Martin 2010).

Evolutionary policy

Considering that political scientists and policy scholars still cannot agree on a standard definition of ‘public policy’, it is remarkable how much the concept is taken for granted. How might evolutionary and complexity views contribute to our understanding of public policy? The policy implications of evolutionary views are not simple or straightforward, and evolutionary thinking can provide arguments for non-intervention (Dalum *et al*. 1992). It is difficult enough to assess how much diversity is desirable, what kind of selection environments are more conducive to innovation and what the units of selection are, let alone to identify the critical bifurcations or branching points that lead to new path creation. Understanding this may only be possible with the benefit of hindsight. As Beinhocker (2006: 283) notes, 'We cannot say a priori what the system is selecting for; one can only observe selection retrospectively, and thus only take an empirical, backward-looking approach to defining units of selection.'

Adopting an evolutionary perspective must thus involve 'a fundamental appraisal of the purpose and limitations of policy action' (Metcalfe and Georghiou 1997), and in particular acknowledging the limited scope for policy makers to influence and direct the evolution of economies. In conditions of uncertainty and complexity, cause-and-effect relations are distributed, intermingled and not directly controllable, so much so that 'policymakers need to become more comfortable with strategies that aim to influence rather than control' (OECD 2009: 13). Given complex interactions between mutually interdependent subsystems, the system's response to change in one element may be highly disproportionate (Sanderson 2009). The resulting difficulty of knowing what effect corresponds to what intervention seriously constrains any attempt to evaluate policies, and gaining greater knowledge of the system by no means guarantees better prediction or control as the observed system does not stand still but is constantly changing and reinterpreting itself (Geyer and Rihani 2010).

Attempts at steering or control by policy actors are made still more difficult by the fact that *they are themselves part of the system* that they are trying to influence. As the concept of multi-level governance (Bache and Flinders 2004) implies, policy decisions emerge out of a complex interplay of many actors across different levels, including non-state actors such as firms, non-governmental organisations, professions and other actors, all engaged in a collective process of negotiation and compromise. This *de facto* governance implies that 'public policy' can no longer be thought of as the work of a single, overseeing policy maker somehow operating outside of the system, even if the distribution of power and resources to influence policy remains asymmetrical (Witt 2003; Flanagan *et al*. 2011). Reflecting on this idea of 'steering from within', Rip (2006) draws the distinction between 'modernist steering', where governance actors see themselves and their goals as outside of the system in which they intervene, and 'non-modernist' steering, in which governance actors recognise they are part of evolving patterns, and they can at best modulate them.

Policy making is increasingly seen as a communicative process based on dialogue, argument, negotiation and persuasion, rather than a technocratic or information-driven process (Majone 1989). This has implications in terms of the scope for scholarly ideas to be translated straightforwardly into rationales for policy making (Laranja *et al*. 2008). As Flanagan *et al*. (2011: 711) note, policy processes, characterised by bounded rationality, interaction, learning and adaptation, can even be thought of 'as a subset of the broader category of innovation processes'. Accepting bounded rationality on the part of all agents, including 'policy makers', leads to the idea of adaptive policy making. 'Adaptive policy makers', according to Metcalfe and Georghiou (1997), can rely on no claim to superior knowledge, operating rather within the constraints of localised, imperfect knowledge. As the arch-critic of linear, mechanistic and overly rational approaches to public policy Lindblom (1959) famously pointed out, policy actors are always biased in the way that they filter information and rely on a degree of learning and routines, with search processes that are partly local and myopic.

The importance of interaction and communication in policy making, as well as the bounded rationality of the actors involved, leads to agenda-setting effects whereby certain ideas and policies are accepted whilst others are rejected (Kingdom 1984). Like innovation, policies are subject to pressures and constraints that determine selection between competing ideas and solutions to problems, leading to the legitimisation of some and the rejection of others. Such selection pressures (for example, coming from media attention, from policy networks, from legislation) are context and time specific institutions that filter certain understandings of problems as well as responses. Past policy decisions tend to become part of the constraining selection environment. Successful policies (or the actors they create, for instance 'intermediaries', such as science parks) become institutionalised and thereafter form part of the foundation for the beliefs of actors, conditioning subsequent policy decisions. This produces an uneven temporality of policy evolution in the form of path dependence and institutional stickiness (Van den Bergh and Kallis 2009). Indeed path dependence and increasing returns may be more pronounced in political than economic systems (Pierson 2000a). Yet, whilst path-dependent processes are stressed in innovation studies, time is generally overlooked in policy analysis. All too frequently analysis is an exercise in comparative statics relating to the time horizons of specific policies and programmes, failing to account for 'different rhythms, cycles and process speeds in the policy learning' (Kay 2006: 7).

Stating that institutional arrangements are change resistant should not entail a static view of things. Path dependence does not preclude change, rather it suggests a sort of bounded change, wherein certain alternatives become less viable (or less attractive) (Pierson 2000a). Understanding change and agency in institutional transformation is challenging. Sotarauta and Pulkkinen (2011: 102) thus ask: 'how can actors innovate and renew institutional settings if their beliefs and actions are all determined by the very institutional environment they wish to change?' How can policy inertia and path dependency be then reconciled with the action of policy entrepreneurs (Kingdon 1984)? Who are these actors? If, as stated earlier, a multiplicity of actors, actor types, and governance levels contribute to shaping policy, then other actors besides 'policy makers' necessarily have agency in policy. As Flanagan *et al*. (2011: 706) state, 'If public policy is part of the system then the agency of actors must be acknowledged both in relation to innovation processes and to processes shaping policy problems and solutions.' It should be obvious from the discussion so far, however, that a recognition of agency should not be taken to imply that institutions can be seen as the result of 'intentional and far-sighted choices of purposive, instrumental actors' (Pierson 2000b: 477).

Whilst the complexity inherent in policy processes necessarily limits the scope for prediction and evaluation, it also highlights the crucial role of knowledge, learning and adaptation. This in turn suggests that we should shift our attention away from heroic attempts at mechanistic evaluation and towards a better understanding of learning processes in relation to public policy interventions over time (including learning from failures), experimentation and trial and error. Potts (2009) suggests a 'Red Queen effect' in evolutionary policy, namely that 'in an evolving economy or open society, policy and governance must continually experiment and innovate "just to keep up"' (p.42). Experimentation and strategy in an evolutionary sense emphasises 'creating choices, keeping options open and making the tree of possibilities as bushy as possible at any point in time' (Beinhocker 2006: 339). Local experimentation becomes important, something already hinted at in the idea of regions as 'laboratories' in RIS programmes (Morgan and Nauwelaers 1999), together with the need to ensure learning across local units. A careful balance is however needed between centralised efforts and decentralised experimentation. In the model of policy innovations developed by Kollman *et al.* (2000), for instance, a trade-off is suggested between the advantages of experimentation and the ability to resolve problems. They conclude that decisions about implementation would hinge on characteristics such as the perceived difficulty of the problem and the heterogeneity of subunit preferences.

In short, rather than prescribing that policy makers 'adapt' to local circumstances (if policy is adaptive it will somehow be better), a truly evolutionary model of policy would recognise that policy actors can only ever be adaptive. The role of scholars and analysts in policy becomes not one of identifying the right configuration for the system but rather of suggesting careful experimentation, drawing attention to complexity and uncertainty, and highlighting and promoting an open discussion of the trade-offs and tensions between inevitably conflicting policy goals. Rather than attempting to assume away *de facto* complexity of governance and politics (or treat them as an 'error term' or noise) in order to make strong prescriptions, innovation policy analysts should grapple with the implications of complexity.

An important part of grappling with complexity would be seeking to understand better how learning and adaptation takes place in real systems. This suggests a need for a richer empirical understanding of actual 'policy histories' than is often seen in innovation policy research. As with the decades of careful innovation case studies from which so much of our understanding of innovation dynamics stems, policy histories would ultimately need to be compared and interpreted in the light of theory (the work of Avnimelech and Teubal 2004, on Israeli cluster development, richly characterising a co-evolutionary process involving the business sector, technology policies, venture-capital, etc. provides one example of what an appreciative policy history might look like).

Summary

We have drawn on contemporary literature on the region and on innovation to critically examine some defining features and problematic assumptions around networks, spatial boundaries, institutions and policy. Recent contributions from evolutionary and complexity economics that advocate a more open and dynamic view of regional systems open up a promising avenue of research but questions remain in relation to how 'policy' is treated. Despite a more dynamic depiction of innovation systems and the role of geography in shaping such systems, current approaches seem to lack a clear framework within which to understand policy dynamics and policy action. Complexity in innovation policy is 'black-boxed' and rendered unproblematic, with potentially negative consequences for the ultimate utility of the policy prescriptions advanced. We call for a different approach. Paradoxically, being *less* ambitious with respect to strong policy prescriptions and paying more attention to complexity and system dynamics – in relation to policy, not just in relation to innovation – might ultimately lead to more useful regional innovation policy analysis.

Notes

1 This paper was presented at the 'Reframing Regional Development: Evolution, Innovation and Transition Colloquium' held in Cardiff on 4–5 April 2011. We are grateful to the participants for their comments and suggestions, and to Phil Cooke and Dieter Rehfeld for their constructive advice on earlier versions. Finally, Elvira Uyarra wishes to acknowledge the financial support of the Autonomous Province of Trento, sponsor of the OPENLOC research project.

2 A good example of the use of the RSI literature in policy is the European Commission funded Regional Innovation Strategies (RIS) initiative, which since the 1990s and during the 2000s, aimed to 'socially engineer' participating regions by creating the right environmental conditions, institutional in particular, in order to improve their innovative capacity (Morgan and Nauwelaers 1999).

3 It is noteworthy that little attention was paid to this issue in the 2000 *Handbook of Evolutionary Economic Geography* edited by Ron Boschma and Ron Martin.

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8 Path dependence and new technological path creation in the economic landscape

James Simmie

Introduction

In this chapter, path dependence theory is adopted as the starting point for the analysis of innovation and transitions in the economic landscape. Path dependence theory, as exemplified by Paul David (1985) and Brian Arthur (1989), seeks to explain the long-term historical development of distinctive patterns of technological and industrial forms, and how, once established, particular trajectories of technological and industrial development become self-reinforcing via various forms of externalities and increasing returns effects. For the purposes of this chapter path dependence is defined:

> as a probabilistic and contingent process: at each moment in time the suite of possible future evolutionary trajectories (paths) of a technology, firm or industry is conditioned by (contingent on) both the past and the current states of the system in question. The past thus sets the possibilities while the present controls what possibility is to be explored.
>
> (Martin and Sunley 2006: 402)

The canonical exposition of path dependence theory focused on the dynamics of the diffusion of new technologies (David 1985, Arthur 1988). In these studies it is argued that there is an inherent tendency towards technological "lock-in". David (1985), for example, argued that keyboard design was locked-in to the QWERTY arrangement of the letter keys on a typewriter not because of their rational efficiency but to slow typists down in order to avoid the problem of jamming keys. This established the technological trajectory of keyboard design even though more efficient arrangements became technically possible and should have been introduced in a perfectly rational world.

David's work on the economic history of technology established the argument that the economy is built on the legacy of its own past. In this view, economic history is seen as an irreversible, non-ergodic process in which future outcomes are strongly dependent on past events. As a result, the state of an economy at any point in time depends on the historical pathways taken up until then (Martin and Sunley 2006). This is not the same as historical determinism in which the totality of the political economy as a whole is derived from the totality of the past. Rather, it is a complex series of histories of how a particular set of outcomes have become what they are. These sets of past events have produced the pathways taken to the present by effectively closing off some possibilities and pursuing others.

Arthur (1994c) argued that one of the main reasons for the path-dependent nature of the diffusion of technological innovation is increasing returns. This means that profits increase as production expands gaining competitive advantages for those technologies and firms that are already ahead and making it more difficult for other technologies and companies to catch up. Arthur identifies four major reasons for increasing returns accruing to the early adopters of a new technology. These are:

- large set-up or fixed costs, which are barriers to entry but also, imply that average costs decrease when production increases;
- learning effects – knowledge from experiences with a technology results in increased returns from continuing to use it;
- coordination effects that imply that benefits for one user increase when others use the same technology, in other words there are positive network externalities;
- adaptive expectations – self-fulfilling expectations that widespread technologies will generate co-ordination effects (see Kivamaa *et al*. 2010).

These theories sought to explain how economies could become “locked-in” to the use of less efficient and sub-optimal technologies rather than, as was claimed by neoclassical economics, converge on the uniform use of the most efficient technology. It was argued that, once a technological trajectory was established by chance, the operation of other contingent events and self-reinforcing mechanisms would eventually lead to lock-in. Escape from this condition could only be instigated by external shocks.

But, the reliance on chance to start the diffusion of new technologies did not provide a satisfactory explanation of how they were started in the first instance nor the initial conditions that provided the breeding grounds that lead to their birth. Paradoxically, as an evolutionary theory, there was no place in the canonical path dependence theory for initial intelligent invention and innovation. New technologies emerged by chance and serendipity. Some were selected as a result of contingent events and self-reinforcing processes to diffuse along increasingly restricted and locked-in pathways. But, as Martin and Sunley put it “To be truly evolutionary, path-dependent systems also need mechanisms that generate novelty and hence new pathways of development” (Martin and Sunley 2006: 407). Thus it is argued in this chapter, first, that historical explanations of the evolution of path-dependent technological developments require, in addition to the restricted analysis of the processes leading to lock-in, explanations for both the initial conditions into which inventions and innovations are introduced and the processes that lead via invention and innovation to the creation of new pathways. In addition, they also need explanations of how existing pathways are de-locked and changed. This chapter will focus on the first of these questions and the contribution that answers provide to explaining transitions in the economic landscape.

Traditional path dependence theory and change in the economic landscape

Traditional path dependence theory has offered four explanations of the processes by which new technologies diffuse in and change the economic landscape. These are:

- windows of locational opportunity (WLO);
- spinouts;
- localisation economies;
- technological enclaves.

Following the canonical starting position of path dependence theory they all commence with some version of a virgin landscape into which new firms are introduced for the first time by random, chance and serendipity.

The concept of windows of locational opportunity (WLO) was introduced by the Californian School of economic geography in the late 1980s (Scott and Storper 1987; Storper and Walker 1989). They argued that during the emergence of a new technology or industry there will be a large number of regions that possess the conditions that would allow the new industry to locate and grow there. New firms could theoretically locate in any of these regions with roughly equal chances of success. What then happens in reality is that one or more of these regions are selected by the firms by inexplicable chance and random events (Martin and Sunley 2006: 425).

During the 1990s, Arthur (1994b) developed two models to explain the creation of new economic pathways in particular localities. The first was a spin-off model and the second focused on localisation (agglomeration) economies. A spin-off is a new firm founded by an entrepreneur who has worked as an employee in a firm in the same, in Arthur's model, local industry. The model attempts to provide an explanation of why a new industry may concentrate in space without falling back on the need for any place specific pre-conditions except one. This is that each region must contain at least one new firm for the spin-off process to start.

The spin-off thesis has little or nothing to say about either the pre-formation phase or the initial creation of a new economic pathway. It does not offer any explanation of the roles of invention and innovation in the actual creation of new industries in particular regions. Again this is "explained" as a largely chance event. On the other hand the model has been shown to describe an important mechanism in the later stages of the diffusion of new technologies.

In Arthur's (1987, 1994) second model he assumes that firms do not spin-off from existing companies but start-up independently. Unlike the spin-off model the location of a start-up is not determined by the location of a parent company but is a matter of entrepreneurial choice. It is assumed that each start-up has a preference for one particular region. Empirically this is often the place where the founder has lived or held employment. A collection of heterogeneous founders could, in theory, start-up in a number of different regions. So in Arthur's model, following traditional path dependence theory, the initial dynamic leading to the creation of a new industry in a particular location is said to be the result of a random, chance decision by one firm to start-up in a particular region. The weakness of this starting point is that it does not identify causal and contextual processes nor explain why some apparently trivial events become significant in some places, while apparently similar chance events do not lead to new path creation in other localities (Martin and Sunley 2006: 425).

David, Foray and Dalle (1998) modelled the possible development and divergence of two technologies in different regions as a result of local positive Marshallian externalities. In this theory there is a probabilistic selection of firm locations according to the presence of different skill sets. The landscape outcomes are said to be the path-dependent evolution of technological enclaves with differentiated technological practices. This approach does not explain how different and specialised labour market characteristics appear in particular localities in advance of the new technology based firms that eventually cluster in these new technological enclaves.

The approaches employed by these four path-dependent explanations of the introduction and diffusion of new technologies into the economic landscape are summarised in Table 8.1.

Table 8.1 Traditional path dependence explanations of new path creation and change in the economic landscape

Theoretical models 1980s–1990s	*Pre-formation*	*New path creation*	*Path dependence*
Windows of locational opportunity Scott, Storper and Walker 1987, 1989	Many possible locations or generic assets required.	Location of successful new industry by chance. No explanation of invention or innovation.	Once started momentum builds. Positive lock-in. Continues indefinitely.
Spin-offs Arthur 1994	No explanation of necessary pre-conditions.	First firm locates by chance in a given region. No explanation of invention or innovation.	First firm starts spin-off process. Firms pass on successful routines to spin-offs. Leads to path dependent development and positive lock-in. Continues indefinitely.

(continued)

Table 8.1 Traditional path dependence explanations of new path creation and change in the economic landscape *(continued)*

Theoretical models 1980s–1990s	*Pre-formation*	*New path creation*	*Path dependence*
Localisation economies Arthur 1987, 1994	No explanation of necessary pre-conditions.	First start-up locates by chance in a given region. No explanation of invention or innovation.	First start-up initiates development. Growing numbers of firms generate localisation economies. Leads to path dependent development and positive lock-in. Continues indefinitely.
Technological enclaves David, Foray and Dalle 1998	Uniform empty landscape.	Probabilistic selection of firm locations arising from influence of local positive Marshallian externalities.	Path dependent evolution of technological enclaves with differentiated technological practices.

Some of these criticisms of the traditional path-dependent explanations of the introduction of changes into the economic landscape were taken up in a second wave of theories. These introduced the concepts of:

- product life cycles,
- related variety.

In order to remedy perceived deficiencies in the Arthur models, Klepper (2001, 2002) proposed combining the idea of spatial concentration as a result of spin-offs within an evolutionary framework of a product life-cycle model. In Klepper's model, a locality starts with a collection of firms operating on the basis of a heterogeneous set of routines. Spin-offs from these firms are said to inherit the routines of their parent companies. It is argued that spin-offs will have a higher probability of survival when they inherit fitter routines from more successful parents. In the early stages of an industry's life-cycle, firms may make super profits which can be reinvested in R&D. As a result they are able to grow faster than later entrants due to increasing returns from R&D. Consequently, earlier entrants will have a lower hazard rate at every age (Klepper 2002). Spin-offs from these companies represent a mechanism whereby fitter routines and competences are transferred or diffused from parent companies to their offspring. Klepper argues that the probability of survival of spin-off firms is correlated with the relative success and fitter routines of parent companies. In contrast, worse performing firms, be they parents or offspring, tend to die in the face of competition from the firms with fitter routines. These arguments, however, are not so much based on path dependence as a Darwinian evolutionary approach of survival of the fittest.

The geographical dimension in Klepper's model follows from the localised nature of the spin-off process. Spin-offs tend to locate near their parents. As a result, distinctive knowledge, competences and routines are diffused locally providing individual regions with production capacities that are peculiar to each different region. In Klepper's argument this is why geography matters in the development of distinctive new economic pathways.

But, as with the first four models, WLO, spin-off, agglomeration and technological enclaves, the start of a new industry in Klepper's model is dependent on the initial accidental and chance presence of one or more successful firms in a locality. Without these, the spin-off process cannot start. As a result, like the other models, it provides a potential explanation of the later stage of path development rather than the initial phases of new path creation.

In a series of papers, Boschma and Frenken (2003, 2006) further developed the Klepper (1996, 2001, and 2002) Darwinian analysis of the creation of new industries in space. They start from the Nelson and Winter (1982) premise that firms develop routine forms of behaviour. These represent the collective, tacit and distinctive knowledge bases of the firms. Boschma and Frenken use this starting point to argue that an evolutionary economic geography should therefore describe regional economic development in terms of changes in the time-space distribution of routines (Boschma and Frenken 2003:186).

It is argued that the degree and intensity of spillovers of the tacit and distinctive knowledge bases of firms within a region is a key determinant of the development of new economic pathways within regions. Such knowledge spillovers are said to be more likely when the variety of technologies are related in some way to each other rather than unrelated (Boschma and Frenken 2006: 1). This is primarily because of the greater cognitive proximity of related as opposed to unrelated knowledge and technologies.

In conditions of related variety new economic pathways are said to be created by the pure Darwinian evolutionary process of branching. This may occur in two different ways:

- A new sector may grow out of an old sector.
- A new sector may be the outcome of a recombination of competences coming from different sectors (Boschma and Frenken 2006: 6).

Routines are said to be passed from generation to generation of firms, primarily at a regional level. The reason for this spatial dimension of branching is that it occurs through knowledge transfer mechanisms such as spin-offs, firm diversification, labour mobility and social networking, all of which tend to rely on geographic proximity and therefore have a local bias (Boschma and Frenken 2006: 8).

Unlike the WLO, Arthur and Klepper theses, the Boschma and Frenken thesis does seek to explain both the pre-formation and the path creation phase of the development of new technologies and industrial sectors in particular regions. The pre-formation phase is explained in terms of the previous historical development

Table 8.2 New path creation and the economic landscape

Theoretical models 2000s	*Pre-formation*	*New path creation*	*Path dependence*
Product life-cycle Klepper 1996, 2001	No explanation of necessary pre-conditions.	First firm locates by chance in a given region. No explanation of invention or innovation.	Historically informed account of localised spin-off process. Rise and fall of product life-cycle.
Related variety Boschma and Frenken 2003, 2006	Historical development trajectories.	New pathways created by incremental branching from local industries based on related knowledge. Does not explain break out from lock-ins using only local knowledge.	Potential for continuation of lock-in due to reliance on limited local knowledge.

of a particular industrial structure. The new path creation phase is explained in terms of the possibilities for branching out of related industries.

This approach, however, does not explain how entirely new pathways emerge from lock-in. The recombination of existing competences in specific localities, particularly those that have experienced long-term economic decline, is seldom sufficient on its own to create a new economic pathway. In such cases, the knowledge base is likely to be too limited to to be recombined into novel new branches. Many of the case studies cited as examples of the recombination of existing knowledge into new technological pathways have in fact relied heavily on the initial local generation of new knowledge through local firms (for example, Emilia Romagna) or research organisations such as universities (for example, Boston), or the importation and absorption of new external knowledge (for example, Coventry–Birmingham).

The main arguments found in this second wave of evolutionary attempts to explain developments in the economic landscape are summarised in Table 8.2.

Niches, agency and innovation in the creation of new economic pathways

The introduction of innovation is the key to new path creation. None of the explanations of the geography of new path creation reviewed above offer a satisfactory explanation of innovation, how it is stimulated in the first instance, or why it takes place in one locality rather than another. Without such an explanation they cannot explain the geography of new path creation. The underlying model of innovation employed in this chapter is the chain-link model of Kline and Rosenberg (1986). Briefly, this argues that innovation is a complex iterative set of processes involving research, the generation of new knowledge, and numerous iterations between potential markets, inventors, designing and re-designing new products and services in the light of customer reactions.

The analysis in this chapter focuses on the early stages of the chain-link model of innovation and seeks to explain how inventions and innovations are introduced for the first time and are diffused across the landscape. This requires an explanation of the processes involved in the introduction of technological novelty in the face of historically path-dependent and locked-in development trajectories.

A group of scholars, based mainly in business schools, have started to address such questions. They have focused on the issue of human agency in new path creation (Stack and Gartland 2003). Prominent among these theorists have been Garud and Karnøe (2001). They argue that any theory of new path creation should attach a significant role to the importance of strategic agency and the considered "mindful deviation" of entrepreneurs from established paths. Puffert (2000) goes further in arguing that the very existence of established pathways may make actors more eager and motivated to attempt to make their new technologies and ways of doing things the basis of new pathways.

Garud and Karnøe argue that entrepreneurs of various kinds create new pathways as they navigate the current flow of events in "real time" and seek to set new processes in motion by "mindful deviation" (Garud and Karnøe 2001: 2). The two ideas "real time influence" and "mindful deviation" distinguish the explanation of new path creation from those of subsequent path dependency. According to Garud and Karnøe a key characteristic of (at least some) entrepreneurs is that they are not just passive observers of locked-in development trajectories but knowledgeable agents with capacities to understand them and to act in ways that are not prescribed by the existing social rules and technological paradigms and trajectories (Garud and Karnøe 2001: 2).

Existing path-dependent development trajectories present substantial barriers to the introduction of novelty for entrepreneurs who are themselves embedded in these very same trajectories. Accordingly it is argued that "niches" are required to incubate and enable new technologies to emerge in the face of historical path-dependent developments. A niche may be defined as an application context in which the new product or technology is temporarily protected from the standards and selection rules of the prevailing paradigm (Kemp *et al*. 1998; Hoogma *et al*. 2002; Markard and Truffer 2006). Niches provide space for novelties to incubate without being subjected to prevailing competitive market pressures or the normal selection criteria that accompany the dominant pathways. The informal rules of niche environments are less articulated and subject to higher degrees of uncertainty than those of the established paradigms (Geels 2004). In niche conditions it is also possible to draw on new local or international knowledge in order to develop new business networks, value chains and user-producer relationships.

Niche environments provide opportunities for inventions and innovations to be introduced. Niche environments may be regulatory, fiscal, economic, political or geographic spaces where it is easier to make changes to existing practices, regulations, institutions and generally accepted "ways of doing things". They do not themselves create inventions or innovations. These are the brain children of pioneering actors and agents. Among others, these may be individual inventors or scientists working in research laboratories. Such actors are responsible for the "discovery" of new knowledge. This does not necessarily lead to innovation.

In addition to discoveries, innovation also requires knowledge recombinations that develop them as commercial products and services. This requires the mobilisation of relevant resources in order to overcome the resistance and inertia that efforts to create new pathways are likely to encounter (Garud and Karnøe 2001: 2). Entrepreneurs, and the firms that they start, are the main agents of the commercialisation of new knowledge into marketable innovations.

One invention or innovation, however radical, does not make a new economic pathway. Changes occur slowly at first while producers, designers, distributors and consumers engage in feedback and learning processes (Perez 2010). This is usually a cumulative process and critical mass builds up over time as clusters of innovations emerge in new economic sectors. This process is preceded by, sometimes, quite lengthy periods of individual inventions. After the accumulation of relevant inventions, entrepreneurs begin to take up these new ideas and commercialise them as innovations.

Eventually, in the case of successful innovations, a critical mass is reached where, in the face of existing network externalities, sufficient economic agents are prepared to switch to the new alternatives Witt (1997). Critical mass is a well-known phenomenon in non-linear dynamic systems (Lorenz 1993). It may be defined as a point of discontinuity that induces a dramatic turn away from an existing system (Witt 1997). Existing path-dependent economic forces, technological paradigms, institutions, power structures and network externalities always favour the existing and widely used product variants. For this reason success in the creation of new economic pathways comes down to the prerequisite to pass a critical mass (Witt 1997).

The diffusion of innovations is the key process that spreads their use from the original niche environments to the point at which critical mass is achieved and a new economic pathway is created that represents a significant discontinuity with the existing path-dependent development trajectories. In contemporary economies, as with the introduction of an innovation, diffusion also requires agents. The roles of diffusion agents have a long pedigree in the diffusion literature (Brown 1981; Rogers 1995). Thus, when a major innovation is introduced, commercial marketing agencies or in-house people are often given the task of promoting them and triggering a diffusion process (Witt 1997).

At the level of individual companies, diffusion agents need to overcome existing network externalities in order to instigate a widening adoption of their companies' new product or service. One way of achieving this is to try to coordinate the adoption decisions of potential users in order to overcome the network diseconomies that early adopters would otherwise have to bear. Such coordination is one way of reaching the critical mass point of economic transition to a new economic pathway.

It has also been argued that external drivers are required in contemporary economies for the more radical technological innovations to diffuse (Kivamaa *et al*. 2010). The transition from one economic pathway to another may well need to be organised by collective action. This is because setting the diffusion process in motion is like providing a public good. Without collective action, the early adopters would have to bear the initial network diseconomies while later adopters would profit from the investments of the early adopters (Witt 1997). A current example of this problem is the barriers to the diffusion of renewable energy technologies in the face of the prevailing carbon-based and hard-networked paradigm.

These arguments are summarised in Table 8.3. This argues that new technological path creation is an iterative process that emerges in the context of the evolution of previous path-dependent development trajectories. Within this selection environment small numbers of intelligent and pioneering inventors in various types of niche seek to introduce some degree of novelty into an existing system. Some of these inventions will be selected by entrepreneurs and commercialised into innovations. The majority of these innovations will involve incremental changes to existing trajectories. A minority will involve radical breakthroughs and an even smaller and infrequent minority will provide radical innovations that provide platforms for the transformation of other industries. The diffusion of innovations will encounter barriers arising from previous historical rounds of path-dependent development. These will include economic competition from existing mature technologies, cognitive barriers in the form of contemporary technological paradigms, institutional inertia and the power of existing stakeholders in the current technological regimes. The outcomes of the interactions between entrepreneurs seeking to diffuse innovations and the path-dependent barriers to such diffusion are uncertain. They may lead to the achievement of critical mass and tipping points where a new technology becomes established or they may lead

Table 8.3 New path creation theory

Initial conditions	*Path creation process*	*New path creation processes*	*Barriers to new path creation*	*Landscape change*
Existing path dependent development trajectories.	Mindful deviation and invention by actors in niches.	Incremental innovation. Radical breakthrough innovation.	Economic. Cognitive: technological paradigms. Institutional hysteresis. Social: technological and other regimes.	Either new technology diffuses to achieve critical mass and tipping points. Or continuation of previous path dependent development trajectories.

to the failure of a new technology to diffuse to a critical mass and the continuation of existing path-dependent development trajectories.

These uncertain outcomes impact on the economic landscape. Some outcomes reinforce the existing path-dependent uneven production and deployment of technologies. Other outcomes create new technological pathways which may adapt and re-orientate existing landscapes or create new distributions of the production and use of new technologies.

New path creation and changes in the economic landscape of the American wind power industry

The theoretical arguments summarised in Table 8.3 are illustrated in this chapter by a case study of two phases of the development of the American wind power industry. The main source of information for this analysis is a recent book by Peter Musgrove (2010) that provides a detailed history of the technological evolution of wind turbines from the early introduction of the use of wind power in the seventh century, in what was then Persia, to contemporary offshore wind farms in Europe and the USA. The two phases of the evolution of the American wind power industry analysed here are the experimental era that lasted from 1941 to the mid-1980s and the Californian wind boom era that lasted from the recession of the 1970s until the 1990s.

American wind power programme

The first comparatively large scale grid connected wind turbine generating AC electricity was invented by Palmer C. Putman, an engineer, between 1934 and 1939. His interest started when he built a house on Cape Cod and discovered that both the local winds and the cost of electricity were rather high. In 1939, he persuaded the Morgan Smith Company to finance the design and construction of a megawatt-sized wind turbine that could generate electricity and attempt to supply it at a competitive price to the Central Vermont Public Service Corporation (Musgrove 2010: 70). The two-bladed turbine, known as the Smith-Putman turbine was installed near Rutland, in Vermont in 1941. Technical failures and the difficulty of acquiring spare parts during the Second World War, combined with the fact that it shed a blade in 1945, led to its permanent shut down. Planned replicas were never built.

The initial conditions of the selection environment for electricity generation changed dramatically as a result of the Yom Kippur War. This led to a fourfold increase in the price of oil in 1973. Governments began to look for more efficient ways of generating electricity. Concern for the environment also began to rise. Electricity generators turned away from oil and towards coal and nuclear power. But the catastrophic accident at the Three Mile Island nuclear power station in 1979 also confirmed fears about the safety and costs of nuclear energy production.

It was in these initial conditions that the Federal Government established an experimental R&D niche for wind turbine development that was funded with some $350m. From the start, a decision was made to go for breakthrough innovations in 1-MW plus wind turbines. The initial brief for these experimental turbines was based on the Smith-Putman design with two blades located downwind from a lattice tower. As a result of this programme, some 12 turbines were designed and built between 1975 and 1987.

The main agents involved in developing these wind turbines were the Lewis Research Centre (a branch of NASA), the Westinghouse, General Electric and Boeing Aerospace Companies. Table 8.4 summarises the activities of these agents and the eventual outcomes of their efforts with respect to the economic landscape. In all cases, it may be seen that these experimental turbines were dismantled or scrapped in relatively short periods of time. This was frequently the result of their technical or reliability deficiencies. As a result they did not lead to the creation of a new economic pathway and therefore had little impact on the economic landscape.

The reasons for the failure of the American Federal wind power programme are interpreted in this chapter as a result of the path-dependent barriers confronting the programme's attempt to make breakthrough innovations in 1-MW plus wind turbines. These barriers may be identified in terms of the limitations imposed by

Table 8.4 American Federal wind power programme

Inventors, research and development	*Location of firms*	*Turbine*	*Location of turbines*	*Date installed*	*Date ceased operation*
Lewis Research Centre (NASA)	Cleveland, Ohio	Mod-0	Sandusky, Ohio	1975	Dismantled 1987
Westinghouse	Round Rock, Texas	Mod-0A (4 built)	Hawaii and Rhode Island	1977–1980	Dismantled 1982
General Electric and Boeing Aerospace	Greenville, South Carolina and Portland, Oregon	Mod-1	Boone, North Carolina	1979	Dismantled 1983
Boeing (second generation)	Portland, Oregon	Mod-2 (3 built)	Goldendale, Washington State	1980/81	Scrapped 1987
	Portland, Oregon	Mod-2	Medicine Bow, Wyoming	1982	Scrapped late 1980s
	Portland, Oregon	Mod-2	Solano County, California	1982	Scrapped late 1980s
Boeing (third generation)	Portland, Oregon	Mod-5B	Oahu, Hawaii	1987	Shut down 1996, dismantled 2003

Source: Musgrove, P. (2010) *Wind Power*, Cambridge: CUP, pp. 89–94.

the technological paradigms that were employed and the institutional inertia that built up during the course of the programme. These represent different forms of lock-in. These cognitive and institutional lock-ins were made more difficult to overcome by the impedance imparted to learning by the geographic separation of research, design and development.

The start of the first of these barriers was instigated in 1948 when Putman published a book called *Power from the Wind* that drew on his experiences with the development of the Smith-Putman turbine. In it, he glossed over both the technical difficulties experienced with the working of the turbine and the fact that, given its total costs, it never generated electricity at a locally competitive price. Nevertheless, this book was influential in establishing the path-dependent and distinctively American technological paradigm that formed the cognitive basis of the NASA-led American Federal wind power programme. As a result, all the first-generation turbines commissioned under the programme were constructed on the same basis as the Smith-Putman machine with two blades located down wind of a lattice tower. This configuration had not worked reliably for Smith-Putman and did not do so in the American wind power programme either.

Accustomed to the technological paradigms of rocket science, NASA wrongly assumed that aiming at breakthrough innovations in building a reliable megawatt wind turbine was a simpler task than it proved to be in practice. Instead of starting by examining international knowledge and experience with wind turbines, NASA commissioned a number of American companies, who all adopted approaches based on the technological paradigms prevalent in their particular industries. Thus Westinghouse and General Electric started with assumptions derived from their experience in building large electricity generators. Boeing started from a technological paradigm based on wing design for constant airstreams. These companies were specialists in their own fields. Nevertheless, this specialisation was not the prime cause of their inability to design and build a reliable wind turbine. Their key blind spot arose as a result of the fact that none of their path-dependent cognitive frameworks provided initial knowledge and experience relevant to the design of turbines that could function reliably in all kinds of turbulent wind conditions.

Despite these cognitive short-comings they became increasingly entrenched in the programme as a result of path-dependent institutional inertia. This was exemplified by the fact that the technological trajectory was established early in the programme and the re-design of the technology, as required in the chain-link model of innovation, was taking place before the lessons of earlier models had been learned and digested. Thus, before the unsuccessful Mod-1 even began testing, Boeing were contracted to design a second generation machine Mod-2. These suffered from a range of relatively simple failures that could have been designed out had testing of Mod-1 been completed first. Boeing was also contracted to design a third generation turbine Mod-5B. Again, design started before the second generation Mod-2s started operation. As a result of this lack of learning from the operation of earlier models, all five Mod-2 turbines had to be scrapped by the late 1980s and Mod-5B was shut down in 1996.

Overcoming the barriers to learning that might have been generated by iterative interactions between researchers, designers and developers was also impeded by the geographic separation of these functions. In most cases, the research and design of the turbines was conducted in the states in which research centres of the various organisations and companies involved in the programme were located. But, the majority of the experimental wind turbines were then constructed in different states sometimes thousands of miles away from the locations of their original designers. This made the iterative learning, development and re-design of the turbines as suggested by the chain-link model of innovation a very difficult, extended and slow process. Thus there was also an element of place dependency as well as path dependency in the slow learning that contributed to the failure of the American wind power programme.

Californian wind boom

The initial conditions in energy markets that arose from the external shock of the fourfold increase in the price of oil following the Yom Kippur War in1973, the Iranian Revolution and the Iran/Iraq war led several western governments to create niche conditions designed to encourage the development of renewable energy technologies and their local manufacture. The main role of these niches was to provide a context in which a new product or technology is temporarily protected from the standards, selection rules and vested interests of the dominant technological regime (Kemp *et al*. 1998, Hoogma *et al.* 2002, Markard and Truffer 2006). The informal rules of niche environments are less articulated and subject to higher degrees of uncertainty than those of the established paradigms (Geels 2004). Thus invention, creativity and deviation from the mainstream regime are made easier in niches than elsewhere.

The niche conditions created in California were among the most notable created during the post-oil-shock period. They consisted of a constellation of three main elements. The first of these was created at the Federal level by the Carter administration when it passed the Public Utilities Regulatory Policy Act (PURPA) in 1978. This required utilities to buy electricity from “qualifying facilities” (QFs) at a price that fully reflected the utilities’ avoided costs. These included both the capital and the running costs avoided by the utilities. QFs were defined as any that produced electricity from biomass or renewable energy sources.

The second was created by earlier Federal legislation that introduced an allowance of a 10 per cent tax credit for capital investment in any manufacturing sector. After the overthrow of the Shah of Iran in 1979, a supplementary tax credit of 15 per cent was also allowed from 1980 for all energy related capital investments made before the end of 1985.

The third element was created in California itself when the Public Utilities Commission (PUC) set the rate for the level of avoided costs at which utility companies had to purchase electricity from renewable energy sources. This was set at the high end of such decisions around the country at about 7 cents per kWh.

Finally, the fourth element of the niche market for renewable energy sources in California was further strengthened by Governor Jerry Brown. He passed legislation that gave a 25 per cent tax credit for all solar and wind energy investments made before the end of 1986. Taken together these niche conditions in California provided tax credits totalling 50 per cent for capital investment combined with the certainty that electricity generated from solar and wind sources could be sold to utilities at a favourable price.

These favourable niche investment conditions in California were exploited by four pioneering and innovative firms together with high net worth individuals who acted as both business angels and investors. The first of these firms was founded by Stanley Chapper in Cambridge, Massachusetts. It was incorporated as US Windpower in 1979. It was both a technological and an organisational innovator in the American wind power industry. Its most significant innovation, however, was organisational. It pioneered the organisational innovation of wind farms. The company developed the first one, consisting of only 20 machines in New Hampshire in 1980, not far from their manufacturing base. It was among the first to recognise the market opportunities afforded by the tax credits available in California. As a result, it leased large tracts of land in the Altamont Pass some 60 kilometres east of San Francisco. It secured zoning approval, contracted with the local utility company for grid connection and installed 100 of its machines in 1981. So began the Californian wind boom.

Unlike the companies involved in the American Federal wind power programme, US Windpower moved the manufacture of their turbines from New England to the Altamont Pass in order to both supply and maintain its booming Californian market. As a result, a new manufacturing pathway in wind turbines was created *de novo* in this location. The company used all its production to supply its own wind farms. It did not sell to other developers. This provided market opportunities for other manufacturers to emerge as the local diffusion agents of the new technology in California.

Two further pioneering American companies that emerged as local Californian diffusion agents were FloWind and VAWTpower. These specialised in vertical axis turbines. This configuration was first invented by Georges Darrieus in France in 1925. The concept was rediscovered in the late 1960s by Raj Rangi and Pete South working in the National Research Council laboratories in Ottawa. Their work stimulated much interest. Further research was funded by the American Federal wind power programme at the Sandia National Laboratories in New Mexico. Thus by the time the original invention was introduced and diffused as a commercial innovation by FloWind and VAWTpower in the niche conditions in California, it had a long pedigree of mostly publicly funded research and development. It was based on the development of new international knowledge that passed over many decades across thousands of miles from France to Canada and on to New Mexico.

As diffusion agents for the new technology, FloWind and VAWTpower developed and manufactured a relatively small 17 metre, 100 kW rated design pioneered in the Sandia National Laboratories in New Mexico. Several hundred were installed in the Californian wind farms of the early 1980s. Although relatively successful by American standards, they proved less reliable than the conventional Danish three-bladed horizontal axis wind turbines that were also available.

The fourth pioneering Californian company was Zond Systems. It was formed by Jim Dehlsen in 1980. Dehlsen was the first innovation diffusion agent in California to start buying Danish turbines. He contracted with Vestas to supply 150 wind turbines in 1983. Starting from scratch in 1980 he was operating and maintaining some 2,000 wind turbines by the early 1990s.

Californian wind farm developers such as these created a large market for the diffusion of Danish innovations in wind turbine technologies. As a result, during the early 1980s, the leading Danish manufacturers, Vestas, Bonus, Micon and Nordtank were exporting around 70–80 per cent of their total production to California. At the time, in Denmark, these turbines sold for around the equivalent of $31,000. Thanks to the generous niche conditions in the Californian market, Zond Systems could sell Californian investors the same machine for between $100,000 and $180,000 (Musgrove 2010: 117).

One of the most significant innovations introduced by the Californian diffusion agents was the wind farm concept. At the time this was a major organisational innovation. Among other things it provided a tax efficient investment product for high net worth individuals and therefore high tax paying Californians that produced profits and avoided taxes. Such individuals played roles as both business angels and investors.

The key events, individuals and firms involved in the initial creation of the Californian wind turbine industry are summarised in Table 8.5. It shows the importance of the niche environment created by Federal and state legislation and fiscal provisions for incubating the new industry. It also shows that none of the key inventors were located in California itself. Stanley Charren, the founder of US Windpower incorporated the company in Cambridge, Massachusetts in 1979. The vertical axis wind turbines manufactured and diffused by FloWind and VAWTpower was originally invented by Georges Darrieus in France in 1925. In both cases the new knowledge that was eventually commercialised in the form of innovations in the new wind turbine industry in California took years and decades to develop and was transferred over hundreds if not thousands of miles.

The technical knowledge employed by Jim Dehlsen and his firm, Zond Systems, was also imported between continents, embodied, in the first instance, in Vestas, Danish wind turbines. Thus the new wind turbine pathway created in California was mainly based on imported external knowledge invented elsewhere.

The niche conditions in the State that came together in the early 1980s provided a period of incubation conditions that allowed a few pioneering innovators to commercialise that knowledge and to create a new economic pathway. Unlike the agents in the US Federal wind power programme, these innovators were relatively unfettered by contemporary path-dependent technological paradigms. They were often already committed to alternative sources of energy. Innovators like Jim Dehlsen created their own institutional arrangements for investment in and the development of new wind farms. These were not fettered by the inertia built in to

Table 8.5 New path creation: the Californian wind turbine industry

Niche environment	*Inventors*	*Locations*	*Innovation pioneers*	*Locations*	*Landscape change*
Carter Public Utilities Regulatory Policy Act 1978, Federal tax credits of 25% for manufacturing and energy capital investments made before end of 1985.	Stanley Charren	Cambridge Mass. 1974	US Windpower	Cambridge Mass. 1979	New American wind turbine industry located in California.
	Georges Darrieus	France 1925			30 manufacturers by 2008.
Californian Public Utilities Commission rate for utilities' purchase of electricity from renewable energy sources of about 7 cents per kWh.	Raj Rangi and Peter South, NRC	Ottawa late 1960s			Wind farms deployed in e.g. Altamont and San Gorgonio Passes and Tehachapi Mountains.
	Sandia National Laboratories,	New Mexico 1974/5.	FloWind VAWTpower	California late 1970s	
Brown tax credit of 25% for solar and wind energy investments made before end 1986.			Jim Dehlsen, Zond Systems	California early 1980s	

the old path-dependent institutional arrangements for the generation and supply of electricity. The relatively high rate set by the Californian Public Utilities Commission at which the private utilities had to purchase renewable energy combined with the Jerry Brown tax credit for solar and wind energy investments circumvented the vested interests of the contemporary electricity generation regime. Thus, unlike the agents involved in the Federal wind power programme, the pioneering innovators of the Californian wind boom were able to overcome the barriers to new path creation arising from previous path-dependent rounds of development in the local electricity generation and supply industries.

The combined niche conditions that facilitated the Californian wind boom started in 1981 and expired in 1986 as the Californian State tax incentives were withdrawn and the price of oil slumped back to not far short of what it had been before the Yom Kippur War of 1973. This should not be taken as evidence that the multi-level perspective suggested by Geels (2004) provides the best explanation for the Californian wind boom. This is a relatively non-dynamic approach and does not explain the roles played by various innovation actors within the niche in triggering the boom. These actors created a new technological pathway. They installed more than 12,000 wind turbines in California.

After a dynamic series of mergers, acquisitions, firm births and deaths, the new Californian wind turbine manufacturing industry developed to consist of some 30 companies by 2008. These developments could not have taken place, however, without the initial activities of the inventors and innovators who created the new pathway in the first instance.

Summary and conclusions

It has been argued in this chapter that new technological pathways are created within the context of ongoing path-dependent development trajectories. These produce significant barriers to the initial introduction of new technologies. These barriers may be economic. In this form, they often embody notions of economic competitiveness influenced by long periods of previous development in established industries. The barriers may also be cognitive. In this case, they are represented by existing technological paradigms, which have established the contemporary conventional wisdoms and approaches to the solution of technological problems. Institutional hysteresis may also present barriers to the introduction of a new technology. In this case, entrenched informal rules and regulations form unsupportive environments that do not facilitate the introduction of a new technology. Finally, the entrenched power structures, and their attendant interest groups, of existing technological regimes represent an environment of possibly “hostile” current stakeholders in which a new technology has to emerge.

Confronted by this possible range of barriers that have evolved over time as key features of past path-dependent development trajectories, the creation of new technological pathways often requires the prior development of “friendly” niche environments. Such environments provide the freedom and space in which new technologies may be invented and incubated until such time as they are sufficiently robust to overcome or circumvent the particular sets of barriers that provide the major obstacles to them being developed into innovations, and to reaching critical mass in the market place.

Within niches, new pathways are created initially by the interactions of intelligent agents. These include researchers, inventors, innovators, firms, business angels and venture capitalists. They are involved in an iterative set of processes that include the development of new knowledge and its commercialisation in the form of innovations. These may be radical breakthrough innovations but more often than not they are incremental, with their development taking years if not decades. New technological pathways are not, therefore, created overnight.

The impacts of the creation of new technological pathways on the economic landscape in the longer term include the start of new industries, the employment that generates together with the effects of the deployment and use of their new products and services. Although it is not possible to generalise from one case study of the emergence of a single technology, there are some indications from the American wind turbine industry that its geography would not be explained by traditional path-dependence explanations of how and why new industries are created in particular locations. This is primarily because they do not offer an explanation of the initial innovation processes upon which new technological pathways are based.

Based on the evidence provided by the failure of the Federal wind power programme and the success of the Californian wind boom, the initial locations of a new economic pathway are not a matter of random chance or serendipity. Instead they are strongly influenced by the existence of niches in which they may incubate, sheltered from the contemporary forces of market competition. The Federal wind power programme failed mainly because the R&D niche created by the programme did not overcome previous lock-ins to inappropriate technological paradigms. It was also hamstrung by institutional inertia that stifled potential learning that could have been produced by the programme. In contrast, the collection of niche-led demand conditions created in California stimulated innovation and entrepreneurial deviation. Much of the technological knowledge on which this was based was imported from outside the State.

The pioneering companies that took first-mover advantages from these niche conditions in California possessed specialised rather than generic assets. They either possessed previous experience in the manufacture of wind turbines or were started in the first instance either to manufacture a specific type of turbine or to exploit the investment opportunities provided by the fiscal and purchasing advantages in the niche conditions created by the Federal and State governments.

None of the key pioneer firms were spin-offs. They either moved from elsewhere to locate in California or started *de novo* in California. This was not a chance process but was driven by a combination of the unique niche conditions established in the State and their mastery of the relevant specialised knowledge either as a result of previous learning by doing or by their abilities to absorb and commercialise research based knowledge generated elsewhere.

In the first instance, none of the firms located in particular places because of existing Marshallian externalities. They required, for example, new forms of labour skills that they developed for themselves. Marshallian forms of locational economies developed subsequently as the industry expanded. It was also the case that in California, rather than the development of different technological enclaves, two different technologies developed in relatively close geographic proximity to each other. Both horizontal and vertical axis wind turbines were developed and deployed in the State respectively by US . Windpower, FloWind and VAWTpower.

With respect to the later path-dependence models of the location of new industries, the Klepper (1996, 2001) model starts with the chance location of a first firm. It has already been argued that this was not the case with the pioneering firms who started the Californian wind boom. Evidence has not been presented in this chapter of the subsequent nature of the development of the industry to its present total of around 30 firms, so no comment can be made on whether the life-cycle of the industry is particularly marked by spin-off processes.

With respect to the Boschma and Frenken (2003, 2006) model of related variety, the failure of the Federal wind power programme suggests that it is impossible to identify *ex ante* which forms of knowledge are positively related to a new economic pathway as it is created. At this stage of the process, it is necessary to explain the contributions of various actors, such as inventors and entrepreneurial innovators to new path creation. It is only after this has been done that the possible forms of knowledge that contribute to the diffusion of innovation and the subsequent development of a new pathway to achieve a critical mass and breakthrough may be analysed.

To sum up, the geography of new path creation often starts with the emergence or strategic creation of niches in which inventions may be incubated as they are slowly developed into commercial innovations. These innovation processes require intelligent agency either in collective decision making or by pioneering individuals or firms. Such agents may source the new knowledge on which innovations are based from around the world. There does not appear to be any necessity for the new knowledge that forms the basis of a new economic pathway to be located, in the first instance, in the locality in which a new industry is started. Previous rounds of path-dependent development provide lock-ins and barriers to the breaking of existing, locked-in, pathways and the creation of new ones. Explaining the geography of innovation is the key to understanding the geography of new path creation.

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9 Proximity and innovation networks

An evolutionary approach

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Introduction

The role of networks in innovation processes has become a key research area in the field of innovation studies over the last decade and a half (Freeman 1991; Powell *et al*. 1996; Hagedoorn 2002; Owen-Smith and Powell 2004; Ahuja *et al*. 2009). Not surprisingly, the rapid increase in the number of studies on innovation networks in an inter-disciplinary field, such as innovation studies, has led to a great variety of theories and concepts (Ozman 2009). Only recently, economic geographers have jumped on the study of the spatial dimensions of social networks in innovation processes (Ter Wal and Boschma 2009), following the literature on national and regional innovation systems developed in the 1990s (Freeman 1987; Nelson 1993; Cooke *et al*. 1998; Cooke 2001). Despite this attention, theoretical accounts of spatial networks are still underdeveloped (Grabher 2006; Sunley 2008; Hess 2008). This is also true for an evolutionary approach to knowledge and innovation networks, although attempts have been undertaken more recently (Giuliani and Bell 2005; Powell *et al*. 2005; Cantner and Graf 2006; Sorenson *et al*. 2006; Boschma and Ter Wal 2007; Giuliani 2007; Glückler 2007; Morrison 2008; Suire and Vicente 2009; Balland *et al*. 2010; Breschi *et al*. 2010; Cassi and Plunket 2010; Glückler 2010; Graf 2010; Balland 2011; Broekel and Boschma 2011; Ter Wal 2011; De Vaan 2012).

Studies on network evolution tend to focus mainly on structural mechanisms driving the formation of networks, like preferential attachment, transitivity, repetition of ties and reciprocity (Rivera, Soderstrom and Uzzi 2010). These endogenous mechanisms of network dynamics explain how network structures tend to be reproduced over time, but these studies do not account for the attributes of network nodes. This is at odds with a basic point of departure in evolutionary economics, that is, that actors differ from each other, especially in terms of knowledge bases and capabilities (Nelson and Winter 1982; Cohen and Levinthal 1990). However, this emphasis on the heterogeneity of actors leaves open the question of how actors come together in networks, and which actors are more likely to connect in innovation networks. In sociology, it is common to explain social networks in terms of similarities in attributes of nodes, such as, belonging to the same social or ethnic group.

This insight has recently been adopted in empirical studies to explain who connects with whom in innovation networks. To account for this variety in node attributes when focusing on the geography of innovation networks, we put the proximity concept (Bellet *et al*. 1993; Rallet and Torre 1999; Boschma 2005; Carrincazeaux *et al*. 2008; Torre 2008; Carrincazeaux and Coris 2011) into the heart of our theoretical and analytical framework (Boschma and Frenken 2010). The main objective of this chapter is to outline an evolutionary approach on proximity dynamics that provides a framework for the analysis of the spatial evolution of innovation networks. To achieve this objective, we explain the commonalities and the differences between institutionalist, interactionist and evolutionary approaches that have formed the most influential contributions of the proximity school during the last couple of decades. We show that the theoretical content of the three approaches leads to an emphasis on different proximity dimensions. We argue that the evolutionary approach is strongly rooted in the interactionist and institutionalist approaches to proximity. In addition, the evolutionary account adds some crucial proximity dimensions for network studies, while it clarifies the content of existing forms of proximity. As such, we highlight the advantages of adopting an evolutionary approach to proximity dynamics and networks for theoretical and analytical purposes.

The structure of the chapter consists of two sections. The first section assesses the advantages of adopting an evolutionary approach for analyzing innovation networks by discussing the commonalities and differences with the institutionalist and interactionist approaches of the proximity school. The second section discusses a number of challenging issues for developing a dynamic evolutionary approach on proximity and innovation networks. Among others, we argue that it is crucial to include heterogeneity of actors and their proximities in network studies, but one should avoid taking the attributes of actors and their resulting degree of proximity for granted and fixed over time. Instead, we claim that the analysis of the spatial evolution of innovation networks should explain how networks also change the attributes of nodes and the proximities between nodes over time, a topic that is still unexplored.

Different perspectives in the proximity school

For some twenty years, the proximity school has developed a theoretical framework for understanding the coordination of innovative activities in economic geography (Bellet *et al*. 1993; Rallet and Torre 1999; Pecqueur and Zimmermann 2004; Boschma 2005; Lagendijk and Oinas 2005; Bouba-Olga and Grossetti 2008; Carrincazeaux *et al*. 2008). The proximity approach is based on the idea that spatial dynamics involves an important *relational* construct, and accordingly that geographical proximity must be understood as one proximity dimension among others (Gilly and Torre 2000). Scholars from the proximity school have developed different perspectives on the relationship between proximity and interaction in economics. Depending on the forms of proximity considered, this literature provides different approaches, mostly referring to institutionalist and interactionist approaches.[1]

In this section, we claim that the analytical distinction in five proximity dimensions proposed by Boschma[2] (2005) and more recently by Boschma and Frenken (2010) have introduced an *evolutionary* approach to proximity dynamics. Even if this approach largely builds on the two other accounts of proximity, it cannot be reduced to these two. This section makes an effort to set out the commonalities and differences of these three approaches and to discuss the advantages offered by such an evolutionary approach for the analysis of innovation networks. Taking a micro perspective, the evolutionary approach conceptualizes two key dimensions for the study of innovation networks, that is, the similarity of knowledge bases of actors (cognitive proximity) and their embeddedness in the same social context (social proximity). In addition, this distinction allows clarification of the content of other proximity dimensions by analyzing the importance of membership in the same group (organizational proximity) and shared norms and values (institutional proximity). In this chapter, we claim that the main components of these four proximity dimensions are present in the institutionalist and interactionist approaches but often remain under-conceptualized.

Institutionalist approach to proximity

From the very start, the role of institutions has been highlighted in the proximity school (Bellet *et al*. 1993). More recently, Kirat and Lung (1999), Gilly and Lung (2004), Carrincazeaux *et al*. (2008) and Kechidi and Talbot (2010) have reasserted such an approach by distinguishing three proximity dimensions,[3] that is, geographical, organizational and institutional proximity. The institutionalist approach of proximity dynamics adopts a macro-perspective, focusing on the analysis of the context of interactions.

The central concept in this approach is institutional proximity, understood as a quite broad category. This dimension includes mainly references to common norms and values shared by actors at the macro-level and, therefore, is very much a structural approach, but some attention is also given to their social embeddedness at a micro-level. Indeed, as defined by Carrincazeaux *et al*. (2008: 3), "institutional proximity rests on the players' sticking to shared rules of actions – explicit or implicit rules (habitus) – and, in some cases, to a shared system of representations, and even values". Thus, institutional proximity denotes a holist, macro-level perspective. Vicente *et al*. (2007) stress that institutional proximity also includes a social dimension in this approach. Indeed, Kirat and Lung (1999: 27) emphasize that "institutional proximity raises the problems of the embeddedness of interrelations between actors". However, the reference to this social dimension is secondary and refers more to the process of constructing institutional proximity, in which social context and collective action are emphasized (Gilly and Lung 2004).

The other non-geographical dimension distinguished in the institutionalist approach is organizational proximity. This dimension plays a less prominent role in this approach but is also defined in a broad sense. Indeed, this form of proximity combines, at the same time, the relatedness of knowledge bases of actors and their belonging to the same group. For Carrincazeaux *et al*. (2008: 3), organizational proximity "refers to complementary resources held by players [. . .]". Organizational proximity stresses the importance of complementary knowledge and thus refers to the degree of cognitive proximity between actors. However, the same authors also argue that the complete definition of organizational proximity also considers that these players "[. . .] could potentially participate in a common productive process, within the same organization (firm, group), or within a set of interacting organizations (cooperation network, industry, local productive system)". Then, real collaborations do not seem to be automatically required for actors to be organizationally proximate, but the belonging to the same group or to a network is fully part of this proximity dimension. Moreover, it is important to stress that group and collaboration networks are not clearly distinguished to define organizational proximity, which can be problematic for the study of the influence of proximity on the spatial evolution of innovation networks.

Following North (1990), institutionalist scholars emphasize the particular importance of the "rules of the game" for proximity dynamics and to understand the coordination of actors (Zimmermann 2008). This approach contributes to a better understanding of innovation networks because particular interest is devoted to the historical, political, cultural or territorial context in which interactions develop. Such an approach is especially useful for case-study research, in order to reveal the complex nature of the geography of innovation networks, and to emphasize its context-specific features. However, the institutionalist approach is less focused on micro-level motives of interactions, like getting access to external knowledge. As such, the institutionalist approach is less likely to sketch a systematic framework for the understanding of the spatial formation of innovation networks from a micro perspective. We discussed above that the institutionalist approach of proximity dynamics refers only in an implicit way to the similarity of knowledge bases of actors or to their social context, while these might be important drivers of linkage formation. In addition, these two dimensions are embedded in the definition of organizational proximity and institutional proximity respectively, as depicted in Figure 9.1. There is a second approach in the proximity school that focuses more systematically on the formation of interactions between actors, that is the interactionist approach to proximity (Carrincazeaux *et al*. 2008), to which we turn now.

Interactionist approach to proximity

Unlike the institutionalist approach to proximity, the interactionist approach to proximity dynamics follows the idea that it is crucial to focus on interactions, rather than on the context of interactions. In this sense, references to institutional proximity are generally avoided (Gilly and Lung 2004). This approach considers that it is crucial to account for the fact that actors do not take their decisions isolated from other actors. This approach makes a fundamental analytical distinction between the geographical dimension of proximity and a *relational* dimension to proximity (Rallet 1993), that is, between geographical proximity and organized proximity (Torre and Rallet 2005; Zimmermann 2008). Organized proximity is further decomposed into two added proximity dimensions, which refer to the logic of belonging and the logic of similarity.

The first dimension of organized proximity relates to the logic of belonging. This form of proximity actually contains the relational nature of the organized proximity. It implies that “cooperation will, a priori, develop more easily between researchers and engineers belonging to the same firm, the same technological consortium or the same innovation network” (Torre and Rallet 2005: 50). The interactionist approach to proximity then stresses belonging to a structure[4] in a very broad sense, without defining its precise form. Indeed, “it designates any structured unit of relations. It might take any form of structure, e.g. a firm, an administration, a social network, a community and a milieu” (Torre and Rallet 2005: 58). Accordingly, this logic includes the belonging to both social groups (communities and social networks) and to more formally organized groups (technological consortia and organizations). This proximity dimension also includes reference to innovation networks, as in the institutionalist approach. When doing so, the distinction between proximity as a driver of network formation and innovation networks gets blurred, and it will become difficult to disentangle empirically cause and effect of innovation network formation.[5]

The second dimension of organized proximity relates to the logic of similarity. Contrary to the logic of belonging, this dimension does not contain any relational aspect. Two actors are considered to be similar if they “share a same system of representations, or set of beliefs, and the same knowledge” (Torre and Rallet 2005: 50). In this sense, this proximity dimension comes close to the conceptualization of institutional proximity, as stressed by Carrincazeaux *et al*. (2008), but this logic of similarity also includes the cognitive dimension (although the concept of similarity of knowledge bases remains underdeveloped). This is problematic from at least an analytical point of view, because the distinction between the similarity of institutions (as systems of representations, for instance) and the similarity of knowledge bases (sharing the same knowledge) gets blurred. We claim that this distinction is crucial for a better understanding of the geography of innovation networks, because the heterogeneity of knowledge bases and capabilities is basically the prime mover of such network formation while other forms of proximity (like institutional proximity) enable this process but not necessarily (Boschma, 2005; Frenken 2010).

Analyzing the way relations are organized, the interactionist approach offers a particularly interesting way to figure out the structural properties of networks (especially to account for network dependencies) and to understand the diffusion of knowledge and innovation. In this case, relational forms of proximity are both resources and constraints to access knowledge (Bouba-Olga and Grossetti 2008). Moreover, such an approach seems more dedicated and equipped to explain the formation of network linkages than the institutionalist approach, because organized proximity can be defined as “the ability of an organization to make its members interact” (Torre and Rallet 2005: 49), in which the term organization includes different drivers of interaction and network formation. However, the most important shortcoming of the interactionist approach for analyzing the spatial evolution of networks is precisely the insufficient level of distinction between these different drivers. Therefore, it is inevitable that analytical confusion will occur when concepts like innovation networks, social embeddedness and groups of firms are all included in this logic of belonging, leading to an inextricable interplay between causes and effects of network formation.

Evolutionary approach

Proximity is also a key concept in the evolutionary economic geography framework (Boschma and Frenken 2010), but also more generally in evolutionary economics, with its emphasis on localized and incremental change (Nelson and Winter 1982). However, in evolutionary economics, the proximity concept has remained underdeveloped until very recently, and has been more or less equated with its cognitive dimension, that is, the absorptive capacity of organizations (Cohen and Levinthal 1990) and the cognitive proximity between agents (Nooteboom 2000). In this context, the proximity concept as defined by Boschma (2005) can be seen as an attempt to extend the understanding of the heterogeneity of organizations in evolutionary economics, which had been defined in cognitive terms primarily (that is, organizations also differ with respect to others in the social, geographical, institutional and organizational dimension), and to link this multi-dimensional concept of proximity to the topic of interaction, collaboration and network formation between organizations.

As compared to the institutionalist approach to proximity, this *evolutionary* approach to proximity dynamics does not explicitly focus on the context of interactions, but adopts a micro perspective to understand linkage formation, conceptualizing five main proximity dimensions in this respect: geographical (same spatial area), organizational (same group) and institutional proximity (same norms and values), but also cognitive (same knowledge bases) and social proximity (common relationships). One of the main claims is that proximity is required in some (but not necessarily all) dimensions to get firms connected and to enable interactive learning and innovation among them (Boschma 2005). Consequently, in addition to (endogenous) structural effects of networks, the various proximity dimensions can, in principle, contribute to reduce collaboration costs or risks and might be considered potential underlying mechanisms of innovation network dynamics (Balland 2011).

Contrary to institutionalist and interactionist approaches to proximity, the typology proposed by Boschma (2005) allows conceptualization of the heterogeneity of knowledge bases and social embeddedness through the concepts of cognitive and social proximity respectively. It appears crucial to consider these two dimensions separately for the understanding of knowledge networks (Brossard and Vicente 2010).[6] The similarity of the knowledge bases of actors is indeed a crucial determinant of collaboration networks, like in technological alliances (Nooteboom *et al*. 2007). In addition, several studies have collected evidence that firms in clusters perform different roles and positions in knowledge networks because they differ in cognitive terms (Giuliani and Bell 2005; Boschma and Ter Wal 2007;

Morrison 2008; Vicente *et al*. 2010). The second dimension stresses the importance of social embeddedness of innovative activity, which is an important channel for trust and the exchange of strategic information between organizations (Granovetter 1985; Grossetti and Bès 2001; Gertler 2003; Breschi and Lissoni 2001). Breschi and Lissoni (2009) found evidence that skilled workers mobility[7] is an important channel of knowledge diffusion between organizations. Labor mobility leads to a spread of former colleagues (that are socially proximate) over different organizations, which makes these organizations more inclined to connect to each other and exchange knowledge, irrespective of whether these organizations are geographically proximate to each other or not (Almeida and Kogut 1999; Saxenian 2006; Agrawal *et al*. 2006).

It is important to note that such an analytical distinction between cognitive and social proximity can do full justice to the analysis of different drivers behind the spatial formation of innovation networks. Moreover, it contributes to reduce the level of complexity when defining and delineating the two other proximity dimensions (that is, organizational and institutional proximity). In the evolutionary typology, organizational proximity refers to belonging to the same group, which goes back to a fundamental distinction made by Simmel (1890) between groups and webs of affiliations (Grabher 2006). Likewise, Grossetti (2008) claims it is crucial to distinguish, analytically, groups (or circles) from networks. Institutional proximity refers less to the context of interactions in this evolutionary typology, but more to the values or incentives shared by pairs of actors. This serves not only theoretical but also analytical purposes. When evaluating the effect of proximity empirically, a proximity approach in five dimensions is more straightforward to operationalize (Balland 2011; Broekel and Boschma 2011). As argued by Vicente, Dalla-Pria and Suire (2007), when discussing the typology proposed by Boschma (2005), "this clear theoretical distinction leads to a better understanding of the weight of each of them in empirical analysis" (Vicente *et al.* 2007: 66). This issue is particularly important for the study of network dynamics in geography, which requires a clear and sharp operationalization of proximity dimensions in order to isolate the effect of geographical proximity from the other proximity dimensions, and to assess whether these other forms or proximity act as substitutes or complements to geographical proximity.

Such an evolutionary account of proximity offers a number of advantages in theoretical and empirical work explaining the spatial structure of networks. First, the list of proximity dimensions can be extended regarding any other dimension without changing the meaning of each of these proximities. Thus, the proximity dimensions are analytically orthogonal even though some dimensions may turn out to be correlated empirically speaking (Breschi and Lissoni 2001). Second, when multiple proximity dimensions are incorporated in one explanatory framework, one can test which proximity forms are more important for explaining network formation (Autant-Bernard *et al*. 2007; Hoekman *et al*. 2009; Balland 2011; Broekel and Boschma 2011; Ter Wal 2011). Thus, one can account for as many proximity dimensions as possible to try to control for all possible reasons that may underlie network formation. Third, this evolutionary account of the

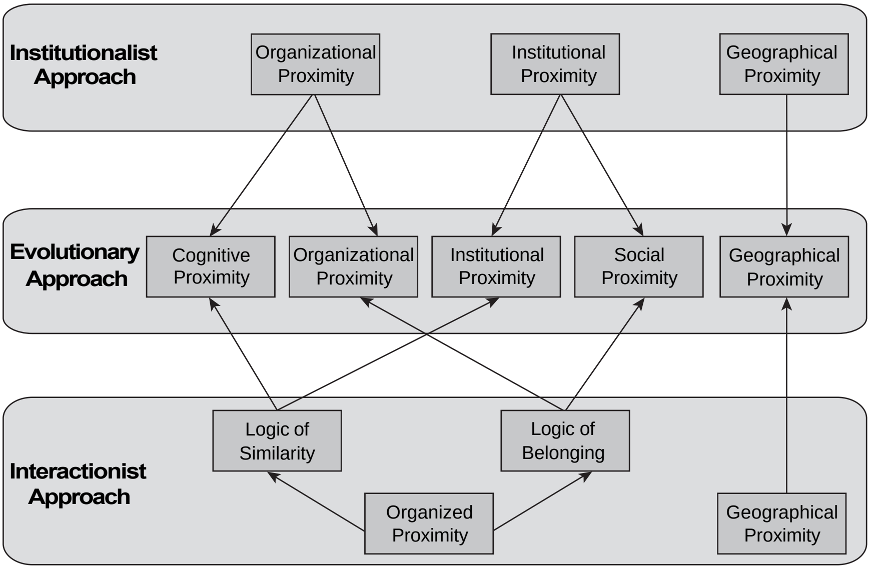

Figure 9.1 The proximity school: different perspectives

proximity concept allows one to understand the interplay between different proximity dimensions. In particular, one can expect proximity dimensions in innovation networks to be substitutes rather than complements (Boschma 2005). To establish a (successful) relation, one is in need of proximity in at least one dimension to manage the uncertainty involved. Being proximate in a second dimension, then, adds relatively little to the probability a link is formed, or the probability that the relation is successful.

In Figure 9.1, we summarize the previous discussion, by outlining the major proximity concepts proposed by the institutionalist, interactionist and evolutionary approach of the proximity school, and how these are related to each other conceptually. This theoretical debate on the various forms of proximity, the different typologies and their resulting conceptual relationships would have certainly required a more thorough discussion but that is beyond the scope of this chapter. This section aimed to introduce the evolutionary approach to proximity dynamics and its advantages for the study of the spatial evolution of innovation networks.

Conclusion and discussion

A major challenge in economic geography is to develop theoretical accounts for explaining the effect of networks on economic performance and for explaining network formation in space. In this chapter, we made an attempt to sketch an evolutionary view on the geography of innovation networks by linking the literatures on proximity and network dynamics. We explored the conceptual relationships between our evolutionary approach and the institutionalist and interactionist approaches of the proximity school. We showed that a micro perspective and a sharp analytical distinction between five proximity dimensions provided by an evolutionary approach cannot be reduced to the two other approaches to proximity. Not only by conceptualizing two important drivers of network formation, but also by clarifying the nature of the other proximity dimensions, we assessed the advantages of an evolutionary approach to proximity for the study of the spatial evolution of innovation networks. Thus, each relationship between two heterogeneous actors can be classified as being more or less proximate in five dimensions (that is, cognitive, social, institutional, geographical and organizational). These dimensions are orthogonal even though these may turn out to be correlated (and thus, the proximity dimensions may either be substitutes or complements). Our theoretical framework suggested that actors that are proximate in some (if not all) dimensions are more likely to be engaged in network relationships.

However, an important shortcoming of all three proximity approaches (including the evolutionary account) is that they have not investigated the *dynamic* nature of the proximity dimensions thus far. A major challenge for a true evolutionary approach to proximity dynamics is precisely to avoid taking proximity between actors as fixed (Menzel 2008). Indeed, not only relations but also attributes of actors change over time. Proximity does not only affect network formation, but network linkages can also change proximity between connected agents, where, for example, processes of learning make them more cognitively proximate (Cowan, Jonard and Zimmermann 2007). Moreover, this is also important for explaining regional performance, as too much cognitive proximity may provide fewer opportunities for true innovations and make local actors inward-looking. The structure of knowledge networks and the retention of ties are likely to increase the level of proximity between actors, which might form a potential source of regional lock-in (Boschma 2005). An important question is, therefore, to understand how related variety (Frenken *et al*. 2007) can persist over time if innovation networks display a tendency to increase the level of proximity between actors in the same (local) innovation network. This requires a thorough identification of the underlying mechanisms of proximity change, and how proximity and networks co-evolve. Padgett and Powell (2010: 3) claim that “in the short run, actors create relations; in the long run, relations create actors”. Indeed, it might be important to note that proximity displays a certain degree of inertia, because attributes evolve less quickly than relations. This might lead to short term stability of proximity, while the creation and destruction of relations can happen very quickly in an innovation context (Gay and Dousset 2005).

More efforts are also needed to develop a theoretical framework to understand whether the different proximities are substitutes or complementarities, and under what circumstances. Taking a dynamic perspective requires a thorough investigation of the different stages of network formation, in order to determine in which stages some proximity dimensions play a more prominent role (Balland *et al*. 2011; Ter Wal 2011). This might be achieved by investigating the changing role of proximity along the industry life cycle (Audretsch and Feldman 1996; Klepper

1997). For example, if geographical proximity affects network formation, is this influence persistent over time? Is it related to the degree of maturity of an industry? This concerns the study of both the creation of new relations by new firms and by incumbent firms linking up with other nodes, and the break-up of existing relations due to the exit of firms or because incumbent firms dissolve their relations with other nodes. Doing so, the study of network formation is not only about who connects with whom and why (being dependent on proximity), but also about firm dynamics, which concerns the formation and dissolution of nodes.

An evolutionary approach that is firmly based on the idea that firms are heterogeneous in terms of knowledge bases and capabilities, should also consider that proximity is not automatically undirected (symmetric). In this chapter, but also in other publications related to proximity dynamics, proximity is treated as a simple "distance" perspective (Gilly and Torre 2000). Such a "distance approach" means that the degree of proximity is the same regardless from which actors "frame" one is looking. However, a huge literature in cognitive science and psychology has strongly criticized the distance approach as a relevant way to measure proximity, and proposed adopting a featural approach[8] (Tversky 1977; Tversky and Gati 1982). Adopting a featural approach allows one to consider asymmetric proximity, that is, the fact that *i* might be more proximate to *j* than *j* to *i*.[9] Asymmetric proximity occurs when *i* has less features than *j*, because *i* is considered more similar to *j* than *j* to *i*. For instance, *j* can have multiple knowledge bases, locations, subsidiaries, friendships ties or institutional regimes and *i* only one feature. It implies that *i* is more similar to *j* and then more likely to propose to *j* to collaborate than the inverse. This distinction also has strong implications for the way we conceptualize proximity, and how the concept of power could be more firmly integrated in the evolutionary approach to proximity.

In this chapter, we considered proximity as a horizontal concept, while it can be considered also as a vertical concept, involving power-related issues. Indeed, two firms can be considered as having similar knowledge bases, but one of them can have higher capabilities and then have more to lose and less to gain from a network link than the partner with lower capabilities (Alcácer 2006; Brown and Rigby 2010). In the case of cognitive proximity, it means that some firms have more to learn in the collaboration than others. For organizational proximity, some firms can have better positions, but also for social proximity some may be more indebted and then the collaboration can turn asymmetric. Even for geographical proximity, two actors can be very close in kilometres, but one actor can be located in a better place and therefore can benefit more from their co-location. And institutional proximity might be hierarchized according to the quality of norms and values perceived by others. These and other issues need to be taken up to develop further a full evolutionary account to proximity and network dynamics.

Notes

1 The 5th Proximity congress held in Bordeaux in June 2006 labelled: *"Proximité: entre Interactions et Institutions"* was strongly oriented toward the debate between interactionist and institutionalist approaches of proximity dynamics. For a critical

survey of the institutionalist and interactionist approaches, the reader is referred to Carrincazeaux, Lung and Vicente (2008).

2 See Balland (2011) for an operationalization of these five proximity dimensions.

3 Pecqueur and Zimmermann (2004) and Zimmermann (2008) also distinguish these three dimensions. However, they first make a distinction between spatial and non-spatial proximity (organized proximity), and then organized proximity is split into an organizational and institutional dimension. Even if their typology comes close to the institutionalist approach, their approach can be considered as interactionist.

4 Rallet and Torre (2005) use the term "organization".

5 When arguing that belonging to the same innovation network increases the likelihood to collaborate, this approach probably refers to endogenous structural mechanisms that may drive the formation of networks, like transitivity. However, this is not explicitly expressed in the interactionist approach.

6 Brossard and Vicente (2010) use "relational proximity" instead of "social proximity", but both concepts can be understood in a similar sense.

7 Inter-organizational mobility, but not so much in space.

8 Using this distinction, Tversky (1977) shows, for instance,that North Korea is more similar to China than China to North Korea.

9 Neffke F. and Svensson Henning M. (2008) use a similar argument to conceptualize asymmetric related variety.

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Part III

Cluster emergence and destabilisation

10 Foresight and innovation

Emergence and resilience of the Cleantech Cluster at Lahti, Finland

Helinä Melkas & Tuomo Uotila

Introduction

Foresight and innovation are activities closely linked with each other – the former providing inputs for the latter. However, there have been few attempts to build conceptual and theoretical bridges between these two activities. An agreement between practitioners and theorists emerges about the strong ties linking strategic foresight, learning and innovation processes, but the true nature of this link still remains rather vague, also in the context of regional innovation systems.

This chapter reviews theoretical literature on foresight and innovation. It is argued that important policy issues involve finding ways to make this link clearer and better known. The first part of the chapter is concerned with presenting a theoretical structure that bridges a number of separate subfields of study of foresight and innovation. The model emphasises the roles of learning, exploration and exploitation of knowledge, absorptive capacity, and knowledge-generating and knowledge-exploiting subsystems in a regional innovation system.

After looking into the interplay between the concepts of foresight and innovation, we move on to discussing a practical case of building and developing the Cleantech Cluster in the Lahti region in Finland. However, our focus is not on the development of the Cluster itself, but rather on how different kinds of regional innovation policy instruments were used and applied in order to promote the emergence of the Cluster from the resilience point of view. Resilience is focused on as the capacity for renewal, re-organisation and development, or adjustment and adaptation (for example, Folke *et al*. 2004; Christopherson *et al*. 2010). The research data consist of strategy documents, research reports and other reports from the last ten years. Finally, the results are linked to the above-mentioned theoretical model.

The Finnish Cleantech Cluster is made up of four Centres of Expertise within the cleantech sector. The activities of the Cluster are coordinated by Lahti Science and Business Park Ltd. In the Lahti region, many enterprises specialise in waste management and recycling in particular, as well as in water and soil-related business. Lahti is also known for cleantech venture capital networks and expertise. The local cooperation between companies, the scientific community and the Cleantech Cluster has led to a strong expert network for generating new innovative solutions. The Cluster was ranked as the third among ‘World’s 10 Top cleantech clusters’ in 2010 by Cleantech Group USA (Lesser 2010).

Resilience and its operationalisation

Simmie and Martin (2010) reviewed different definitions of resilience and their potential application in explaining the long-term development of urban and regional economies. They rejected equilibrist versions of resilience and argued that we should seek an understanding of the concept from an evolutionary perspective. This is because the firms, organisations and institutions that comprise regional economies are continually changing and adapting to their economic environments. These changes are increasingly driven by the creation, acquisition and commercial exploitation of new knowledge. These processes are never in equilibrium. Following these arguments, Simmie and Martin turned to an evolutionary theoretical perspective. This emphasises adaptation and change as key processes in the development of regional economies. They argued that these processes are the bases of regional economic resilience.

We explore the applicability of a theoretical structure linking foresight and innovation to describe, for instance, these knowledge-related issues in emergence and resilience of the Cleantech Cluster. In addition to economic resilience, we are interested in what is called social resilience; the ability of human communities to withstand and recover from stresses, such as environmental change or social, economic or political upheaval. Social resilience is related to adaptive governance, networks and learning; analyses of the social, institutional, economic (and ecological) foundations of multi-level governance that are successful in building (social-ecological) resilience. There is a need for new flexible, inclusive and multi-level forms of governance that can deal with the complexity of (social-ecological) systems, and their associated services (cf. Reed *et al*. 2010; Newig *et al*. 2010).

A key feature of resilience thinking is that changes, sometimes abrupt, often interpreted as crises, perceived or real, can trigger renewal and innovation if there is resilience. Learning plays a central role in resilience of (social-ecological) systems, in particular the recombination of experiences from different areas and diverse fields that may lead to new insights and pathways for development. Resilience thinking emphasises learning, recombination of experiences and diversity, and focuses on the dynamic interplay of gradual and sudden change. Such thinking helps us avoid the trap of simply rebuilding and repairing the structures of the past, but instead anticipate, adapt, learn and transform human actions and societies for improved wellbeing in light of the unprecedented challenges of our inter-connected and turbulent world (Folke *et al*. 2010). This view, together with the knowledge emphasis, comes, in a way, close to definitions of innovation, various types of innovation, innovativeness and innovation systems – as noted also by Flanagan *et al*. (2011: 711), according to whom policy processes can be thought of 'as a subset of the broader category of innovation processes' characterised by bounded rationality, interaction, learning and adaptation; and Majone (1989), who saw policy making as a communicative process based on dialogue, argument, negotiation and persuasion, rather than a technocratic or knowledge-driven process.

Within social resilience, the most relevant sub-theme is knowledge, learning and social networks, but also adaptive governance and multi-level governance are of interest for us. We do not claim that our model would comprehensively cover all these wide topics, but the link between foresight and innovation is something that could increasingly be focused on in research on resilience. Adaptive governance approaches must be able to not only coordinate relevant actors at multiple scales, but also achieve meaningful collaborations and collective action before essential services are depleted or critical thresholds are transcended. Learning is therefore essential for individuals, communities, other stakeholders and agencies to develop their ability to deal effectively with new situations and to prepare for change and surprise (Folke *et al*. 2010).

Knowledge, learning and social networks, in relation to resilience, addresses information sharing, knowledge generation, participation, learning, organisation, leadership, agency, (co-)management of common pool resources, social networks and social simulation, in order to explore how different structures and processes promote or constrain sustainable management (cf. Newig *et al*. 2010). Successful management of complex systems requires adaptive approaches and a system of continuous learning for building knowledge and effective management practices to interpret and respond to feedbacks. Knowledge generation is an ongoing process that typically takes years to accumulate. In addition to learning, the cumulative knowledge should be embedded in the management process. Many communities of resource users possess intricate knowledge of their local resource base, local resource needs, and of resource extraction/harvesting practices. Such knowledge can provide a valuable base for resource management alongside scientific knowledge. Thus, effective learning of complex systems typically requires participation of many different actors ranging from local resource users, government agencies, other types of organisations, and scientists. Likewise, adaptive management practices able to manage these complexities will also need the active involvement of different actors (Newig *et al.* 2010).

These factors concerning knowledge and learning, as well as social networks and governance, connect this research to the model to be introduced, linking foresight and innovation. The regional Cleantech Cluster at Lahti is seen as a 'meso-level' structure (cf. Newig *et al*. 2010); a learning network to be analysed with the help of the model. Resilience is thus seen also as 'breaking up of regional path-dependence'. This chapter contains a retrospective account of cleantech as a regionally important field in the Lahti region and looks into the developments in the last ten years. These years contain, for instance, the use of the Regional Development Platform Method, various versions of the regional innovation strategy, and technology foresight initiatives. The chapter also contains future research topics concerning foresight and the Cleantech Cluster. From the regional level, the need has arisen to move on to the hands-on organisational level in foresight-related matters in the Cluster. The path or retrospective account to be described reflects – not only the Cleantech Cluster but also – the theoretical development of the wider innovation environment in the Lahti region. Foresight is thus treated in this chapter with a multi-lateral perspective containing regional foresight initiatives, regional vision building, and regional foresight and innovation research from around the year 2000. The questions behind the retrospective account are how the cleantech focus developed in the Lahti region, which actors played roles in that process, and which interventions were helpful in creating the regional development platform for cleantech.

Interplay between foresight and innovation

The success of economic actors is strongly related to their adaptability to the emerging techno-economic environment. Sotarauta and Srinivas (2006) made a distinction between strategic adaptation and pure adaptation, the former referring to an actor's capacity to change its destiny by adapting itself to changes and reshaping its local environment. Pure adaptation is more reactive by nature as opposed to proactive strategic adaptation, which is also strongly related to actors' ability to learn. Especially strategic adaptation is a concept that is close to resilience, as defined in this chapter. Strategic adaptation is based on decisions that have to be made in a great uncertainty, that is, risk that is immeasurable and thus not possible to calculate (Knight 1921). This uncertainty can be reduced by creation of future-oriented knowledge. Future-oriented knowledge is often very challenging to use in an actor's renewal process, since (i) the possible futures are hard to outline, (ii) future-oriented knowledge is even more abstract than tacit knowledge, and (iii) due to its nature, future-oriented knowledge is hard to adopt in an actor's organisational learning processes and strategic routines (Uotila, Harmaakorpi and Melkas 2006). To make use of future-oriented knowledge, actors need a special dynamic capability: visionary capability. In this context, visionary capability refers to an actor's ability to outline the potential development directions based on paths travelled − utilising the opportunities emerging from the changing techno-economic paradigm (Harmaakorpi 2004).

Even the most specialised forms of knowledge are becoming a short-lived resource, for example, due to the accelerating pace of technological change. This emphasises the need of foresight activities at all levels; national, regional and organisational, and the integration of foresight, innovation and learning activities. Salo (2000) saw the need to integrate foresight activities more closely in today's decision-making and (action) planning processes as an important challenge for those carrying out foresight activities.

The new network leadership tries to promote learning and includes an active interpretation of signals for change (Pihkala *et al.* 2007). In order to obtain technological, political, social, environmental, and so on, signals, central players and decision-makers need tools that can provide them with meaningful, future-oriented information and shared visions (or frames of reference, such as evolutionary versus neoclassical, resilience versus equilibrium, path-dependent versus historical, and so on) with the help of which they can anticipate the consequences of their choices and negotiate relevant strategies. Foresight is among the tools considered useful in this respect (Eerola and Jørgensen 2002). Coates (1985) defined foresight as the overall process of creating an understanding and appreciation of information generated by looking ahead. It goes further than forecasting, including also aspects of networking and preparation of decisions concerning the future. Still it is not planning, but provides 'information' about the future and is, therefore, one step towards planning and the preparation of decisions (Cuhls 2003). It includes qualitative and quantitative means for monitoring clues and indicators of evolving trends and developments, and is most useful when directly linked to the analysis of policy implications. Thus technology (and also other) foresight activities can, at best, have a vital role in renewal processes by 'giving time and direction' to decision-makers and thus supporting, for example, strategy formulation.

Some authors consider the use of futures research (in its various forms) in innovation processes crucial for the success of an innovation, or argue that at least it can contribute positively to the quality of an innovation process (Van der Duin 2004). When analysing the connection between foresight and innovation processes, Van der Duin (2004) noted that futures research seems to have the most impact in the first phases of the innovation process, the fuzzy front-end, where it has the function of inspiring people to think about new innovations, new future developments and to challenge prevailing perceptions. Although this relation is acknowledged and foresight activities may be regarded as an activity providing inputs to the learning and innovation process, not much literature has been published on either evaluation of foresight processes (in terms of their success) or how foresight is actually used to facilitate innovation processes and how it relates to organisational renewal processes. However, when thinking about the evaluation of foresight, one must bear in mind that 'foresighting' is not forecasting, and thus these processes cannot be evaluated using similar criteria (see Cuhls 2003). From the evaluation point of view, accuracy of forecasts, for example, is easier to evaluate, while in foresight processes the process itself, including not only easily measurable quantitative data but also many kinds of qualitative inputs, is in many cases more important than the final outcome.

Foresight, innovation, knowledge and learning in a regional innovation system

A conceptual model integrating foresight activities and innovation

There seems to emerge an agreement between practitioners and theorists about the strong ties linking strategic foresight and learning processes (especially organisational learning), but the true nature of this link still remains vague (cf. Bootz 2010). In this chapter, we utilise a conceptual model depicting connections between foresight, knowledge, interpretation, innovation activities and learning (Figure 10.1). Although the basic elements of the model are already well known and documented in several writings, in this model they are combined in a novel way. The model emphasises the role of absorptive capacity as an important dynamic capability for carrying out innovation processes, and ways to enhance absorptive capacity in order to better link, for instance, the results of foresight processes and organisational innovation activities and learning. The main idea

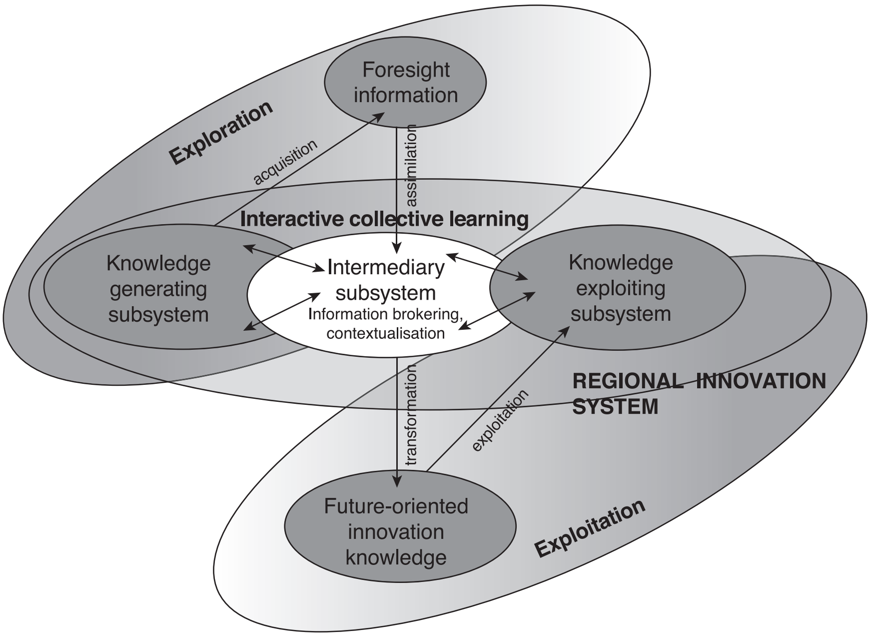

Figure 10.1 From foresight to innovation in a regional innovation system

Source: Uotila 2003.

behind the model is that foresight processes can only generate *information* about possible future developments. When this information is contextualised and embedded into the environment where it will be utilised, to an organisational context, it will be refined or transformed into future-oriented innovation *knowledge* to promote innovation processes (Uotila and Ahlqvist 2008). This is done via information brokerage, which requires, among other things, a deep understanding of the user's knowledge interests, prior technological choices and general knowledge level.

We use this model to highlight resilience factors of the Cleantech Cluster at Lahti that will be identified in the following case study. In relation to resilience, the model reflects topics we are interested in – information sharing, knowledge generation, participation, learning, organisation, and networks – helping to explore how different structures and processes promote (or constrain) sustainable management of foresight and innovation. The main parts of the model are:

- *Exploration and exploitation* (March 1991); a central issue in studies of adaptive organisational processes is the relation between the concepts of exploration and exploitation, the former relating to search of new possibilities and the latter to old certainties. Exploration includes things such as search, variation, risk taking, experimentation, play, flexibility, discovery and innovation. Exploitation, again, includes such things as refinement, choice, production, efficiency, effectiveness, measurement, selection, implementation, and execution. Exploration and exploitation by the same firm varies according to stage in the resilience (or business) cycle (Lester and Piore 2004). Both exploration and exploitation are essential functions for organisations to prosper in the long run, but the problem relates to the fact that they are competing for the same scarce organisational resources.

- *Absorptive capacity* (Cohen and Levinthal 1990; Todorova and Durisin 2007); information and knowledge are fuels for innovation, and in sourcing them from networks, organisational absorptive capacity becomes a key issue. Absorptive capacity is an organisation's ability to value, assimilate and apply new external knowledge. Two types have been identified: potential absorptive capacity that is important in acquiring and assimilating external knowledge, and realized absorptive capacity that refers to functions of transformation and exploitation of the knowledge collected. Absorptive capacity consists of four parts:

  1 acquisition; an actor's capability to identify and acquire externally generated knowledge that is critical to its operations;
  2 assimilation; the actor's routines and processes that allow it to analyse, process, interpret and understand information obtained from external sources;
  3 transformation; an actor's capability to develop and refine the routines that facilitate combining existing knowledge and newly acquired and assimilated knowledge;
  4 exploitation; a capability based on the routines that allow actors to refine, extend and leverage existing competencies or to create new ones by incorporating acquired and transformed knowledge to their operations.

- *Information brokerage* (Burt 1997; Melkas and Harmaakorpi 2008; Nooteboom *et al*. 2007); even within the supportive infrastructure of an organisation, receiving and building on new knowledge can prove difficult. A special interpretation function is needed – information brokerage. Brokerage means more than just linking together partners involved in an innovation process; it includes the aspect of transforming ideas and knowledge being transferred, and – at best – allows the widening of optimal cognitive (as well as social, cultural, temporal, and so on) distance between partners of an innovation process and enhances their absorptive capacity. Translation and interpretation is a crucial step in foresight processes, but still it is poorly understood and has only few theoretical techniques.
- *Knowledge subsystems* (Autio 1998); in regional innovation systems, there is, (i) a knowledge generation and diffusion subsystem, and (ii) a knowledge application and exploitation subsystem. The former consists of four main types of institutions that all participate in the production and dissemination of both explicit (codified) and tacit (technological) knowledge and (technical) skills: public research institutions, technology mediating organisations,

educational institutions and workforce mediating organisations. The knowledge application and exploitation subsystem consists of four C's: companies, clients, contractors and competitors. Nowadays, a large variety of public sector organisations may also be included in this subsystem. Dialogue and interaction between subsystems and actors within subsystems are a necessary prerequisite for regional innovation systems to operate sufficiently.

The case study

Background of the Cleantech Cluster

The Finnish Cleantech Cluster is made up of four Centres of Expertise within the cleantech sector: Lahti, Kuopio, Oulu, and Helsinki (Uusimaa) and the surrounding areas. They all focus on different cleantech competence and know-how:

- In the **Lahti** region many enterprises specialise in waste management and recycling in particular, as well as in water and soil-related business. Lahti is also known for cleantech venture capital networks and expertise.
- The most important national initiative of cleantech in **Kuopio** is a network of organisations and companies that study and create products and services for improving air quality and promoting better health. They also have expertise in the energy efficiency of homes and clean indoor air.
- **Oulu** strives to become the world's leading hub of research and provision of materials for water purification. In addition to water technology expertise, enterprises in the Oulu region specialise in air purification technology and material efficiency.
- **Uusimaa** (the Greater Helsinki Region) focuses on combining ICT with environmental monitoring and clean energy, with a special focus on energy efficiency in the urban environment (see www.cleantechcluster.fi for further information).

The Cleantech Cluster is one of the thirteen Finnish competence clusters mandated by the Ministry of Employment and the Economy for the years 2007–13. Cleantech has been referred to as the next cornerstone of the Finnish economy. The Cluster's targets are to increase cleantech know-how and innovative business in Finland as well as to internationalise the Finnish environmental, energy and clean technology SMEs. Quantitative targets are: 1,500 new jobs by 2013, 40 new companies annually, 20 new spearhead companies to international market by 2013, and R&D&I venture portfolio of 170 Meur by 2013. Support to SMEs is seen to be of utmost importance; in the Cluster, SMEs get the opportunity to network with big companies and the science world (Pantsar-Kallio 2010; cf. Lesser 2010).

The Finnish Cleantech Cluster was ranked third among the world's cleantech clusters in a comparison made by Cleantech Group USA in 2010 (Lesser 2010), after Austria Eco World Styria at Graz, Austria and The New England Clean Energy Council at Cambridge, Massachusetts. The Cluster's internationalisation programme has led to several Finnish cleantech companies' success on the Chinese market, and the interest towards this market is growing. In Russia the focus is on technology projects. Key areas are energy efficiency and solid waste management. The Cluster is also active in India and Poland, and they monitor the development of other potential markets. For foreign companies, the Cluster represents a gateway for finding research and business partners in Finland. Finnish cleantech competence is regarded, throughout the world, as very reliable (Pantsar-Kallio 2010).

This chapter focuses on the Lahti region, in particular. Lahti Science and Business Park (LSBP) Ltd produces services for national and regional cleantech business development; business incubator services; support for organic growth of SMEs' R&D&I; services for enhancing of national and international venture capital on Finnish cleantech companies; and internationalisation programmes. The Cleantech Cluster's keys to success have been identified by Pantsar-Kallio (2010) as follows:

1 Focused regional business strategy: cleantech, design and practice-based innovations.
2 Commitment of all actors on the strategy: to build Lahti into a world class cleantech centre (the Regional Council of Päijät-Häme, the City of Lahti, companies, business and research entities).
3 Flexible and innovative use of EU and other funding.
4 Willingness of the actors to start renewal under difficult financial situation.

Pantsar-Kallio (2010) also identified lessons learnt from activities since 2007. It has been beneficial that regional strategy is the driver for participating in projects, and not vice versa. Innovative and flexible use of EU funding and focusing are keys to success: use of structural funding for developing the regional Lahti Cleantech Cluster; bilateral funding for neighbouring regions for opening international markets to companies, and FP7 and Competitiveness and Innovation Framework Programmes for creating business and research networks as well as for sharing best practices.

Emergence and resilience of the regional Cleantech Cluster at Lahti

Although this paper mainly focuses on the use of innovation policy instruments to promote cluster creation at the regional level, it is important to acknowledge also wider, national and global contexts that greatly affect regional initiatives (for example, Tekes 2011). This research concerning the regional Cleantech Cluster at Lahti is based on regional and national strategy documents, research plans and reports compiled during the last ten years. They are investigated to find out about emergence and resilience of the Cluster. It needs to be noted again that the coordination of the national Cleantech Cluster is also taken care of at Lahti, but the national Cluster development is not the focus of this chapter. On the basis of the literature and regional research, the following topics have been selected for a closer investigation in order to 'circle' the Cluster's emergence and resilience from several points of view:

- development and use of the Regional Development Platform Method in the Lahti region;
- regional (innovation) strategies;
- technology foresight;
- innovation studies and tools.

Emergence

The Lahti region, located close to the Helsinki metropolitan area, is a special case among the Finnish city regions. It is the fifth largest region and one of the most important industrial centres in Finland. It suffered heavily from the economic recession of the 1990s, resulting in major changes in its economic and social structures. The Lahti region is by far the largest Finnish region without its own university, and its regional rate of R&D investments has been very low.

The Cleantech Cluster is part of the national Centre of Expertise Programme that paves the way for diverse innovation activities. For almost twenty years, the programme has been a tool for regional innovation that contains ready-made operating models, networks and services for the national and international markets. The Lahti region was not initially admitted to the national programme when it was first established in 1994, but in 1999, Lahti became part of the programme. Design and ecology were the region's focus areas already from the beginning. In a national comparison, business development in these areas in the Lahti region was not yet very strong in 1999–2005 (Kanninen *et al*. 2007). An important development step was, however, membership in the International Association of Science Parks (IASP), and particularly its network project 'IASP Enviroparks' focusing on environmental business. In 2005, IASP gave Lahti Science and Business Park a mandate to widen its operations towards the other member parks, and thus IASP Enviroparks started to develop rapidly under the coordination of LSBP. This gave access for companies in the Lahti region to international environmental competence, partners and knowledge, and strengthened Lahti's position as an environmental hub. In 2007, in the evaluation of the Centre of Expertise Programme, it was still assessed that 'The Lahti region is – in quantitative terms (number of researchers in environmental sciences, number of students, degrees obtained, etc.) – not significant at the international level, but by means of efficient networking, its position can be strengthened' (Kanninen *et al*. 2007).

Between 1999 and 2006, business development and building of networks were the most typical types of projects in the Lahti region's programme (Kanninen *et al*. 2007). This has also provided a strong institutional basis for the environmental and ecological focus in the Lahti region. The regional work has thus begun already in the end of the 1990s (for example, Karjalainen 1999). By 2001, the regional priorities had already started to become conceptualised; that could be seen in, for instance, regional seminars concerning opportunities provided by the environmental and biotechnological industries. In 2001 and during the next few years, the Regional Development Platform Method was formulated by Vesa

Harmaakorpi and his colleagues – and tested in the Lahti region. This has had an impact on the regional development. The method is described in the following.

The Regional Development Platform Method (RDPM)

Regional innovation/development platforms have been defined as regional resource configurations based on past development trajectories, but presenting future potential to produce competitive advantage existing in the defined resource configurations. The central power of development platforms may be found in exploiting distance as innovation potential, but synergy in the platforms is emphasised in terms of related variety (cf. Harmaakorpi 2004; 2006). The actors of a regional innovation platform are firms, technology centres, expertise centres, research centres, educational organisations and the like, contributing to the defined development platform. A regional development platform must be separately defined each time. It is often based on an industry, area of expertise or future megatrend, or a combination of those. Identification of new innovation platforms requires a special regional dynamic capability – visionary capability, as well as continuous resource-based futures research (Harmaakorpi and Uotila 2006; Uotila, Harmaakorpi and Melkas 2006).

The Regional Development Platform Method was presented in the Lahti region in 2001 as an institutional and social innovation and a tool for regional innovation policy (for further information on the method and its testing, see Harmaakorpi 2004; 2006). The tool was planned to make regions sensitive to adapting to changes in the techno-economic paradigm. Another central basis for the tool is recognition of the networked regional development environment. Particular attention is paid to an interactive manner of designing and running the regional innovation system. All the phases of the method are planned so that they can be conducted in networked interaction (Harmaakorpi *et al*. 2011).

The dominating idea in developing the RDPM was the importance of individual regional development paths in designing development strategies. Such strategies need to be based on a thorough assessment of regional resources, capabilities and competencies as well as future possibilities leading to business potential that can give regional competitive advantage (Teece *et al*. 1997; Scott 2000). Moreover, the RDPM may be seen as a network leadership tool that helps regional actors to interact during a development process and to promote social capital and dynamic capabilities in the region. At the regional level, dynamic capabilities are defined as a region’s ability to generate competitive development paths in interaction in a turbulent environment. The RDPM consists of eight phases:

- analysis of the changing techno-socio-economic paradigm and benchmarking through the assessment of regional innovation system theories and conventions;
- background study of industries and areas of expertise in the region;
- expert panels;
- assessment of future scenarios;

- definition of potential regional development platforms;
- conceptualisation of the regional innovation system;
- search of core processes of the regional innovation system; and
- definition of a knowledge creation and management system (Harmaakorpi 2004).

This work on the RDPM since 2001 may be seen as the beginning of a proper science, technology and innovation policy in the Lahti region (cf. Harmaakorpi 2004: 139). The RDPM responded to the strong regional need for conceptualisation and development of the regional innovation system, regional network leadership, shared vision and creative social capital. The Lahti region had been lacking the features for producing science-based innovations, so it was understood that the regional competitiveness should originate from some other kind of innovation activities. Due to the strongly industrial history of the Lahti region, it was seen as beneficial to form competitive resource configurations based on the traditional industries and the regional areas of expertise, if these resource configurations were modernised and the demands of the changing techno-economic paradigm were taken into account. Interestingly, regional factors supporting environmental technology and ecology were already seen as very positive in 2001, although they were not yet labelled with the fine (and perhaps more comprehensive) 'cleantech' title[1] (Figure 10.2, Figures 10.7–10.9 in the Appendix). For a detailed description of the method and its results, see Harmaakorpi (2004; 2006). The importance of developing innovation management was already identified, which gave a good basis for further regional work on it.

Regional (innovation) strategies

In fact, Lahti's route to becoming a cleantech city appears to have started from research concerning the state of Lake Vesijärvi that the City of Lahti had already conducted, together with University of Helsinki, at the beginning of the 1970s. Lake Vesijärvi was Finland's most polluted lake, at that time, with many industrial sites around it. As a result of this research, University of Helsinki established its Department of Ecological and Environmental Sciences at Lahti. Connections to universities increased in general, and the environmental emphasis became stronger. Research operations required increased productisation of the knowledge produced, as well as networking. After various turns, Lahti Science and Business Park Ltd was established; now it advances the work in the cleantech sector both within the region and more widely. In the business strategy of the City of Lahti, cleantech has been raised as one the three most important priority areas (LSBP 2010) (Figures 10.3 and 10.4).

Figure 10.4 presents the holistic combination of priority areas and their specifications for the Lahti region. The development steps that took place prior to the present-day situation included a focus on DQE – Design, Quality and Environment. The DQE method was profiled and developed in Lahti within the framework of the Regional Centre of Expertise Programme around the year 2000. Later, the DQE emphasis was brought up in regional strategy documents; for

The criteria for assessing the industries ↓ / Industries →	Plastics	**Environment**	**Biotechnology**	Construction	Electronics	Information technology	Mechanical wood products	Furniture	Machine and metal	Textiles and clothing	Food products and beverages	Media	Tourism and culture	Logistics	Commerce
Amount of entrepreneurial activity and employment capacity	7.77	5.90	3.23	6.27	5.00	4.57	7.70	8.87	8.70	6.83	6.27	5.07	5.87	5.67	7.37
Growth potential	8.27	8.17	7.20	5.23	6.30	7.27	6.50	6.43	7.30	5.00	5.40	6.97	6.97	7.47	6.57
Balance of the entrepreneurial structure	6.10	5.62	3.63	6.10	5.66	4.93	6.93	7.00	7.90	5.66	5.48	5.40	5.34	6.15	6.86
Internationality of entrepreneurial activity	8.37	6.00	5.52	2.87	6.00	5.90	6.97	6.07	7.80	7.47	4.34	4.60	6.13	6.30	3.79
Innovativeness of entrepreneurial activity	8.03	7.03	6.88	4.27	6.10	6.77	5.47	5.00	6.53	5.41	4.76	6.63	5.79	5.31	4.17
Processing value/know-how intensity of entrepreneurial activity	8.20	7.23	6.86	4.45	6.23	7.13	6.27	6.20	7.33	6.00	5.33	6.57	5.20	5.28	5.15
Capability of the leadership of top enterprises	8.43	7.07	6.50	5.62	6.38	6.70	7.00	6.97	7.43	6.97	6.52	6.61	5.79	6.31	6.46
Regional adequacy of educational opportunities	7.13	7.50	4.83	5.07	5.79	6.83	7.03	7.73	7.10	6.60	5.59	7.00	6.37	4.64	6.62
Regional research inputs	7.63	7.03	5.29	3.80	5.37	6.37	5.83	5.77	6.27	4.57	4.63	5.11	4.20	4.17	4.27
Regional technology transfer activities	7.29	6.76	4.33	3.86	5.59	6.72	5.38	5.45	5.76	4.25	3.89	5.28	3.89	4.00	3.74
Average	7.72	6.84	5.41	4.75	5.84	6.32	6.51	6.55	7.22	5.89	5.24	5.92	5.57	5.54	5.51
Standard deviation	1.58	2.00	2.72	2.15	2.10	2.15	1.94	2.00	1.63	2.08	2.10	2.01	2.12	1.92	2.33

Figure 10.2 Assessment of industries in the RDPM

Note: Figures 10.7–10.9 are in the Appendix.

Source: Harmaakorpi 2004: 229.

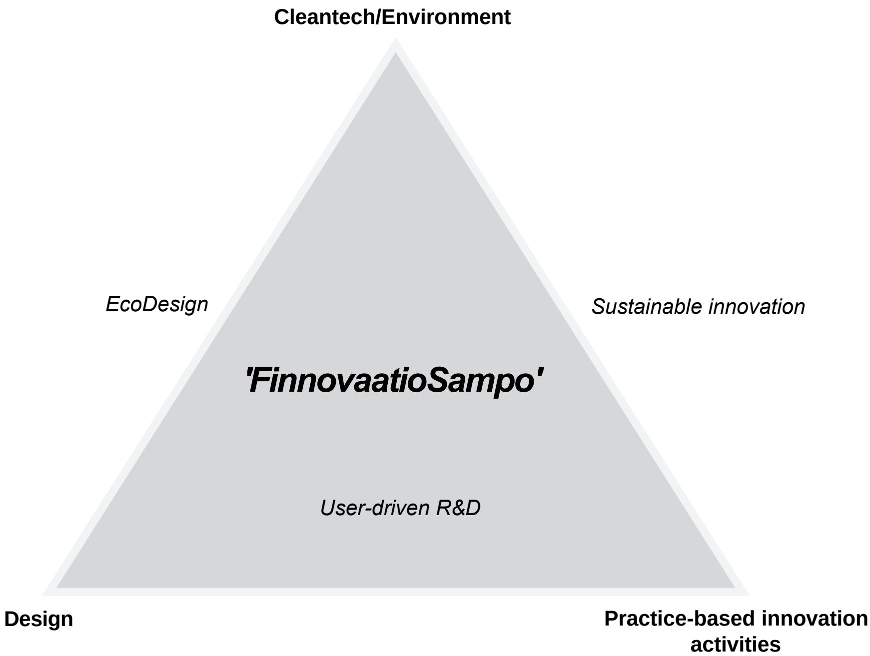

Figure 10.3 Focus of the regional innovation strategy, FinnovaatioSampo* (2009–15), in the Lahti region

* In the Finnish national saga 'Kalevala', Sampo was a mystical artefact that brought good fortune and wealth to its possessor.

instance, in the Design Strategy of Lahti (Lahti Design Manual 2006), the Structural Model of Lahti City Region 2040 (Lahden kaupunkiseudun . . . 2004), and the Development Strategy of the Innovation Environment of Lahti City Region (2005). The DQE tool was built on the principle that at business and product levels, sustainability and economic competitiveness come together when a product or a service simultaneously serves business, individual, and societal objectives. The method was later used also in international projects.

The cluster-based development strategy was adopted in the Lahti region during 2004–5. Strong clusters in the region were at that time mechatronics, environmental, grain, wood, furniture and plastics clusters. It was stated that the development resources during the coming years would mainly be allocated to the development of these clusters, and especially the environmental cluster. At around the same time, the Lahti region set a goal to be the leading area in *practice-based innovation activities* in Finland, and the framework of network-facilitating innovation policy was adopted in the region in order to promote innovation activities. The Lahti region's future competitiveness was seen to be greatly dependent on its ability to promote practice-based innovations, due to the absence of a whole university and

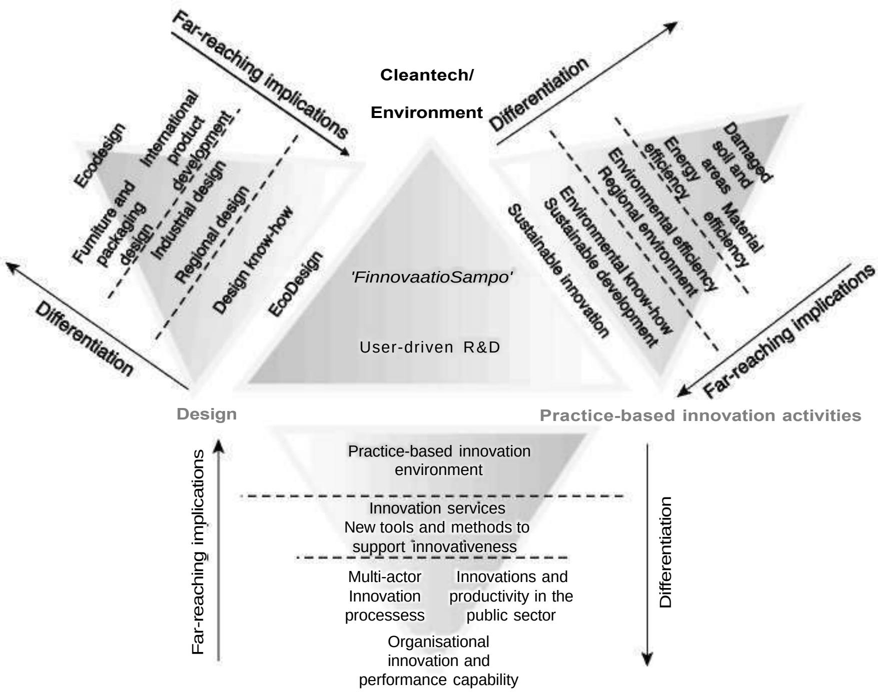

Figure 10.4 The combination of priority areas and their specifications for the Lahti region

Source: Harmaakorpi 2009, personal communication.

very low regional research inputs. One aim of the network-facilitating innovation policy was to search for structural holes (sometimes referred to as 'White Spaces') between the regional knowledge-base and the future-oriented knowledge-base found in the surrounding research centres; that is, to absorb the surrounding future-oriented knowledge to the regional innovation system. The network-facilitating innovation policy emphasises social capital and the social nature of innovation environments, where innovations are found in unorthodox combinations and interfaces of actors, disciplines, institutions, industries and regions (Tura and Harmaakorpi 2008). The policy is combined with other economic development policy activities.

The 'quality' viewpoint of DQE was thus later replaced with the holistic topic of practice-based innovation activities (for example, the Development Strategy of the Innovation Environment of the Lahti Region 2009–15). This change took place in line with the increasing international research activities within innovation studies that will be focused on later in this chapter. Practice-based innovation processes have been defined as innovation processes *triggered by problem-setting in a practical context and conducted in non-linear processes utilising scientific and practical knowledge production and creation in cross-disciplinary innovation* *networks* (Harmaakorpi, Tura and Melkas 2011; Melkas and Harmaakorpi 2012). It has been highlighted in the region that, in such processes, there is a strong need to combine knowledge interests of theory and practice, as well as knowledge from different disciplines. The social nature of practice-based innovation implies that knowledge production takes place within groups of people having a common interest determined by the practical context in which the group is working.

The various actors within cleantech, too, have started to focus more and more on skilful combinations of various fields. For instance, within Lahti Science and Business Park, cleantech is a priority area, but the aim is to increasingly include the cleantech viewpoint into all the other operations of the Park. Structures have also been created to support this aim; the local habitation cluster is included in the same team as the Cleantech Cluster (LSBP 2010).

Technology foresight

To absorb the surrounding future-oriented knowledge to the regional innovation system – as part of regional innovation policy – a comprehensive resource-based technology foresight process was carried out in 2005. It was acknowledged that the existing resource configurations in a region set the basis for future development and, therefore, regional foresight processes have to be tightly connected with an audit of the region's resource base. Bearing this in mind, the technology foresight process was carried out in three phases:

1 defining the regional development platforms and clusters to be assessed and identifying the related technologies;
2 exploring the future opportunities for the clusters and technologies using the Delphi process;
3 organising future-oriented innovation sessions in order to disseminate the results of the Delphi process within the clusters.

The aim of the regional technology foresight was to create an open, exploratory foresight process, the limits of which were drawn on the basis of the regional cluster strategy. The focus was on mechatronics, environmental and plastics clusters. The actual process is depicted in Figure 10.5.

The idea behind the foresight process was to identify and evaluate technology signals[2] related to nano-, bio- and ICT technologies that may have significance for the three clusters focused on in this foresight process. Potential technology signals were identified from several sources, out of which *The MIT Technology Review* was the most important. Around 200 potential signals were 'muddled through', grouped and pre-evaluated. Finally, around 30 signals were selected to the Delphi process, one selection criteria being the potential link to the cluster strategy in the Lahti region.

It was also acknowledged that using Delphi in that context was not enough. The results of the Delphi process must be again rooted back into the clusters to support practical innovation processes in companies. This was done by organising

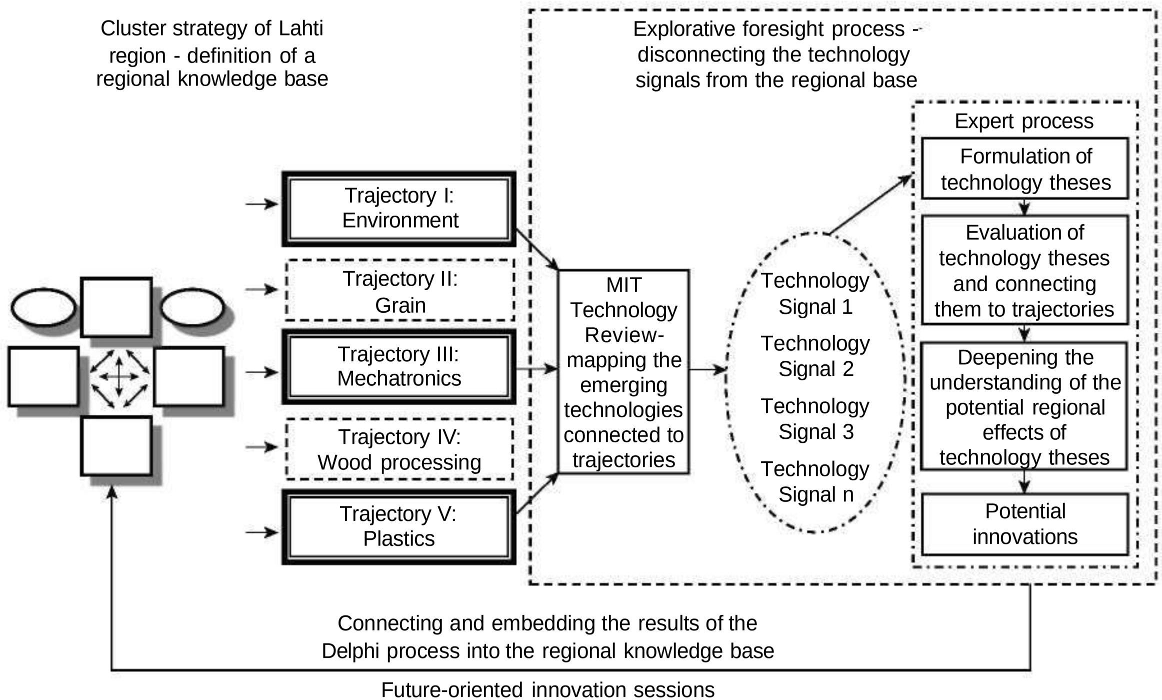

Figure 10.5 The technology foresight process in the Lahti region

Source: Uotila and Ahlqvist 2008.

future-oriented thematic innovation sessions. The aim was to organise altogether 60 sessions in the Lahti region during 2005–6. This succeeded, and by 2009, almost 100 innovation sessions had been organised in the Lahti region. Almost 200 organisations had benefited from the sessions (Uotila and Melkas, forthcoming). Some 125 of these are companies. In the future-oriented innovation sessions, the aim was to assimilate and transform the foresight information gained during the Delphi process to future-oriented innovation knowledge to be exploited by companies. The innovation sessions were one instrument in contextualising the information that the foresight resulted in. Not all the 100 sessions were related to cleantech or used the results of the foresight process as inputs, but there were many successful cleantech-related sessions, for instance with Greenvironment (a company that was founded at Lahti; it sells, builds and operates Combined Heat and Power plants, fuelled by either biogas or natural gas). The company won an EBN EuroLeaders Award with an idea that was developed in an innovation session. All in all, it is estimated that 95 per cent of the sessions resulted in a new business idea, new service concept, improved product idea, an idea for R&D process or an 'articulated need' for preliminary research.

Innovation studies and tools

In the Lahti region, from around 2000, the field of innovation studies has been strongly emphasised. This has been beneficial for the whole regional innovation environment and system of which the Cleantech Cluster has also been part. From a meagre start, the innovation research community has grown and become established in the region. As part of the network-facilitating innovation policy, different practical tools and instruments have also been developed to achieve the goals of the innovation strategy and to trigger innovations. Many of the different instruments developed in the Lahti region – such as innovation sessions (and also theatre-based methods) – focus on the early, fuzzy front-end phase of innovation. The front-end phase may be claimed to be vital for any type of innovation, whether it is a process, product, social, organisational or other type of innovation (Uotila and Melkas, forthcoming).

The regional innovation system and environment have benefited from numerous innovation studies that have circled challenges of multi-actor, multi-sectoral innovation activities from different points of view, such as knowledge brokers, different types of innovations, distances and proximities, foresight, innovation tools and policies, expertise, user-driven innovation, and so on. It has also been emphasised in the region that research studies need to be turned into practice in various organisational and sectoral development projects. Many researchers are actively involved in the formulation of regional strategies and priorities and the smallness of the local research community is an asset, as the researchers and their expertise are better known than perhaps would be the case in a big city with thousands of researchers.

In the early years of innovation research in the region, environmental technology was already identified as an important regional substance sector for that kind of research. For instance, in 2001, a regional research plan was compiled concerning the sector's success factors related to foresight and innovation processes. It was seen as essential to combine research concerning innovation environments, innovation processes and technology foresight. These three parts would then complement each other so that challenges and development views of innovations in environmental technology form a multi-faceted and multi-level picture. It was noted that it is essential to combine various scientific fields in this research, and emphasise participatory action research. Companies' abilities to collaborate and network should also be enhanced by means of the research. What was seen as important ten years ago has become reality in many inter-connected ways. From design of support services for companies (for example, the 'Innopipe'; CORDIS 2002), the horizon widened to cover different types of organisations in different sectors, and the various levels at which innovation needs to be enhanced. Ten years later it can be stated that these issues have been investigated in innovation research and developed in practice in the Lahti region, in addition to consistent development of the Cleantech Cluster itself, based on its core competence and substance.

Resilience factors

A major resilience factor behind the success of the Cleantech Cluster is naturally the global megatrend of people's increasing worry over their own living environment and the growing demand for the sustainable use of natural resources as well as increasing regulation. The cleantech business is estimated to grow at a rate of 5–15 per cent per year worldwide, so it has also been a 'safe choice' regionally. However, we now return to the regional level and link the issues discussed in the previous sections to the theoretical model of ours. In Figure 10.6, we have summarised and positioned the factors and activities that have promoted resilience in the regional Cleantech Cluster and connected them to the theoretical concepts of the foresight model (that is, types of renewal processes, absorptive capacity, information and knowledge brokerage) discussed earlier in this chapter. At the back end of the continuum there are factors, such as, 'strong links inside the regional industry', that relate to the exploitation phase of absorptive capacity and renewal processes, while at the front end of the continuum, a factor, such as, 'multi-disciplinary innovation research that circles various challenges' relates more or less to the exploration type of renewal processes, or acquisition or assimilation phases of absorptive capacity. Promotion of interactive collective learning is, on the other hand, a critical activity when aiming to utilise differences as sources of innovations and to cross the various distances (cognitive, geographical, temporal, and so on) in order to promote information and knowledge transfer in different kinds of innovation networks.

This research did not focus on the individual level, although investigating individual people who have been behind the success of the Cleantech Cluster would also be intriguing. The individuals do, however, need to be mentioned in Figure 10.6. Apart from them, and the national (and international) level, the

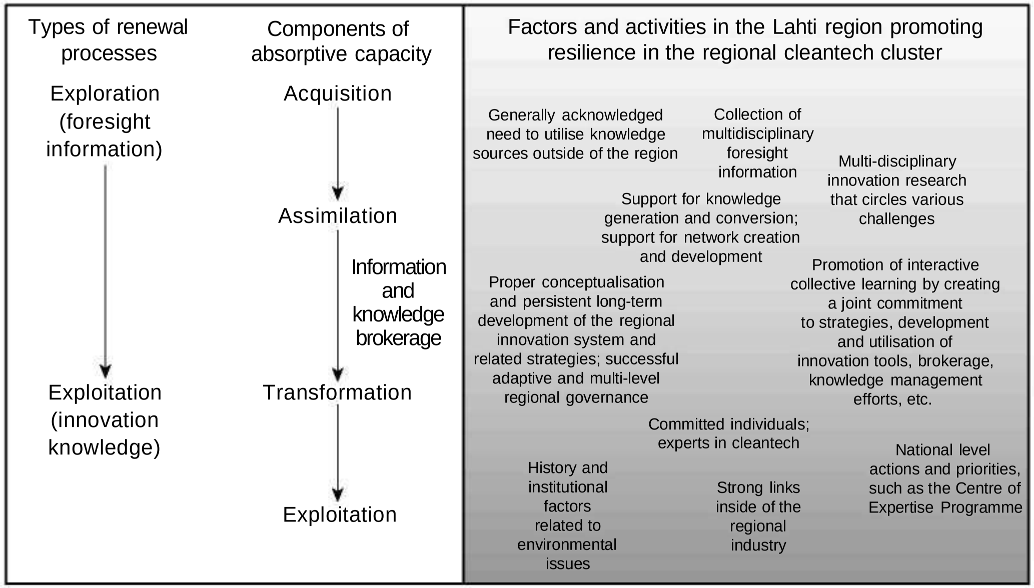

Figure 10.6 Resilience factors of the Cleantech Cluster in the Lahti region in relation to the foresight model

regional resilience factors during the last ten years could, in our view, be divided into three groups: community factors, cultural factors and factors related to the physical environment.[3] Such groupings are always somewhat problematic and arbitrary, but still this highlights the variety of the factors and their combination. A few of these factors have not been discussed in detail in this paper, and all of them are not included in Figure 10.6 for the sake of clarity.

Community factors

- Focused regional innovation and business strategy: cleantech, design and practice-based innovations, and their combination (leadership and governance).
- Strong commitment of regional actors to fulfil strategies (and adapt them, as necessary).
- Access to regional, EU and many other types of funding.
- Focusing on certain regional core areas in cleantech.
- Access to learning resources (cleantech-related educational opportunities and other fields; Lahti is the only place in Finland that offers the combined expertise of four cleantech educational institutions).
- Commitment to adaptation and continuation of knowledge generation and research and development projects also in phases of discontinuity (for example, changes in the educational institutions of the region).
- Long-term development of adaptive and resilience capacities, driven also by conscious decisions of local entrepreneurs making use of endogenously created new knowledge (cf. Simmie and Martin 2010).

Cultural factors

- Participation of many types of organisations in the region in the development of cleantech.
- Trust and tolerance for different approaches, methods and ideologies (in, for example, innovation tools).
- Adequate management of changes or shifts in values and priorities.
- Having a common vision.
- Being culturally grounded (Lahti has managed to turn weaknesses and constraints into strengths; priorities have been turned into practice to become strengths).
- Support for social networks and social capital (advantages of ‘mid-sizedness’).

Factors related to the physical environment

- Services and research facilities (low cost) aimed at and tailored for cleantech sector companies (cf. Simmie and Martin 2010, on co-evolution of facilitating institutional environments).
- Good road and rail connections.

- Closeness of Russia; bilateral funding for neighbourhood areas.
- A pleasant living and working environment (cf. also Lesser 2010; Lakes 2010).

It needs to be emphasised again that this research focused on a regional development path; the development of the Lahti region's innovation environment including the cleantech focus. Deeper understanding on the cleantech itself would be gained by focusing on that substance area only, but this is an issue for further research.

In their study on innovation policy in the Lahti region, Tura and Harmaakorpi (2008) summarised three mutually independent development processes that led to the 'great turn' in the innovation environment of the Lahti region after the year 2000. They were, (i) organisation (of roles, responsibilities, strategies, clusters, institutions), (ii) focusing (on the environmental sector), and (iii) ideology (adoption of a novel pragmatic innovation policy model). The above-mentioned resilience factors are also related to these processes, but the issue of resilience also appears to emphasise mutual dependencies.

In his article on 'The top 10 reasons Finland is a cleantech leader', Lesser (2010) presented his findings. In addition to the Lahti team and Finnish Cleantech Cluster, strong R&D support for cleantech development, gateway location and vivid venture capital ecosystem with public and private risk sharing, he also listed the Finnish lifestyle (challenges caused by nature and distances in the everyday life, and dependence on forests and clean water for livelihood over time, have led to valuation of clean nature), waste to energy since the 1930s (practising and developing cleantech industries since the 1930s in some form), and modest and law-abiding people.

Christopherson *et al*. (2010) summarised novel research on resilience – what factors enable a region to adjust and adapt over time – by noting that the answer is likely to lie in a number of areas, but the following appear to have been helpful in the past:

- a strong regional system of innovation (for example, Clark *et al*. 2010);
- strength in factors that create a 'learning region' (Archibugi and Lundvall 2001);
- a modern productive infrastructure (transport, broadband provision, and so on);
- a skilled, innovative and entrepreneurial workforce;
- a supportive financial system providing patient capital;
- a diversified economic base, not over-reliant on a single industry (cf. also Wolfe 2010, on civic capital, and so on).

When comparing this list with the factors identified in this study, we can see that it corresponds to the situation in the Lahti region rather well. Traditionally, the workforce in the region has not been highly educated, but the cleantech focus demands a 'non-traditional' workforce, which appears to be available in the region nowadays. Christopherson *et al*. (2010) further noted that for many researchers, resilience provides an umbrella under which to explore multiple disciplinary perspectives. Regional change may be understood through the idea that space is constructed via human action and social relations; regions are manifestations of those actions and are in a constant process of transition. The *longue durée* in regional adaptation is, however, vital to understand (cf. Hassink 2010; Pike *et al*. 2010); resilience should not be associated with easily measured, short-term, 'pop-up' recovery. It would seem unwise to rush too quickly to identify policies and relevant governance structures that somehow enhance the capacity of regions to be resilient (Christopherson *et al*. 2010).

The issue of resilience has the ability to cut across the so-called 'grey area' between academic, policy and practice discourse. Caution is, however, necessary. It is often the case that those responsible for formulating regional policy seem to be preoccupied with regional competitiveness and view the concept of resilience through that lens. Such an approach is likely to lead to a narrow view of what resilience may have to offer. Since competitiveness is associated so heavily with the promotion of economic growth, there is also a tendency to consider resilience in the same way and ignore the contribution it can make to understanding more about the determinants of regional sustainability and key interfaces between environmental and economic development (Bristow 2010).

Discussion and conclusions: next steps to the future

In 2010, the strategy of the Cleantech Cluster was revised and focused in the context of intermediary evaluation of the programme period of the Centre of Expertise Programme. The Cluster's activities will focus, during 2011–13, increasingly on identification of national top competence in environmental technology and enhancement of international business to be generated around that competence (OSKE 2010). In the Lahti region, the focus will be on the use of foresight information in cleantech business (LSBP foresight report 2010). For instance, operational models to collect signals from Russia will be developed in the future. Special emphasis will be placed on customer-drivenness and forming of value networks.

In addition to collection of foresight information, emphasis continues to be placed on its incorporation and utilisation in companies and other organisations. This is in line with the notion that to promote effective knowledge transfer from outside of the region, the knowledge (or rather still information in this phase of the transfer) must be contextualised and re-interpreted in its intended user context to promote its proper use in regional innovation processes (Uotila 2008). Knowledge-brokering functions will also be focused on in the knowledge transfer. From a more regional level, the need is now to move on to the hands-on company level in the use of foresight information (see Uotila *et al*. 2012).

As Simmie and Martin (2010) put it, resilience is a process rather than an unchanging characteristic. Regional development policy remains dominated by a narrow discourse of competitiveness that appears to have negative implications for resilience. It is necessary to avoid repeating the mistakes that have been commonly made in relation to competitiveness (Christopherson *et al*. 2010). Competitiveness is also a process rather than an unchanging characteristic. The same drivers of change are not at work everywhere, so there are no 'one size fits all' policy responses (Chapple and Lester 2010). The concept of resilience helps to understand the dynamics behind regional change, but it also leads to a very wide range of governance and policy issues.

Ungar's (2010) notion (although originating from the individual level) is interesting; resilience is the result of both successful *navigation* to resources that sustain wellbeing (in that case psychological, social, cultural, and physical) and individual and collective capacity to *negotiate* for resources to be provided in culturally meaningful ways. This is what appears as essential for regions, too. Resources need to be seen from a holistic perspective, and negotiation implies the need for civic capital, trust, social networks – community and cultural factors, as identified in this study. The case study in this chapter hopefully showed that sometimes change is gradual and things move forward in roughly continuous and predictable ways, while at other times, change is more sudden, even disorganising and turbulent. The resilience approach focuses on the dynamic interplay between periods of gradual and sudden change, and on how to adapt to and shape change. It is important to know more about how regions mobilise their assets, including particularly their knowledge assets. As Bristow (2010) argues, this enables resilience to play more to concepts of sustainability, localisation and diversification and thus avoids the rather 'place-less' interpretation that often results from a focus on competitiveness alone.

According to this research, core issues in the emergence and resilience of the Cleantech Cluster in the Lahti region may be summarised as follows:

- a holistic analysis (a framework) of the regional innovation environment has been formulated, in which different actors (and projects) have their own places;
- a story has been built around this holistic analysis;
- perspectives have not been restricted to the local/regional zero-sum game but have been kept wider;
- proper leadership has been taken (someone has to function as the 'high priest'; it is also a question of belief; and in a small region, social capital is of utmost importance);
- although the process may seem highly planned and rational when looking back, it has not always felt like that at the time;
- it is necessary to have an ability to sense the potential and see 'behind fashionable concepts'; concepts change, different rhetoric is used, but the substance remains.

Our aim was not to perform '*ex-post* rationalisation' of the development. It is however clear that regional actors need to identify things that change in their environment and act accordingly, in the same direction as the movement – not 'kick against' them. This could be expressed with a metaphor from *aikido*; in it, the opponent's own kinetic energy is used against her/him; no juxtaposition is sought, but speed is increased in the direction of the opponent's kinetic energy.

Appendix

Areas of expertise → / The criteria for assessing the areas of expertise ↓	Design	Quality	**Environmental technology and ecology**	**Biotechnology**	Information technology	Mechatronics	Communication and content production	Economy and administration	Innovation management	Wellbeing	Assembly	Marketing	Internationalisation
Quantity and quality of entrepreneurial activity (KIBS)	6.37	5.63	6.37	3.67	5.27	6.53	5.80	6.48	4.83	5.21	5.90	5.57	4.77
Regional pioneering quality/ innovativeness in the area of expertise	7.87	6.90	7.13	4.63	5.10	6.27	5.77	4.79	4.50	4.83	5.57	4.66	4.50
Regional and interregional networking in the area of expertise	6.80	6.13	7.14	4.52	5.93	6.31	5.59	5.04	4.71	4.93	5.69	4.59	4.79
Regional adequacy of educational opportunities	8.47	7.20	7.40	4.23	6.67	6.93	6.17	6.97	4.27	6.62	5.23	5.97	4.60
Regional technology transfer activities	7.66	6.86	7.34	4.22	6.52	6.17	5.54	5.04	4.90	4.62	5.10	4.36	4.07
Average	7.43	6.54	7.07	4.25	5.89	6.45	5.78	5.67	4.64	5.26	5.50	5.04	4.55
Standard deviation	1.87	1.81	1.85	2.50	1.96	1.53	1.73	1.92	1.89	1.93	1.84	1.95	1.88

Figure 10.7 Assessment of the areas of expertise

Source: Harmaakorpi 2004: 230.

Areas of expertise ↓ / Industries →	Plastics	**Environment**	**Biotechnology**	Construction	Electronics	Information technology	Mechanical wood products	Furniture	Machine and metal	Textiles and clothing	Food products and beverages	Media	Tourism and culture	Logistics	Commerce
Design	7.73	4.61	3.64	5.71	5.60	4.55	5.99	8.47	7.00	8.34	4.93	5.93	5.03	3.39	5.18
Quality	8.13	6.72	6.21	6.31	7.47	7.03	7.48	7.70	7.90	7.34	7.55	6.38	6.11	6.18	6.55
Environmental technology and ecology	7.40	8.83	7.70	6.14	5.66	5.21	6.37	6.53	6.52	6.24	7.28	4.37	6.37	5.83	6.13
Biotechnology	5.45	7.67	8.63	3.50	3.54	4.07	4.41	3.89	3.44	4.15	7.21	2.96	3.33	2.77	4.22
Information technology	6.67	6.40	6.62	5.28	8.53	9.00	6.55	6.20	7.03	5.97	6.03	7.57	5.17	6.73	6.43
Mechatronics	7.23	5.45	4.68	4.86	7.40	6.43	6.97	6.80	8.23	5.52	4.93	3.77	2.36	4.79	3.67
Communication and content production	4.67	5.13	4.38	4.32	5.10	6.60	4.17	5.53	4.63	5.97	5.10	8.50	7.07	5.00	6.33
Economy and administration	6.55	5.83	5.50	6.71	6.62	6.90	6.59	7.14	7.03	6.82	6.79	6.39	6.10	6.69	7.62
Innovation management	7.73	7.60	7.29	5.07	7.48	7.57	6.43	6.47	6.80	6.07	5.52	6.21	5.59	5.14	5.00
Wellbeing	4.37	6.21	5.34	5.34	4.76	5.24	4.48	5.97	5.04	6.07	6.32	4.52	6.30	4.19	5.50
Assembly	7.55	5.00	4.11	6.39	7.71	5.71	6.55	7.97	7.83	5.50	4.28	3.19	2.75	5.12	4.32
Marketing	7.10	6.60	5.55	5.86	6.27	6.33	6.77	7.87	6.77	7.62	7.07	6.90	7.20	5.87	7.60
Internationalisation	7.63	7.07	6.17	4.41	6.23	6.70	6.77	7.23	6.73	7.52	5.48	5.60	6.83	6.30	5.34

Figure 10.8 Significance of the areas of expertise for the industries

Source: Harmaakorpi 2004: 231.

Industries ↓ / Industries →	Plastics	**Environment**	**Biotechnology**	Construction	Electronics	Information technology	Mechanical wood products	Furniture	Machine and metal	Textiles and clothing	Food products and beverages	Media	Tourism and culture	Logistics	Commerce
Plastics		5.83	4.69	5.73	6.93	5.34	3.62	6.17	5.70	4.03	6.13	3.03	2.24	3.69	4.83
Environment	6.30		7.43	6.30	5.23	4.55	5.90	5.67	5.73	5.20	6.73	3.25	5.55	4.97	5.24
Biotechnology	5.07	7.27		2.89	3.93	3.96	3.86	2.71	3.36	3.32	6.93	2.64	2.46	2.39	3.31
Construction	5.72	5.80	3.21		4.10	4.00	7.30	6.00	5.70	2.93	2.93	2.97	3.90	4.52	5.33
Electronics	6.70	5.47	4.97	4.90		7.67	4.97	4.66	7.20	4.03	4.10	5.00	3.24	4.57	4.93
Information technology	6.40	6.17	5.83	5.33	8.23		5.87	5.77	7.20	5.40	5.37	7.57	5.13	6.40	6.50
Mechanical wood products	3.17	4.76	3.43	7.30	4.04	4.29		7.57	5.14	2.29	2.21	2.86	3.07	4.68	3.43
Furniture	5.25	4.36	2.70	6.00	4.00	4.43	7.43		4.82	4.21	2.00	3.61	3.46	5.43	5.29
Machine and metal	5.33	5.27	3.10	6.50	6.37	5.68	6.23	5.90		3.48	3.90	3.41	2.41	5.45	4.45
Textiles and clothing	3.57	4.00	3.21	3.04	3.22	4.11	1.96	5.33	3.11		2.04	3.83	3.76	4.61	5.83
Food products and beverages	4.72	5.00	6.41	2.70	3.00	4.25	1.93	2.57	3.74	2.11		4.00	4.54	5.55	6.66
Media	3.50	4.17	3.25	3.59	4.79	6.55	3.27	4.30	3.43	4.37	4.10		6.80	3.82	6.07
Tourism and culture	2.04	4.70	2.34	4.37	2.54	4.11	2.61	3.59	2.15	3.79	4.66	5.71		4.61	6.24
Logistics	5.63	4.93	3.25	6.66	5.03	5.34	6.07	6.63	6.48	5.87	7.07	3.69	5.38		7.53
Commerce	4.93	4.55	3.10	4.63	4.00	5.00	4.52	5.97	4.93	6.30	6.77	5.34	6.24	6.34	

Figure 10.9 Mutual significance of the industries

Source: Harmaakorpi 2004: 232.

Notes

1 From the point of view of resilience, it is noteworthy that concepts change, while the substance remains more or less the same.
2 The definition of technology signal is analogical to that of weak signal; only in this case, the content of the signal is related to technology.
3 Also national level changes have had an impact; for instance, re-organisation of Tekes and Ministry of Employment and the Economy, and changes in R&D investments, but these are beyond the scope of this chapter.

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11 'Twilight of the gods'

The rise of Asia Pacific and Californian convergent media and the demise of Nordic mobile telephony in the ICT global innovation network[1]

Philip Cooke

Introduction: the geographies of GIN-TIS co-location

This chapter brings together two related bodies of theory that assist understanding of complex processes of socio-technical system change on the global scale. These are, first, the Global Value Chain perspective (GVC) that has now mutated into Global Production Networks (GPN) and, more recently, Global Innovation Networks (GIN). Examples of why this should be are indicated (for example, Scandinavia's mobile telephony 'creative destruction'). The second perspective is that of Territorial Innovation Systems (TIS). This addresses the innovative core of 'creative destruction' events which, in turn, explains economic growth and development (Cooke *et al*. 2011). In recent times TIS analysis has been significantly undergirded by means of concepts like 'relatedness', 'proximity' and 'path dependence'. These perspectives are combined to produce a framework for analysing the contribution of an increasingly commoditised ICT assembly industry to high-value, customised 'chipset' and 'apps' design around smartphones, tablets, netbooks and flat panel display (FPD) technologies that express the GIN-TIS complex in global 'value curve' integration. Here 'creative destruction' recombinations arise because, from an evolutionary perspective, the regions in which they emerge display technological 'relatedness' and regional 'regimes' that foster co-innovation, in this case ICT-based co-innovation. Typically, the evolution of global node and network integration capabilities constitutes a linked but easily de-stabilised suite of regional 'innovation platforms.' These are composed of inter-cluster knowledge flows and their transformation into co-innovations.

According to the Asian literature, in particular (Chen and Wen 2011), the GIN seems fairly straightforwardly to be replacing the GPN, while overlapping with it in that evolution. Making it happen innovatively is a series of value 'islands' of innovation on the ever-shifting curve of globalisation. These islands we here term Territorial Innovation Systems (TIS). These can be national (for example, Taiwan, thereby a national innovation system, NIS) or more frequently, regional (hence a regional innovation system or RIS). A RIS has at least two main sub-systems, one for knowledge exploration by research organisations, the other for exploitation, mainly by firms. They exist as regional governance 'regimes' embracing regional technological 'paradigms'. The latter are specific mixes of path dependent industry trajectories passing through specific regional spaces. In between is a 'transition zone' of intermediaries, mediating paradigm and regime as investors, knowledge brokers, patent lawyers, management accountants and the whole panoply of other public and private innovation support entities (Cooke *et al.* 2010).

The chapter is entitled 'Twilight of the Gods' because the by no means long-wave longevity of 'convergent' ICT began in the Nordic countries, who held sway in the span of technologies from ground infrastructure to handsets for some twenty years. The chapter reports on the demise of some key incumbents, notably the Swedish firm Ericsson and the decline of the other, Nokia of Finland, currently locked in a global market struggle. This involves being squeezed from the top by Apple and Google and from the bottom by companies like HTC from Taiwan and Huawei from China. The tale of the rise of firms from Asia Pacific (including California) to prominence as the new 'smartphone' and 'tablet' gods has possibly as important lessons for European innovation polices as it does for Ericsson and Nokia. Nokia's slide in competitiveness compared to Apple and Google (Android) from the US and HTC and Samsung from south-east Asia offers important insights into the stickiness and path dependence of some national innovation systems and related policies within education as well as the supply base of innovators and entrepreneurs in the innovation ecosystem. First, asks Andersson (2011) why is Nokia being squeezed out of their own game from both US companies like Apple and Google and Chinese, Taiwanese and Korean companies like Huawei, MediaTek and Samsung? Second, did innovation policy fail in respect to Nokia's decline, and can innovation policies use the Nokia case, especially, to better prepare for tomorrow within new industries?

We shall see that a large part of the answer to the first question as to why Nokia suddenly finds its market share declining starts from the vantage point of mobile platforms. In today's competition within the mobile phone industry, the key issue is to have a platform for developers and to add new applications. As discussed further below, Nokia's management failed for too long to understand these game-changes going on within the mobile industry and failed to instil a sense of urgency for change and a corporate re-set within the organisation. This is ironic given that this talent for chameleon-like change in corporate path dependence had once typified the company and earned it the admiration of many. This time, however, management stuck for too long within its 'comfort zone' of design and superior mobile cameras. Furthermore, Nokia forfeited a connection with mobile software developers due to its dependence on its own Symbian operating system and thereby missed out on the opportunities of getting new applications from global co-creation among entrepreneurs and innovation eco-systems. Regarding the implications for innovation policy, Andersson (2011) is clear that when mobile handsets went from competing on technology and the design of a physical product to platforms and open source applications the industry changed profoundly. Accordingly, gazing on technological 'lock-in' might not be the most important thing to which attention should be paid. European innovation policy might produce longer-term benefits if more resources and funding were dedicated to programmes for experimentation with new management, organisational and indeed 'orchestration' models and less on product and technology driven innovation.

The chapter is constructed as follows. Global development studies and economic geography have seen a conceptual evolution from global value chains (GVC) in the 1990s (Gereffi *et al*. 2005) to Global Production Networks (GPN) in the 2000s, when hierarchical relations between Asian governments and Western MNCs prevailed. The latest evolution is to a new, post 2010 concept emanating strongly from Asian research (for example, Chen and Wen 2011; also Ernst 2009) that highlights Global Innovation Networks (GINs) distributed along a global value curve whose shape gives it the title 'smiling curve'. In this, the highest value is taken by system and applications ('apps') software designers, on the one hand, and 'flagship' design and marketing firms like Apple, on the other. At the lower reaches are the contract manufacturers of various capability dimensions ranked where the competition is toughest and value returns are, accordingly, the lowest. For them, the future means becoming more innovative, like some Taiwanese and South Korean, increasingly also Chinese, incumbents have done. This 'Asian emergence' de-stabilised the more hierarchical GPN and heralded the GIN, the nature of which is more TIS-integrated between 'paradigm' and 'regime' than the earlier models. In turn, this has led to the departure of an increasing number of European and US pioneers from the field. Accounts are provided of the economic geography of nine Territorial Innovation Systems (TIS), meaning local, regional and national innovation systems distributed along the value curve of the contemporary global innovation network (GIN) for information and communication technologies (ICT) especially the drivers of change in 'smartphone' and 'tablet' computing and communication technologies. These are three clusters in the Nordic countries, California, Cambridge (UK), Singapore, South Korea, and together, Taiwan and China. There follows a brief summary of the 'smiling curve' representation of this complex adaptive system. A brief discussion and conclusions section rounds off the chapter.

Twilight of the gods: the demise of Nordic mobile telephony

In the space available, we can examine three Nordic TIS set-ups to try to understand the internal cluster-platform weaknesses that left them seeking to express *resilience* faced with the external market 'shocks' exerted by the 'convergent modularity' of Apple and Google, on the one hand, and the 'bottom of the pyramid' Shanzhai and 'white box' competition coming mainly from China. The first cellular 'node' we focus attention upon is Sweden's southern region of Skåne. Large firms like Ericsson and Ericsson Mobile, later SonyEricsson, used to animate this region's ICT paradigm, but increasingly SMEs initiated 'open innovation' GIN activity. At 'regime' level, such engagement was carefully promoted by the regional development agency. Included here are various localised cluster initiatives: first, for mobile telephony ('Mobile Heights'); second, new media ('Media Evolution'); and third the Skåne film industry (Wallander detective films), including computer gaming. These, nowadays, constitute the core of a globally interactive regional 'Convergent Media' platform. There is cross-over from 'Convergent Media' especially through gaming, but also 'visioning' and 'positioning' towards ICT applications in other regional, national and international TIS platforms such as 'Medicon Valley Life Sciences' which spans the Swedish–Danish frontier. This is a keystone of regional innovation strategy here, which is founded on facilitating firm quests for 'relatedness' among potentially path inter-dependent industries, by regime stimulation of 'transversality' policy to bridge 'structural holes' or what are referred to regionally as 'white spaces' for innovation among different industries.

'Mobile Heights' and 'Media Evolution' in Skåne, Sweden

During the decade after 2000, markets and the Swedish production home base, were invaded by rapidly expanding Asian smartphone producers from South Korea (Samsung), Taiwan (HTC) and China (Huawei). This resilience 'shock' led SonyEricsson to begin reducing shipments of hardware. The corollary to this was a re-focus upon managing global services, such as selling network services to mobile telephony suppliers such as Telenord and Telia. To the latter they also sold network management services, Telia simply managing billing and cash flow. This led to Telia itself cutting employment after the mid-2000s, also filing no more patents. Finally, SonyEricsson disbanded in late 2011. ST Ericsson, the telephony infrastructure arm of the Ericsson Group also seems vulnerable as a stand-alone company, Chinese telecoms 'flagship' Huawei being a likely suitor. Global rivalry in markets is one thing but in core mobile telephony design and contract assembly SonyEricsson mostly feared Huawei, which located a third Swedish research centre in Lund, Mobile Heights' home base, for the development of basic components for mobile phones. This augmented their earlier locations at Kista Science Park in Stockholm and Gothenburg, together employing 250 engineers. In Lund, SonyEricsson cutbacks had made further hundreds of qualified engineers available. Huawei spans the telecoms range from base stations to mobile Internet modems and its own telephone handsets. Too late, it seems, there had been a response from Swedish mobile telecoms: at firm level, SonyEricsson evolved 'open innovation' relationships with innovative start-ups. ST Ericsson, a classic 'closed innovation' telecoms infrastructure firm, began to buy from external suppliers while actively seeking to contract to or acquire them. The regional innovation system's clusters had spawned quality entrepreneurial firms such as Malmö user-interface maker The Astonishing Tribe (TAT), acquired by RIM (BlackBerry), the similarly troubled Canadian smartphone flagship. Moreover, Polar Rose, a Malmö start-up which built a facial recognition programme that linked into Facebook photos, was bought by Apple for $29 million, both in late 2010. Both belonged to the Media Evolution cluster.

This is some indication of the 'resilience' capacity of a complex adaptive system to respond to shocks by drawing upon its industrial relatedness *potential* through the interaction of which innovation was forthcoming. Nevertheless, while innovative, such 'apps' firms are small and vulnerable to absorption into the parent corporate culture. Such ‘potential’ was relatively swiftly mobilised at the lower level in the multi-governance hierarchy of systems support policy – in a medium-sized reconverting city – rather than by decree of multinational capital or central government, as in GPNs. The key mediating role was performed by the Skåne regional development agency, first supporting cluster-building (with national innovation agency financial support) then by a platform-building policy of pursuing innovative ‘white spaces’ (or ‘structural holes’; Burt 1992) among the cluster-platform elements. Small, smart start-up entrepreneurial businesses were then incubated (by Teknopol, the ‘Mobile Heights’ business centre) as spin-outs from SonyEricsson and others to engage in ‘apps’ innovations, many originating at universities of Malmö and Lund innovation labs.

Nokia, Finland

In January 2008, Nokia announced it was closing its factory in Bochum, Germany. Altogether, some 4,300 workers lost their jobs (2,300 workers employed directly by Nokia, another 1,000 temporary workers, and a further 1,000 working at suppliers to Nokia). Production was shifted to a new factory in the Romanian city of Cluj. But already by September 2011 Nokia announced that it would be transferring the manufacturing of the low-end phones made in Cluj to larger factories in China and South Korea, where production costs and economies of scale were more favourable. The Cluj factory was subsequently closed in late 2011. But this was almost certainly too little, too late. Nokia’s problems lay in a path dependent *cognitive* lock-in, on the one hand, and a failure to develop the necessary internal and external ‘radar’ for effective foresight, on the other. Hence Nokia failed, myopically, to pay attention to, and purposefully anticipate, ‘convergence’ trends in the industry. Such attentiveness would have shown mobile telephony, the company’s core competence, to have become possibly the least important function on a contemporary ‘smartphone’.

Thus for some twenty years Nokia enjoyed being the undisputed global market leader in mobile handsets. It is, nevertheless, the view of industry expert Jon Andersson (2011) that this situation has come to an end, which for Nokia, in particular, came to a halt with the arrival on the market in 2007 of Apple’s smartphone – iPhone, iPod and related iTune platform for music and applications (‘apps’) of all kinds. Apple and Google’s (Android) mobile platforms nowadays attract a global network of developers who constitute a global ecosystem of innovators, the main focus of whose innovation is the creation of new applications (‘apps’). In addition, as chips for mobile handsets became more and more powerful the mobile handset changed from a mobile phone to a mini computer with increasing possibilities for software applications ranging from banking to gaming and city maps. Consequently, the physical mobile handset is today the least important part of a mobile phone and where the least added value accrues.

As the Nokia case in the near Arctic Oulu region and elsewhere like Espoo and Tampere shows, globalisation and agglomeration of knowledge into competence centres could have profound impacts on company strategy. Integration with the TIS, in the form of the VTT and Tekes electronics research programme and government-university support for spinout business were also important (Castells and Himanen 2002). But Nokia lost contact with many of these resilience structures. It first acquired a Cambridge (UK)-based consortium operating system – Symbian – that in 1999 was ahead of the game but which was never rendered usefully convergent. This was the origin of Nokia's pernicious cognitive lock-in to a telephony-only path dependence. The firm lost sight of the importance for firms to make the right selection of ecosystem location, for which Oulu, with its new technological university and electronics cluster plus external electronics research expertise was, once but nowadays, less valuable. Second, Nokia's success led it to undervalue its TIS, both nationally and regionally, where managers of innovation agencies, at the outset attractive co-creation partners, were sacrificed for the most important corporate customers. The innovation agency has the eyes and ears to pay attention and advise on purposive anticipation of market changes. It is, accordingly, a key innovation stakeholder in the TIS relationship portfolio of global and, especially, regional enterprises. This role of national and local innovation agencies as active alliance partners to individual firms is of course a mainstay of regional innovation systems analysis.

NorCom, Aalborg, Denmark

This is a brief and rather poignant sketch of cluster rise and demise in a sphere of mobile telephony addressed above in relation to the early days of this pioneering technology (Stoerring and Dalum 2007). The key lay in the Nordic communication standard eventually being adopted by the EU, giving European cellular service providers the advantage of a uniform GSM standard before anywhere else in the world, notably the USA, could achieve this. Infrastructure electronics was a centre of research and teaching excellence in the University of Aalborg. Research showed that this was because of a tradition of fisheries path dependence in the region of north Jutland and early innovation histories in ship-to-shore communication with firms that specialised in this technology and grew in the emergent field. But the NorCom cluster itself grew because of proximity to Aalborg University's NOVI science park and research expertise in radio communications that readily translated into spinout companies. By the 1990s, these had mostly been acquired by MNCs like Texas Instruments, Motorola, Siemens and Amstrad alongside smaller but 'born global' ICT firms like Cambridge Silicon Radio (CSR) nowadays one of the mainstays of Cambridge's toe-hold on the ICT GIN through its expertise in 'fabless' chip design, particularly for 'smartphones'. The MNCs quarried the knowledge base and one by one they all left, making hundreds of engineers jobless each time. From this some, new start-ups emerged but the base station infrastructure had become a commodity item sold into, for example, the Nordic market by the likes of Huawei. NorCom is by now an undifferentiated element in a diffused software and systems design ecosystem of niche businesses in the broader north Jutland region (Reinau 2010).

California: home of the 'smartphone'

The global power of smartphone 'apps' platforms is testified to in the following narrative. Thus Apple and Google in 2011 ended a 'phoney war' to engage in an all-out contest, the victor in which would be the one attracting the most desirable apps for the smartphone and tablet platforms that used their proprietary operating systems. Industry experts expected Google to prevail, which in 2011 it did in terms of market share, because of its open source and open innovation model. This meant the quantity (if not the quality) available on its Android system with 46 per cent global market share by late-2011 ensured it overtook Apple's 28 per cent smartphone share (LMS 2011). A counter-argument favouring Apple was that 'apps' entrepreneurs interested in profits rather than experiencing the glory of publication on Google would prefer Apple's closed innovation model (iOS system) because of its superior IPR regime. This allows for contractual appropriation by suppliers of income streams (for example, digital newsprint). Apple's newsprint 'app' scheme charged 30 per cent of subscription fees and disallowed data sharing (for example, subscriber addresses). Google's model charged publishers only 10 per cent of subscription fees and subscriber information was passed along. It is basically a scope versus scale contest in which Apple's App Store runs on tight control, high vetting and censoring of apps, while inducing high customer loyalty. Google's approach is more liberal but also less quality-minded since Android has been an open source project from the start. Thus customers buy Android through buying an HTC, Huawei, Samsung or LG smartphone rather than from Google itself. Global Android sales were also pushed up by extremely low cost devices including a ZTE Android device that is sold for just $20 in China. Contrariwise, to access its IPR assets Google in 2011 acquired Motorola Mobile whose Droid 4 device competed with Samsung's Galaxy Nexus powered by its new Android 4.0 Ice Cream operating system.

It is worth bearing in mind that while key 'apps' customers (Apple especially) are based in California, many more 'apps' start-ups are also located elsewhere, optimizing on 'related variety' among software, system design and creative 'search' integration. Similar platforms exist in London's 'silicon roundabout', Malmö's Western Harbour, Toronto's downtown creative district and other places, both in Canada (such as, Ottawa; Waterloo) and elsewhere (for example, New York's Silicon Alley).

To judge the scale of this potentially next 'tech-boom' industry, it is instructive to compare anticipated or actual stock-market valuations being placed on social networking sites in 2011 (Table 11.1). By comparison, at the same time Google was valued at $192 billion and Amazon at $77 billion, as leading Internet companies. What is argued by Patrick (2011) to be characteristic of a stock-market 'bubble' is observable in these valuations. The process is defined as evolving in the following manner: arrival of 'hard to value' innovation; bloated claims made for innovation; spin-outs from innovation firm access record venture capital; flurry of new investment funds; firms funded 'off the slide deck' (for example, Power Points only); MBAs leave banks for start-ups; big 'flotation' occurs; taxi drivers day-trading; innovator firm buys 'old world' corporation and the end is nigh.

Table 11.1 Valuation of internet apps firms, 2011

Company	*Indication*	*Value*
Facebook	Social networking	$60 billion
Groupon	Discount site	$15 billion
Twitter	Social networking	$10 billion
Zynga	Social gaming	$9 billion
Linked-in	Business networking	$3 billion
Bebo	Social networking	$850 million (AOL price)
Huffington Post	News site	$350 million (AOL price)
Foursquare	Location sharing site	$250 million
GoViral	Video network	$100 million (AOL price)

Source: Centre for Advanced Studies, Cardiff University

This was, paradigmatically, AOL and its place is currently occupied by Facebook and, to a lesser extent, the rest in Table 11.1. However, AOL had in 2011 swiftly acquired leading 'apps' sites for social networking, news and video as it positioned itself in the new 'digital services' market. Where an 'apps' platform principal like Apple or Google fails to evolve and upgrade sufficiently swiftly, it suffers a fate comparable to that of Nokia. For the first time in its history, the Finnish firm appointed a non-Finn as CEO, choosing Canadian former Microsoft executive Stephen Elop in 2010. In early 2011, Elop referred to Nokia as a 'burning platform' in recognition of its failure to keep up with the 'smartphone apps' generation. Elop's announcement admitted that Nokia had been comprehensively out-manoeuvred by Apple's iOS (first shipped in 2007) and Google's Android (2009) platforms. Nokia's profits were eroding at 20 per cent per quarter in late-2010/early-2011 and it still at that time had no competitor platform to those of the two global leaders. A tie-up with Microsoft meant its Windows Phone 7 operating system now had a much-needed platform company on which its system product could, in principle, reside. However, with Nokia's smartphone market share halving in two years from 47 per cent (end 2009) to 38 per cent (end 2010) and 24 per cent (end 2011), its future as a global competitor was not helped by industry opinion that its new Microsoft-powered Lumia 800 smartphone was 'disappointing' (Naughton 2011). Microsoft-powered devices had 5 per cent global market share at end-2011 (LMS 2011). Thus the smartphone plus 'apps' world of 'Convergent Media' has caught out many of the plain vanilla old mobile telephony leaders from Nokia to Motorola, Siemens, SonyEricsson and Alcatel, some of whom have vacated the market, as evolutionary theory, notably its Darwinist variety, would predict.

Cambridge, UK software and systems design excellence

In GINs, an intriguing issue arising concerns the importance of (possibly small) firms as *system integrators* in or among innovative clusters. In an industrial world characterised by lean production, open innovation and modular clusters (as Andy

Grove, former CEO of Intel refers; Grove 1996) such ‘hub firms’ or *‘firmes pivots’* as they are referred to in France (Gilly 2011) become crucial actors. They play major roles in aggregating ‘relatedness’ of knowledge, business model and industry. Clearly, the question of how there might be an interface or complementarity between what firms do regarding orchestration of a value chain changes over time. For example, what was beginning to be called the ICT ‘Global Value Chain’ had changed by the end of the 1990s into the ‘global production network’ (GPN). This had changed again by the end of the 2000s from the GPN to the GIN (Global Innovation Network; Chen and Wen 2011). In this, systems integration for major ‘smartphone’ brands (for example, Apple, Google Android) could be managed by a company like Cambridge-based Ubisense. The role of such an SME, floated on the AIM tech-market in London in June 2011, is to assess production metrics, track consignments, personnel and vehicles as orchestrator of a decentralised system such as production of the Airbus A380, tracking parts brought together from different countries (Ubisense 2011; Table 11.2). We may understand how transformative their role became in ICT even in the 1990s by referring to Grove’s diagram explaining that historic shift in industry organisation from ‘vertical silos’ to ‘modular clusters’ in Figure 11.1 (right side).

This kind of systems integration represents the ‘modular tracking’ capability of the company. Another division (‘geospatial networks’), tracks fixed assets for utilities, telecom companies and so on, mapping and making sense of their vast networks. Although far too ‘granular’ in nature for policy purposes, such tracking competences are what TIS innovation agencies (for example, Tekes, Finland; VINNOVA, Sweden; and ITRI, Taiwan) may be expected to do in the early phases of a transversal platform process when orchestration deals with cognitive, problem finding or framing issues. Back in the corporate world such ‘geospatial networks’ capabilities have attracted large customers such as General Electric, Deutsche Telekom and BMW to Ubisense.

Regarding BMW, the production line at Oxford uses ‘scope’ (not only ‘scale’) economies in an assembly line that assembles different kinds of Mini one after another. Every car has custom fittings so such variety of options needs to be carefully managed to ensure smooth flowing production: in this Ubisense

'Vertical Silos' *(circa 1980)*

IBM	DEC	Sperry Univac	Wang
Sales	and	Distri-	bution
Appli-	cation	Soft-	ware
Oper-	ating	Sys-	term
Co–	mp-	ut-	er
C	h	i	ps

'Modular Cluster' *(circa 1995)*

<table>
<tr><td>Sales and Distributon</td><td colspan="2">Retail Stores</td><td>Superstores</td><td>Dealers</td><td colspan="2">Mail Order</td></tr>
<tr><td>Application Software</td><td>Word</td><td>word Perfect</td><td colspan="4">etc,</td></tr>
<tr><td>Operating System</td><td colspan="2">DOS and Windows</td><td>OS/2</td><td>Mac</td><td colspan="2">UNIX</td></tr>
<tr><td>Computer</td><td colspan="2">Compaq</td><td>Dell</td><td>Packard Bell</td><td>IBM</td><td>etc.</td></tr>
<tr><td>Chips</td><td colspan="2">Intel Architecture</td><td>Motorola</td><td colspan="3">RIS Cs</td></tr>
</table>

Figure 11.1 Vertical to horizontal transition in ICT

Source: Adapted from Grove (1996: 44).

Table 11.2 Leading firms in the Cambridge GIN system's design platform and challenges for MNC incumbents

- Autonomy purchased 2011 by Hewlett-Packard ($10 billion)
- Datanomic bought by Oracle ($80 million)
- Now ARM and CSR (Cambridge Silicon Radio) are the two independent Cambridge chip designers
- Yet Ubisense (GIN-mapping - 'positioning and logistics software') IPR
- But HP in crisis, moving out of hardware (selling Compaq)
- Also Motorola Mobile bought by Google for Android
- Plus patent purchases by Microsoft Consortium and Microsoft partnering Nokia in decline

Source: Centre for Advanced Studies, Cardiff University

orchestrates what could be compared to 'indoor radar' where sensors keep track of the various moving parts, sending signals to a central system allowing managers to observe the process 'panoptically'. Even more important players in the Cambridge platform engaging with the GIN under discussion are firms like ARM, CSR and Autonomy, the first two supplying over 90 per cent of the world's chipset designs for consumer ICT products. Here is clearly a key element of the left corner of the 'smiling curve' for global ICT value-added. Aspects of these and their networks of innovation in Cambridge are displayed in Table 11.2.

South Korea: AMOLED touchscreens

Under the influence of its corporate and national innovation system path dependence on electronics, South Korea's ICT giant Samsung broke through into touch-screen technology so crucial to the smartphone and tablet innovations in ICT in 2009. Working on the same polymer discovery from Chiang *et al*. (1978), Sweden's ACREO electronics researchers were blindsided for this application by path dependent lock-in to the pulp, paper and packaging industry. Their attempt to evolve advanced radio frequency identification (RFID) with polymer-based printed electronics failed to find a market after some thirty years of effort. Now, as noted, Sweden's mobile telephony pioneer Ericsson, refreshed ten years ago by its alliance with Sony to form SonyEricsson, has exited the market it helped to create. So South Korea's presence relatively high up the 'smiling curve' of value creation in the global innovation network for ICT has to be understood. One of the fields 'picked as a winner' by the national innovation system had been, as with Taiwan, Flat Panel Display (FPD) technology. In 1995, Asan-Tangjiung was selected as a site where Samsung and a further 153 firms, including three Samsung affiliates, would locate as an LCD (Liquid Crystal Display) megacentre. Nowadays Samsung controls 45 per cent of the South Korean market and 17 per cent of the world market from this location. More than a decade later, LCD and plasma screens generally have given way to LED (Light Emitting Diode) and specifically AMOLED (Active Matrix Organic LED) technology because it is far less energy-intensive when powered up as TV or other kinds of FPD screens.

With Asan-Tangjiung as Samsung's fiefdom, the South Korean government in 2002 selected Paju as the site for a competitor FPD development for LG Display, successor firm to the former LG-Philips joint venture. This megacentre began with eighty firms, including four LG affiliates and two foreign firms, Nippon Electric Glass (NEG) to provide LCD glass substrates, some 20 per cent of product added value, and Sony as partner to Samsung for early LCD technology transfer. Close to the demilitarised zone with North Korea, Paju has grown enormously in population and GDP as the megacentre itself has grown. A further Gyeonggi province mini-centre supplying both Samsung and LG hosts another group of foreign firms of consequence to South Korea's FPD industry, including photonics firms Asahi, NEG and Hoya from Japan and Schott from Germany. The role of the state was significant in these developments in declaring Asan-Tangjiung an official Company Town Project and relaxing planning control by the Seoul SMSA to facilitate the Paju complex. This exemplifies the directional manner in which the TIS swiftly translated policy into reality, in this case close to the purlieus of the national capital Seoul (Lee 2011).

This proved a strategic industry into which the TIS made an innovative intervention as the following demonstrates. Three upcoming trends will secure the fortunes of these megacentres: transparent displays, flexible displays and colour eBook readers. Regarding transparent displays, Samsung's 46-inch touch-screen portrays pictures, movies and graphics on shop-window images that are movable in a manner comparable to that on a smartphone. Although aimed first at the domestic market, transparent displays also allow retailers to show dynamic content on their store-front windows. Other applications are in heads-up displays on car windscreens and transparent OLED notebooks. Samsung Mobile Display also leads LG, as it does with transparent displays, in flexible displays. These are basically bendable displays that can be rolled out of a holder like a drawer, printed on flexible materials, or wrapped around facilities (for example, as photovoltaic panels) or containers. Finally, there is a trend towards coloured eBook readers, led by Chinese firm Hanvon, although Fujitsu was the initial innovator. Problems with quality and reliability of these more agile and flexible FPD displays are the main obstacles to their diffusion in global markets. To summarise, South Korea's insertion in the ICT GIN is a good example of a TIS-Corporate led establishment of a significant value-adding growth element in an ICT market segment requiring huge upfront innovation investments, leaving only limited competition until even larger incumbents, such as Hanvon, enter the fray.

Singapore's hierarchical production network

Singapore is one of the most developed territories of south-east Asia, in large measure due to adoption by its TIS of successive ICT strategies. Unlike other 'tiger' economies in the georegion, Singapore impressed its locational value for inward investment upon MNCs rather than nurturing local firms, as in Taiwan, to develop endogenous technological capabilities. This also applied to research where instead of promoting indigenous R&D, Singapore relied upon MNCs to generate external economies like knowledge spillovers and knowledge transfer. This enabled an indigenous firm like *MMI* to become a close alliance partner of Seagate, at first fulfilling expectations of technological development. In a different segment of the market, Singapore's *Venture Corp* supplied printers to Hewlett-Packard, from whom it was a spin-off firm, for many years. As we have noted, Hewlett-Packard has been on the verge of forsaking hardware for ICT services markets (for example, acquisition of Autonomy, Table 11.2). Singapore's locational approach earned admirers from a development perspective, especially when it involved attracting then leading edge platforms in computing such as Hard Disk Drives (HDD) and urging foreign ICT component assembly firms to divert to developing Johor and Penang in Malaysia. This was also seen as politically astute, given Singapore's asymmetry with its large neighbours who in turn were emerging in Singapore's wake. However, the legacy has turned out to be something of a lock-in from path dependent evolution based on overseas controlled computing (especially global HDD leader Seagate). A possible alternative path was endogenous control of rapidly changing global demand for notebooks, tablets and 'convergent' smartphone applications. As we have seen, these innovations are led by US MNCs Apple and Google (Android) who neither have a presence nor significant smartphone or tablet supplier relations with Singapore. The same can be said for Penang and Johor in Malaysia's similarly locked-in to desktop PC platform technology, the markets for which have been under disruptive attack from Taiwan's and increasingly China's innovative mega-clusters around Taiwanese OEMs like Acer, Asus and HTC, Taiwanese modular suppliers like MediaTek, Wintek and Foxconn based in China, and Chinese all-purpose telecoms corporations like Huawei and ZTE.

As an innovation regime, Singapore's early TIS strategy can thus be characterised as emphasising technology adoption, notably by assimilation and diffusion of MNC (mainly US) technology through attracting inward investment. Belatedly, this has changed to a more symmetrical approach that searches for more indigenous innovation capability, by the formation of local new technology businesses. This recognises the success of Taiwan's alternative, endogenous development strategy but probably too late and not in the right innovation networks. As we shall see, Taiwan has swiftly gained both enormous industrial scale through its 'Asian offshoring' to China and innovated advanced ICT modules and products as supplier to the leading global 'flagships' in convergent ICT such as Apple, Google (Android), Dell and, while it remains a hardware producer, Hewlett-Packard. The primary TIS institutions associated with support for Singapore's ICT industry include the Economic Development Board (EDB) for general investment promotion; for more specific support the Ministry of Communication & Information Technology (MCIT), the Infocomm Development Authority (IDA), and the Media Development Authority (MDA); and the National Science and Technology Board (NSTB), the principal task of which was to help attract private sector R&D and to channel resources to construct R&D supporting infrastructure (Monroe 2006).

According to Yeung (2011) in an effort to establish Singapore as a regional R&D and innovation hub in the global electronics industry, local firms in Singapore were encouraged to be able to access the know-how of ‘modular flagship’ firms in Singapore TIS-designed local clusters. Thus in the hard disk drive (HDD) industry, local precision components suppliers such as MMI developed technological know-how and market expertise through their global production network (GPN) supplier relationships to global lead firms such as Seagate (in April 2011 adding Samsung HDD to its consolidated US acquisitions like Conner Peripherals, Control Data, DEC and Maxtor) and Western Digital (in 2011 acquirer of Hitachi Global Storage Technologies). Seagate and Western Digital thus have approximately half the global HDD market each; Western Digital supplies HDDs from south-east Asia to the likes of Apple and Dell while Seagate supplies Hewlett-Packard, Dell and IBM. The advent of ‘cloud’ computing is one important source of the de-stabilisation of HDD markets, the 2011 floods in Thailand exacerbated this, affecting Western Digital’s Thai production plants and Seagate’s component supplier base, both located on the Chao Phrya floodplain in Bangkok. Singapore was a global mainport for HDDs in the 1990s but lost its previous locational advantage in global HDD production networks.

What on the surface looked a wise ‘flagship dependent’ development strategy was fine in the days of hierarchical GPNs but seems less-suited to the modular Global Innovation Networks (GINs) characteristic of the fast-moving ‘smartphone’ and ‘tablet’ product markets (Vind and Fold 2007). In these, as noted, the ‘open’ Google model of ‘convergent apps’ contests the ‘closed’ Apple model of ‘Convergent Media’ based on innovative modularisation in creative nodes sustaining global networks. This, in turn, influenced Sony to dissolve its somewhat dated mobile telephony handset joint venture with Sweden’s Ericsson to, first, join forces with Apple’s Convergent Media model by supplying it with iTV then, presumably seeking to surpass it, drawing on its vast recorded music and film division Columbia. Singapore’s HDD ‘nodality’ can seem a somewhat risky over-specialisation in a few computer peripherals like printers, HDDs, networking and smaller-scale storage devices. In other words, what began as a rather advanced way of building global nodes in the form of local clusters supporting the complexities of producing precision high-tech components for a globally dominant HDD customer turns out to have been static and technologically vulnerable. The alternative approach followed in Taiwan seems more suited to the agility and flexibility imperatives of indigenous innovators capable of purposefully *anticipating* the innovation needs of global ‘flagships’ like Apple and Google because they have, often accompanied by their TIS, invested in core capital equipment such as silicon foundries or, in the case of South Korea AMOLED touch-screen innovations applicable to the newer ‘smartphone’ and ‘tablet’ markets.

Taiwan’s cross-straits platform with China’s ‘world factory’

Of interest here is the integration in the GIN of the Taiwanese ICT sector and the role of Taiwanese R&D performed by the firms becoming embedded within the GIN. As indicated in Figure 11.1 (right side), in general, Taiwan’s ICT sector followed modularisation and the pursuit of original equipment manufacture/original design manufacture (OEM/ODM) contracts for brand marketers or 'flagships'. Accordingly, flagships focus their own R&D on product concept initiation and product architecture, while delegating some R&D to Taiwan-based ODM suppliers. Such offshore collaboration results in a network form of inter-organisational, cross-border collaboration for global innovation. But, crucially, this capability is significantly enhanced by being embedded in a TIS, in the Taiwanese case facilitated by its Industrial Technology Research Institute innovation agency (ITRI), a dense network of other firms, large and small, university research and co-location in science and technology parks, notably Hsinchu in Taipei. Accordingly, Taiwan-based ODM suppliers typically establish separate R&D teams to serve different customers. As a case in point, Quanta, a leading ODM supplier of netbooks has some six R&D teams, serving different flagships for both system products and key components. The position is similar for Taiwan-based manufacturers of inverters for LCD TVs who also provide customised solutions to different flagship LCD TV companies. Moreover, Taiwan-based ODM suppliers in that part of their GIN-TIS set-up began shrinking local manufacturing and assembly operations and exploiting their offshore sites in China and elsewhere. Such GIN 'decomposition of production' (Schmitz and Strambach 2009) or 'de-linking of manufacturing and R&D in terms of location' (Chen and Wen 2011) swiftly became prevailing practice. Clearly this repeats 'flagship' practice by Western and Japanese OEMS a decade earlier consequent upon 'modularisation' (Figure 11.1). The difference is that for such ODMs, Taiwanese headquarters focus upon R&D and administrative functions and their offshore subsidiaries perform manufacturing and assembly operations. This business model, which Ernst (2009) refers to as 'Asian offshoring' rests on a firm innovation governance system (the exploration 'regime' of a TIS, in our terms) and the evolution of intra-firm divisions of labour allowing domestic prototype development followed by mass production in 'world factory' set-ups across the Straits of Taiwan.

In this way, Taiwanese ICT took advantage of swift TIS evolution to become a network of innovators as well as assemblers of ICT products novel to the global market, moving rapidly from GPN to GIN status. Thus Taiwanese firms supplied the top three netbook/notebook flagships (HP, Dell and Apple) as key innovators as well as suppliers of the key sub-systems, modules and parts integrated through their TIS and global logistics networks. This is evident in the practices of ODMs like Hon Hai, Quanta, Wistron and Inventec who, according to Chen and Wen (2011) follow the 98-2 formula of global logistics (compare Ubisense 'geospatial networks', Table 11.2 above). Set by the flagship firms, this consignment system requires 98 per cent of 'build-to-order' volume reaching end-users within two days of the order being issued. Clearly, all partners, from flagships to key suppliers and parts contractors have to collaborate closely to ensure development and design of successive generations and varieties of, for example, notebook computers, 'tablets' or 'smartphones'. Hence, Apple's success in iPhones benefited from and was augmented by the R&D efforts of a variety of Taiwanese ICT firms and their innovation, production and logistics networks. According to Isaacson (2011) ARM was preferred for chipset design and Taiwanese firms for innovation because Intel was 'too slow'. This illustrates the passage of what had begun as a GPN set-up from that rather linear, flagship-led production network (GPN) to the 'emergence' (in the complexity theory sense) of a move to a higher order of complexity, of a non-linear, flagship-orchestrated GIN in which the role of Taiwan's TIS and 'Asian offshoring' was a crucial interlocutor in the process. The 'potential' of the TIS to innovate, because of its 'requisite variety' of creative companies, alongside its incumbents' 'connectivity' capabilities (networks, logistics, efficiency) which enabled space to be compressed by time, represent a milestone in GIN-TIS convergence and spatiality.

Having recorded this triumph, it remains to consider some weaknesses of this model that require facing up to for the future evolution of the GIN-TIS model. In the process this also underlines the importance of TIS to the maintenance and development of the innovation gains that have been made thus far. First, it is extremely expensive to leapfrog into pole or flagship position in a GIN-TIS set-up. Ernst (2009) makes this point evidentially by reference to issues of technological leadership in newly industrialised country (NIC) territorial innovation system (TIS) contexts. He cites the case of the Taiwan Semiconductor Manufacturing Corporation (TSMC), the world's leading integrated circuit (IC) foundry. Founded in 1987 as a joint venture between the Taiwanese government and Philips, it was based in ITRI on Hsinchu science park. Financially, TSMC alongside Taiwan's further UMC facility is successful with expected joint earnings of $22 billion annually. Present day investment costs for such a 'fab' would consume a large portion of such annual income and staying at the innovation frontier requires much further investment. By 2011 China, India, South Korea and other Asian competitors had invested in various kinds of silicon foundries. Thus this initiative was a strategic choice by Taiwan's TIS, meaning all but a few Asian competitors at the time would baulk at the price, especially without government aid. A second issue relating to the evolving GIN in ICT from Taiwan's perspective concerns various key bottlenecks. One is that the industry is at the bottom of the GIN value curve (the 'smiling curve') where profits are excessively squeezed in comparison to the upward curving corners of the smile that are occupied by the likes of ARM and Apple (Figure 11.2). Furthermore, the Taiwanese ICT industry has limited capabilities to innovate in the 'architectural' product design space (Henderson and Clark 1990) for future generations of ICT products. It is feared that these constraints may lock it into the trajectory of OEM/ODM manufacturing. Third, Taiwan suffers from over-specialisation in its core ICT cluster and is especially vulnerable to downturns in the global economy. This happened in the current global financial crisis, when Taiwan's DRAM and LCD subsectors suffered the 'Bullwhip effect' which amplifies variations between demand and inventory further up the supply chain, away from the end-user. However, some of these fears may signify a cognitive 'lock-in' to a linear, Global Value Chain (GVC) precursor. That is, an 'emergent' model of development facilitated in GIN-TIS contexts is the 'technological diversification' model that has many virtues. It, too, has origins in complexity science (Kauffman 2008) where innovation occurs Schumpeter-style not only by drilling down into a specialisation for ever-decreasing novelty, but through exploring the 'adjacent possible' by cross-pollinating knowledge horizontally among clusters.

Where such 'related variety' (Boschma and Martin 2010) may be limited in the domestic space, it can be searched for in adjacent spaces. Even 'architectural' innovations may emerge by pursuing this alternative strategy, according to Ernst (2009) who cites China's Huawei as such an innovator with its ME60 Integrated IP Service Platform that achieved the definitive innovation achievement of improving quality and lowering the cost of fixed and mobile telecom infrastructures. Another example is the Taiwanese smartphone company HTC that exploited collaborative open source platforms with its web of suppliers. Yet another is Taiwan's notebook 'gazelle' Asus that similarly used a 'related variety' global product development network '. . . to bring to market at record speed the first commercially viable ultra-low cost laptop' (Ernst 2009: 47). Striking is the resonance of this with the practice of 'Apps' innovators in Malmö, Sweden – and possibly elsewhere – cross-pollinating from mobile telephony to media and new media, including computer games and TV, to innovate. Or more grandly, the manner in which Apple positioned itself at the crossroads between technology and the humanities as the heart of its creative innovation capability in the personality of Steve Jobs constitutes a guiding light not only for modularised complexity but also innovative competitiveness (Isaacson 2011).

Another of Ernst's (2009) but also Chen and Wen's (2011) exemplars of this 'transversal' approach to deploying 'relatedness' to secure innovation is Taiwan's chipset innovator MediaTek. This firm was founded in 1997 and is a globally leading fabless integrated circuit (IC) innovator for wireless communications and digital multimedia solutions. MediaTek's GIN strand includes Hsinchu, Taiwan as its HQ and IC R&D centre; Austin, Texas for R&D in digital signal processing (data compression); Shenzhen, China (software tools and 'apps') and Noida, India (handsets and printed circuit design); Singapore for SoC (system-on-chip) design; Norwood and Wilmington, US, for software and mixed-signal design; and finally Tokyo where it has a research centre. It out-competed the likes of Texas Instruments, Infineon, Broadcom and Qualcomm, who supplied the flagships, in chip stacks for mobile telephony handsets and smartphones. Chen and Wen (2011) see it as representing a departure from the stereotype of Taiwanese ICT firms. MediaTek holds a unique position as a major catalyst in the proliferation in variety and fast expansion in quantity of 'Shanzhai' handsets in China. Ernst (2009) refers to these politely as 'white box' handsets while Chen and Wen (2011) are more direct in specifying their producers in the following terms: 'many refer to Shanzhai handsets as copy cats or "bandit" phones' (Chen and Wen 2011: 15). MediaTek began making 'chipsets' in 2004 as a total solution stacking processor-, radio- and other handset chips together with the co-ordinating software. This was a radical *innovation* that revolutionised design and markets. MediaTek's innovation shortened time to market from nine to some three months, simplified handset design requirements and allowed an enhanced variety of mobile phones to be produced. Accordingly, from its system of technical support platforms in China, some 150 million Shanzhai handsets were produced in 2007, with 40 per cent of them exported to such countries as India, Russia and Brazil. From humble, largely illegal beginnings, Shanzhai handsets in China have been upgraded with local incremental innovations and features based mainly on MediaTek's chipset 'stacking' technology involving up to thirteen separate elements in the design. MediaTek had acted on Prahalad's (2005) observation that tremendous economic growth opportunities lie at the 'bottom of the pyramid' of affluence.

The 'smiling curve' expression of the GIN for ICT

This brings us, conveniently, to the final reflections on the relatively loose ties that bind the emergent GIN to a variety of TIS set-ups, signifying a further upward twist in global capabilities, shifts in centres of innovation gravity and assessment of concepts that informed thinking in this chapter. The sub-text has been the global 'Convergent Media' patent wars among the flagships in contemporary ICT. The geographical and developmental narrative has focused on the deeper global, possibly 'self-organisational' system adaptations that increasingly turn knowledge exploration ninety degrees from the vertical to the horizontal dimensions as firms seek to innovate by searching adjacent 'white space' possibilities for solutions and opportunities. This ambition is for future applications away from the 'red ocean' of cut-throat competition fuelled by litigation described above into the 'bluer ocean' of shared value, social need and more 'democratic' innovation that, as the brief sojourns in Sweden, Cambridge (UK), California, Singapore, South Korea, Taiwan and China showed have now evolved in integrated fashion. Evolutionary economic geography (Boschma and Martin 2010) is a new discipline which has

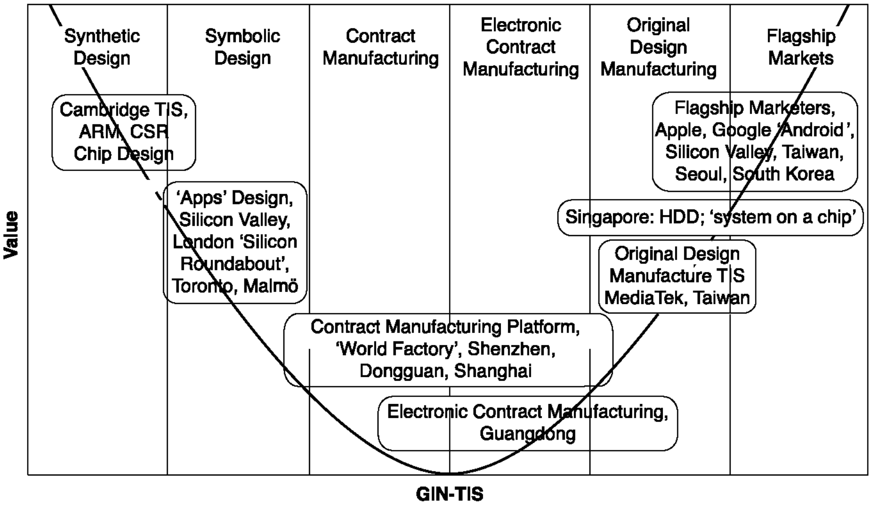

Figure 11.2 'Smiling curve' of value in ICT GIN-TIS

Source: Centre for Advanced Studies, Cardiff University.

worked with concepts as old as nineteenth-century classical economics, the forebear of the neoclassical perspective. 'Cumulative change', Veblen's (1898) precursor of Myrdal's (1957) 'circular cumulative causation' (CCC), was an early species of 'increasing returns' (Krugman 1995) or what complexity theory calls 'positive feedback' (Arthur 2009).

The 'smiling curve' is a simple representation of a highly complex, time-related and spatially shifting global process. Arguably, it is marginally less complex than its hierarchical GPN predecessor where fully modularised contract manufacturing, on the one hand, and localised innovation upgrading, on the other, had yet to evolve. Now, with Asian innovation and affordable production in TIS settings like South Korea and Taiwan, with evidence of innovation upgrading also in China, a global relational space opened up. Itself more flattened than the preceding, hierarchical MNC-inward investment clustering model more common in the GPN, it also facilitates 'Asian offshoring'. Such bottom-of-the curve locations have shown regional innovation capabilities, testimony to which is the shift in such assembly mega-complexes as Shenzhen, China from Shanzhai, or 'white box' hidden economy production to Huawei's entry into the smartphone market. The key question is whether the example of MediaTek can be repeated for higher value systems and software design services from Asia that undercut the likes of ARM or CSR. 'Apps' are produced massively for Asian markets served by firms like Samsung, HTC and Huawei. These will also challenge Apple and Google but need swiftly to evolve beyond the Android operating system to do so. It is noteworthy that much of Android's supremacy in the global smartphone market rests upon its Asian 'open source' adopters.

Hence it is evident that a complexity perspective on the co-evolution of (regional) institutional regimes and related (regional) paradigms is an extremely fruitful way to conceive of regionally and globally adaptive systems of innovation. A clear instance of this was the Skåne, Sweden region's modest resilience faced with multiple downturns even in its modern industries like cellular telephony. The most recent blow struck here is the termination of Ericsson's presence in mobile telephony with the purchase of the SonyEricsson brand by Sony, itself intent on emulating Apple's integrated iPlatform of digital content (Palmer and MacCarthy 2011). The cross-pollination of technology and creativity pioneered in Apple's integrated, closed platform 'Convergent Media' business model contrasts vividly with the competing 'modularisation' model that underpinned Microsoft's successful era and associates with Google's Android model. Furthermore, the fact that Nokia's 'burning platform' had to be extinguished by alliance with Microsoft could signify another important turn in the global ICT innovation spiral. It marks the linkage of Microsoft's operating system expertise with Nokia's radio communications heritage, which is logically superior to either invading the other's territory. The history of such partnerships is strewn with alliance wreckage, starting with AT&T and its various links to computer firms starting in the 1980s (Cooke and Wells 1991). Such evolutionary experimentation urges caution despite the complexity theory insight that it is the interaction of these multi-level and path dependent knowledge flows that produces innovation (Kauffman 2008; Beinhocker 2006; Geels 2007). Arthur (2009) calls this 'combinative evolution' in his treatise on the nature of technology and innovation. For Martin (2010) this constitutes 'path inter-dependence' and for Geels (2007) 'multi-regime interaction', both more dynamic concepts than 'path dependence' because it is in such 'collisions' that, ultimately, all innovation lies.

Discussion and conclusions

There are two discussion points and three conclusions to this investigation of the ICT GIN as a complex adaptive system. The first is that previous attempts to map global value and production flows have been informed by extensions of 1980s value chain analysis. This has neoclassical economic origins which emphasise static specialisation in divisions of labour, economies of scale in privileging the role of MNCs, and leaves little room for other than market transactions rooted in the narrow confines of cost/price ratios. While evolutionary complexity theory (ECT) is not wholly immune to value analysis it is clearly more able to capture shifting path dependencies and, importantly, path interdependencies in the evolution of complex relational space. Crucially, it is alert to 'strange attractors' like the manner in which Taiwan monopolised the world's silicon foundry business, innovated in the chipset business and how South Korea and Taiwan innovated in the application of polymer science to tactile controls in smartphones and tablets. In such deeply systemic innovations ECT proposes that understanding of socio-economic change really lies.

ECT also proposes that by its focus on variety, selection and amplification (Beinhocker 2006) it cannot predict but it can explain. Explanation of this kind ought to be able to stand the test of policy relevance. Three lessons can be drawn for policy learning from the account just given of the rise of the ICT GIN-TIS. The first that business managers and policy makers – especially those responsible for product and process innovation – could usefully be re-trained along lines suggested by Andersson (2011) to make them conscious of the perils of the kind of negative system feedback that produces cognitive lock-in. The second lesson is that both professions should seek to be far more open in their knowledge search and selection processes, especially when they seem to be sitting atop the innovation mountain in their particular market niche. Third, they need each other, in the sense that ECT shows most if not all innovation comes from horizontal rather than vertical knowledge recombination and, for this, economic geographic capabilities, advice and support are indispensable. The innovation agency is more catalytic to the innovation process than it was in the days of GVC or GPN, even for MNCs, especially those still locked in 'silos'.

The conclusions are that this has been a worthwhile exercise. However it focuses on just one, highly dynamic industry, namely global ICT and mainly in the new 'Convergent Media' segments of smartphones and tablets. Other industries warrant GIN-TIS style analysis to build up an explanatory portrayal of the economic geography of complex global adaptive systems. Second, more practically, is there an inevitability about the rise of Asia and the demise of the West in regard to innovation in the global GIN-TIS for ICT? Much popular commentary suggests this is probably so for manufacturing and possibly so for advanced knowledge-intensive services like chipset software and systems design, (Western) apps, and original product design and integration. Apple and Sony's future lies in making accessible the huge archives of Western popular culture they own or over which they have contract control. Accordingly, advanced services seem likely to remain in Western hands for Western consumption, but far larger potential but parallel markets exist in Asia. Finally, are GPN strongholds like Singapore, Malaysia and Thailand able to break free from their legacy of dependence on possibly declining Western hardware design MNCs and join or even advance the smartphone and tablet revolution? ECT would allow for such an eventuality, but, where for example is Japan in this new narrative? With the exception of Sony and its Western cultural archives, largely absent it would seem.

Note

1 The interview and documentation research reported in this chapter was conducted mainly in 2011. In the Nordic countries Arne Eriksson and I conducted firm and agency interviews in Sweden for a VINNOVA funded research project on 'Transversality & Innovation'; on Nokia, our colleagues at Synocus, notably Johan Wallin, led the interviewing and documentation work on a project to evaluate Tekes for the Finnish Ministry of Employment & Economy; in Denmark, with my late colleague Bent Dalum, I examined doctoral candidate Dagmar Stoerring and supervised doctoral candidate Kristian Hegner Reinau in my role as adjunct professor at Aalborg University. Secondary documentation inquiry and scholarly and expert face-to-face interviews were conducted with cited authors from California and Asia. All are thanked, none is responsible for the results.

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12 The remarkable resilience of cities of art

The challenge of a new renaissance in Florence[1]

Luciana Lazzeretti

Introduction: creative city, innovation and resilience

The debate on the relationship between cities and innovation, which started from Jane Jacobs' seminal work (1969), has then focused on the effects of diversity versus specialization in localized knowledge spillovers (Feldman and Audretsch 1999). An intensification has recently taken place thanks to the literature on creative economy. The concepts of creative city, creative clusters (Chapain *et al*. 2010) and cultural-creative industries (Lazzeretti 2013) have come to the fore and have developed alongside that of creative class (Florida 2002). Moreover, the notion of creative city has expanded to involve not only large metropolitan areas, but also suburbs, small towns and rural areas (Andersson, Andersson and Mellander 2011).

In parallel, the safeguard and preservation of artistic, environmental and cultural heritage within historical centres has become a relevant issue not only for urban planners and art historians, but also for economists and management scholars interested in creativity and innovation (Belussi and Staber 2012). If culture was previously considered as an asset to protect and preserve for its capability to foster economic development (Cooke and Lazzeretti 2008), nowadays it is mainly considered as a resource for innovation (Pratt and Jeffcutt 2009). Creative industries have become a driver for the wider economy (Bakshi, McVittie and Simmie 2008) whilst innovation for cultural entities and non-profit organizations has found a first codification (Bakhshi and Throsby 2010).

The social and local dimension of creativity is rapidly asserting itself, making the relationship between creativity, community and place all the more relevant (Perry-Smith and Shalley 2003; Drake 2003). The main underlying hypothesis is that ideas and innovations develop more easily in informal settings and public spaces – whether they be physical places such as cities of art and industrial districts or virtual spaces like online social networks such as Facebook and Twitter (Piore 2009; Lazzeretti, Capone and Cinti 2011). These observations must be seen in connection with the emerging open innovation paradigm, which stresses the role of creative contexts and external knowledge in addition (or in replacement of) to knowledge created in internal R&D labs (Chesbrough, Vanhaverbeke and West 2006; Dahlander and Gann 2010).

At the same time, evolutionary economic geography has applied the concept of firms' absorptive capacity (Cohen and Levinthal 1990; Zahra and George 2002) to industry clusters, cities and regional innovation systems. New types of transversal, path-dependent innovations are discussed according to the related variety approach (Cooke *et al*. 2011). If following Cohen and Levinthal (1990), the absorptive capacity (AC) is the ability of a firm to understand and absorb external knowledge, dependently on its own knowledge base, cluster AC (Giuliani 2005) corresponds to its ability to identify, assimilate and exploit knowledge coming from external sources. Frenken, van Oort and Verbung (2007) refer to inter-sector AC linked to the related variety approach, thus broadening this perspective to cities and regions. Finally, Lazzeretti (2009) relates this concept to the creative economy and to cities considered as new creative milieux. She defines *creative absorptive capacity* as the ability to transform generic creativity (exploration) into a goal-oriented one (exploitation), so as to generate and transfer ideas and innovations. Such a capacity depends on the tacit knowledge accumulated within a creative habitat and on the path dependence from creative actors.

Over the last decade, the variety of contributions to the debate has been further enriched thanks to the ecological approach with its application of the concept of resilience to social systems (Vale and Campanella 2005; Pendall *et al*. 2010). Resilience, adaptability and transformability are considered the three related attributes of social-ecological systems that determine their future trajectories (Walker *et al*. 2004).[2]

Swanstrom (2008) explores the value of the resilience framework for thinking about how metropolitan areas respond to challenges, stating that resilience can be understood as a process that takes place in three distinct sectors: private, public and civic (or non-profit). Simmie and Martin (2010) review the different definitions of resilience and their potential application to explain the long-term development of urban and regional economies, applying the adaptive cycle model from panarchy theory to the Cambridge and Swansea city-region economies. They distinguish between the concepts of 'engineering' and 'ecological resilience'. The first notion seems closer to the notion of 'elasticity', that is, the ability of a system to absorb and accommodate perturbation without experiencing major structural transformations. The second notion focuses on whether disturbances and shocks cause a system to move into another regime of behaviour, linking resilience with the idea of adaptability that is fruitable in its evolutionary scope (McGlade *et al*. 2006). Finally, Cooke, Parrilli and Curbelo (2012) focus on the relationship between innovation, global change and territorial resilience, arguing that local and national territories have to improve both their competitiveness and their capability to innovate though the continuous upgrade of policy platforms.

In this chapter, we aim to contribute to the still under-researched debate on urban and regional economic resilience by proposing some reflections focused on cities of art. In particular, we aim to study the stable resilience of cities of art facing the challenge of the second modernity and the globalization process.

According to Holling (1973), resilience is not only the capacity to absorb shocks and maintain function, but it also includes a second aspect concerning the capacity for renewal, re-organization and development, to be taken into consideration for redesigning a sustainable future. In this sense, we discuss the idea that some creative cities are also resilient cities, as they are capable not only of preserving and economically enhancing their material and immaterial cultural and artistic heritage, but also of transforming themselves in response to external pressures, generating local development and growth.

Following the concept of *creative capacity of culture*, we consider the city of art as an informal, collective open space that can absorb and recombine art and culture leading to novelty and renewing (Lazzeretti 2009; 2012). We present and discuss three case studies of lateral, transversal and path-dependent innovation occurring in Florence through cross-fertilization and serendipity between cultural and creative clusters, museums and art restoration centres. We look for an 'innovation Renaissance' combining arts and sciences as a result of a commonly shared and embedded value.

The chapter is structured as follows. After this introduction, the second section synthesizes the main risks that artistic and creative cities need to face in the second modernity, with a particular reference to the loss of meanings and authenticity. We then propose to overcome such threats by considering Florence as a resilient city capable of turning risks into opportunities by going back to its Renaissance roots in order to establish a new proactive creative milieu. In the third section, three cases of heritage- and science-driven discoveries and innovations are described: the 'Florence and Science' exhibition and the network of scientific museums, the innovation of laser technologies for the conservation of artworks and, finally, the discovery of the Stendhal syndrome. Some concluding remarks on the creative capacity of culture and on cities of art considered as creative and resilient cities are provided at the end of the chapter.

The risks of second modernity and cities of art

The risks of second modernity: an overview

The start of this millennium sees profound changes marked by the emergence of new technological, productive and consumption paradigms and by the diffusion of a pervasive sense of uncertainty. The sustainability of cities has become a relevant question for post-modern societies (Cooke 1990), characterized by the transition from a 'solid', 'tangible' Fordist model of capitalism to the 'liquid' and intangible post-Fordist paradigm of knowledge economy (Bauman 2000). In this context, the question we ask ourselves is: which are the risks for cities of art facing the new globalization challenges?

We can here identify two main categories of risks: the first related to the condition of 'surmodernité' (Augé 1992) and the second connected to 'environmental concerns'. There are also more specific risks, caused by the excesses in the economic enhancement of the artistic heritage, that can be brought back, in broad terms, to one of these two categories.

Specifically, to the first category refers the 'risk of a loss of meanings and authenticity' that involves cities and towns endowed with – and identified by – a tangible or intangible artistic and cultural heritage. Due to its relevance for the present discussion, this will be discussed in more detail in the next section.

As regards the second category, we can only briefly recall the sustainability risks involved in pollution, environmental degradation and catastrophic events (floods, earthquakes, eco-terrorist acts, and so on) that have intensified in recent times. In this context, cities of art have been particularly subject to the increasing pressure of tourism, that impacts on the conservation of cultural goods, their fruition, and the quality of local environment (UNWTO 2004a; 2004b). The necessity to promote sustainable and responsible fruition and a smarter management of tourist flows is a priority need which is widely recognized at different scales of governance (Chabra 2010).

As regards the risks deriving from the economic enhancement of culture, which affect both the supply and the demand of cultural goods, we may recall the improper management of cultural heritage (monuments, mobile and immobile assets) and organizations (museums, theatres, and so on), as well as the governance of small-medium cities of art. Some authors have raised concerns about the ‘disneyfication’ (Zukin 1991) or ‘serial reproduction’ of culture (Richards and Wilson 2006), whilst others have discussed the risks of an application of managerial practices to cultural organizations, and also the excesses of place branding and marketing of cultural goods (Colbert 2009). These add to the demand-driven risks, which are related to the excess in the search for and accumulation of cultural experiences and to the consequent improper consumption behaviours of tourists and citizens.

All of these risks, that can be only briefly listed here, require a strengthened commitment to the conservation and protection of the cultural heritage incorporated in cities of art, which is necessary if they are to still represent not only high-culture places but also creative and resilient milieux. Each risk mentioned above is surely worth a specific deepening, but because of space limits we will only explore the first, and basically more general and all-embracing, category.

The risk of a loss of meaning and authenticity

The main threats emerging from globalization can be brought back to the condition that Marc Augé (1992) has defined as ‘surmodernité’, which implies the excesses of time (embodied by the sensation of ‘imminent history’), space (with the rise of ‘non-places’) and ego (witnessed by individualization processes).[3] In particular, non-places distinguish themselves for being anonymous and impersonal due to their lack of history and their transit function (examples are underground stations and airports). Places, instead, are located in the vital centre of cities where the memory of the past is concentrated, such as cities of art. The condition of *surmodernité* implies a loss of meaning which manifests itself in a loss of identity, relations and history (Lazzeretti 2005).

Therefore, cities of art and museums are places loaded with meanings, but may see their identity vanishing for several reasons, such as the failure of their most qualifying functions, the loss of meaning of the broader context in which they are placed, the improper management decisions or the unsustainable behaviours of tourists and citizen visitors.

For instance, some museums can dismiss their characterizing functions of conservation and transmission of knowledge to become mere stages of entertainment, trade and consumption. Some cities can cease being places of life and work to turn into open-air museums (think of the so-called 'Venice effect') from which tourists have displaced native residents (Costa and Manente 1995). This process has sometimes been labelled altogether as a process of 'tourismification' (Ashworth and Turnbridge 1990) of historical centres (Caserta and Russo 2003) which is typically associated with a loss of authenticity and commoditization of the tourist (and the residents') experience.

In this context, the superabundance and excesses of economic enhancement of culture, place branding and experience economy may alter the idiosyncratic values of territories (Gilmore and Pine 2007). For instance, the 'society of events' sees the rapid multiplication of small and big festivals and happenings throughout the year, an accumulation which may denature the soul of the town by transforming it into a mere stage of entertainment.

In contrast, economists, geographers and sociologists increasingly stress the importance of authenticity and the safeguard of the identity of places and their traditions.

The identity of a place is fundamental for the individuals' creativity, and research on artists suggests that place provides a single surface against which the artist constructs a sense of the self. The identity of creative workers is place-based but not place-bound (Staber 2013). Authenticity is a value to preserve also at an industry level, as shown for example by the case of Swiss watchmaking, where mechanical watches represent the frontier of today's technical and cultural authenticity while constituting the major export value of this industry (Jeannerat and Crevoisier 2013). Authenticity and experience economy have to be correctly balanced. Indeed, the value of the experience for the consumer is somewhat related to the fact that it happens in that specific place. A crucial aspect, in this sense, is that establishing a real connection with the place enables the authenticity of the experience (Lorentzen 2009).

In the post-industrial era, the sense of place reflects geographical mobility, social construction and marketing strategies that contribute to creating or re-creating a distinctive and authentic sense of place. Our changing tastes remake the urban landscape of the 'naked city', as Sharon Zukin describes referring to the Starbucks stores. Cities transform themselves and their authenticity needs to be searched not just in their symbolic landmarks (such as the skyscrapers of Manhattan), but rather in the cultural vitality of its streets and everyday life (Zukin 2010).

How to transform risks into opportunities?

Starting to discuss our hypothesis to consider cities of art as resilient ecological systems, we focus on Florence, that is one of our privileged fields of investigation. Building on our previous research on culture and creativity, we searched for innovations implemented within this town with the involvement of activities and actors belonging to the domain of culture, art and science in a sort of 'new Renaissance' path. We thus defined as 'Renaissance innovations' those innovative paths between art and science that seem guided by the combinatory capacity of culture and which found a favourable environment in local networks and clusters.

By analyzing these innovations, we searched for links with the three categories of risks identified above, and showed how new types of problems open to unpredicted opportunities.

The cases were categorized according to four types of innovation between renewing and novelty: (a) urban renewal, that pertains to the idea that culture can rejuvenate places through three main strategies (city branding, physical renovation and flagship developments, and culture-led strategies); (b) economic renewal, that relates to the idea that culture can rejuvenate not only places, but also mature or declining products, professions, *filières* and sectors; (c) cross-fertilization, that is, the ability to search and build new relationships among 'related' or 'unrelated' sectors; (d) serendipity, that is, the capacity of discovering pleasing or valuable things by chance, identifying unusual correlations which may lead to new uses of a product, multiplicity of interests or technological correlations (Lazzeretti 2009).

In the attempt to identify a common Renaissance path to the innovations examined in our case studies, we referred to the seminal work of Padget and McLean (2006), 'Organizational invention and elite transformation: The birth of partnership systems in Renaissance Florence'. In their paper, these authors analyze, using a network approach, the birth of the 'partnership system' in Renaissance Florence as a new form of organization. Their aim is to unveil the social process of invention in action in this creative place: inventions in literature (Dante, Boccaccio, Petrarca), in art (Giotto, Masaccio, Donatello, Michelangelo), in architecture (Brunelleschi, Alberti), in science (Leonardo, Galileo), in constitutional design (Bruni, Savonarola), and in business (Datini) were in fact produced in breathtaking numbers and speed. In this context, 'the most striking global feature about Renaissance Florence' is identified in 'the sheer multiplicity of domains in which inventions occurred: inventions seemed to cascade from one domain to another' (Padget and McLean 2006: 1465).

Starting from these suggestions, we aim to understand if something of this process is still present in the mechanisms of creativity that occur in contemporary Florence. In view of that, we studied three cases and linked them to the risks of second modernity.

The first case regards the 'Florence and Science' exhibition and the network of scientific museums. As will be argued, this represents a case of urban economic renewal which faces the challenge of a 'loss of meaning' through the safeguard of the local scientific tradition. Florence, in fact, has been in the past a primary scientific centre, and the identification of a local network of scientific museums represents not only a case of economic enhancement of culture, but also a chance for renewing the *filière* of scientific education starting from primary school up to university.

The second case focuses on laser technologies for the conservation of artworks, an innovation that took the lead from the dramatic floods of Venice and Florence in 1966. Serendipitously originated by the need to face environmental risks, over two decades it has become a successful innovation through the cross-fertilization among creative actors of the Florentine restoration cluster.

The last case concerns the Stendhal syndrome: this was a discovery made through chance that has contributed to the development of the new discipline of art psychology, also opening up new frontiers to art therapy. It can be considered as a response to the aforementioned excesses of the economic enhancement of culture in terms of art fruition, whose ‘aesthetic overload’ can also have negative effects on the psycho-physic conditions of visitors. The discovery has been made possible by the ‘multiplicity of interests’ of the team coordinated by Professor Magherini and it has been favoured by the physical proximity between the hospitals and the museums, both located in the centre of Florence.

In the following section, the histories of each innovations are synthesized.

Back to Florence Renaissance: three innovation cases

Case of renewal of city image and cultural filières: ‘Florence and Science’

An interesting case of urban regeneration based on cultural events is the exhibition ‘Florence and Science. The nineteenth-century collections, places and personalities’ held in Florence in 2010.[4] The main goal of the initiative was to renew and promote the image of Florence not only as a city of artistic and historical heritage, mostly from the Renaissance, but also as the intellectual capital of Italy, and one of the most lively European scientific centres of the nineteenth century. The event was organized as a sequence of four interconnected exhibitions: the main scientific museums in the historical centre exposed rare scientific instruments belonging to the collections of the Medici and Lorena families, while the prestigious venue of Palazzo Medici Riccardi evoked the cultural climate of the pre-unification season through artworks and historic documents. Overall, the results of ‘Florence and Science’ were more than satisfactory, receiving a total of 104,000 visitors.

The event was studied according to the following objectives:

- analyze the cultural and economic role of the exhibition in connection with the demand and the local territory;
- understand whether it represented just a temporary promotion initiative, or it was rather the ‘top of the iceberg’ of a permanent network of museums and creative actors focusing on the promotion of scientific culture and education.

In the first step of analysis, the profile of visitors was analyzed through 133 questionnaires administered at the end of the visit.[5] It emerged that the audience of the exhibition was mostly composed by families (27 per cent) living in the area of Florence (55 per cent), endowed with a high level of education (38 per cent of graduates), a specific interest in the exhibition theme (52.6 per cent) and a strong propensity to return and/or visit all of the exhibitions (71.4 per cent). These results attested the strong appeal of 'Florence and Science' for the local community – especially compared to the more tourist-oriented events held in Florence – and witnessed the function of the scientific museum as a place of social aggregation.

In the second step of analysis, the investigation on the supply side was extended to all of the 34 scientific exhibitions held in the area of Florence from 2000 to 2010, in order to evaluate the scientific museums' capability to activate relationships of various nature with different actors, both within and across the local territory.[6] To this purpose, we mapped the number and types of actors involved, and applied the social network analysis (Wasserman and Faust 1994) to identify the relationships connecting museums among each other, with the relevant local bodies (cultural and creative organizations, local institutions, non-profit associations) and the external stakeholders.

A total of 480 actors were identified and classified according to the function played in the organization of the exhibition (direction/management; patronage; financial and technical support; loans and related activities; arrangement of the exhibition; catalogue; diagnostics, restoration and consultancy for conservation; other services). Interestingly, the dataset of actors is mostly represented by non-profit organizations (51 per cent) based in Tuscany (50.1 per cent), witnessing that other-than-economic motivations played a relevant role in the organization and activated a network of regionally embedded relations.

In the overall network, by considering a high level of co-participation (with at least six exhibitions; see Figure 12.1), what emerges is that the gatekeeper role was played by the bank foundation, which connects with each other the two main venues and organizers – the Galileo Museum and the Museum of Natural History of the University of Florence – as well as the two main patrons – the Ministry of Culture and the Tuscany Region. Under closer investigation, the two groups of actors present distinct characteristics that centred upon the Galileo Museum includes small- and middle-sized firms, active in the promotion and economic enhancement of scientific heritage. The one related to the Museum of Natural History, instead, interacts more with the local and regional institutions and seems more embedded in a *filière* of scientific knowledge and education, including the University.

Two different functions of cultural and scientific heritage seem to be at play here. In the first network, culture can be dealt with as a resource to be economically enhanced through promotion and image-oriented strategies, while in the second, it can also contribute to stimulate an open conversation between cultural institutions, firms and the local community, combining humanities and scientific knowledge with potentially beneficial effects on territorially embedded creativity.

We have here a case of urban and economic rejuvenation that constitutes a possible reaction to the challenges of 'losing meaning' and to the preservation of the city's scientific identity.

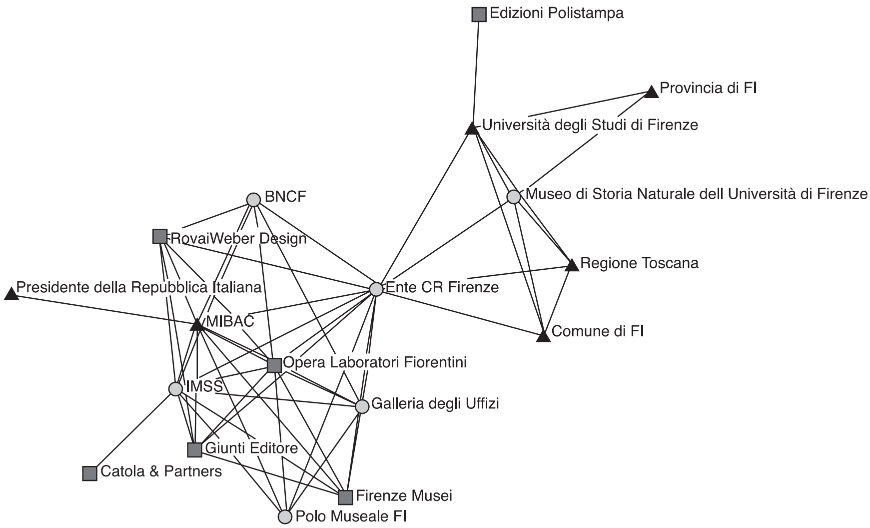

Figure 12.1 The network of actors with c ≥ 6

Note: The different shades of gray of the nodes indicate the *site* (dark grey for Tuscany, light grey for the rest of Italy, black for Europe); the different shapes of the nodes show the *typology* (a triangle for research centres, a square for universities, a circle for firms); the *dimension* of each node is a proportional representation of the financial resources received. The value expressed by 'c' stands for the minimum number of projects shared by each couple of actors.

Source: our elaboration.

Case of cross-fertilization: laser technologies for conservation[7]

The application of laser for the restoration of cultural goods started off in the 1970s, with the works of John Asmus (Asmus, Murphy and Munk 1973), who first tested the potentialities of laser in cleaning a column in the church of St. Gregory in Venice. Asmus realized that the ruby laser technique, usually applied to holographic processes, could be also applied for cleaning frescoed surfaces. This 'accidental' discovery led Asmus to develop a series of tests on several materials, which he undertook between 1972 and 1974. The importance and high potential of this technology was soon understood all over Europe, and in the subsequent years the countries with the greatest cultural endowments started to plan and implement activities aimed at developing the use of laser. However, it was not until 1994, with the approval of two European projects, that it was possible to implement the serial production of the first neodymium laser, which used the optic fibre to transport radiation to the light-emitting hand-piece. In 1995, the first conference on *Lasers in Conservation of Artworks* (*LACONA*) was held in Crete, gathering an international community composed of physicists specialized in restoration of cultural heritage, restorers and developer enterprises, which since then meet regularly every two years.

In Europe, many initiatives to develop laser-technology tests were undertaken, often funded by the European Union. However, although there has been a wide experimentation to appreciate the impact of using lasers in the preservation of cultural heritage, by the late-1990s, in Europe, there was no well-developed laser system for restoration fully accredited from restorers and conservators.

In this situation, Tuscany reveals to have been the context where the strongest commitment was shown and the best results achieved in the testing of the laser technology for preserving and restoring cultural and art works. This undertaking was made by a public body, the Opificio delle Pietre Dure (OPD) – a centre of excellence in restoration headquartered in Florence – that made a first attempt of technological transfer at a local firm back in 1979. Although the result of the application of a CO2 laser was not encouraging, because the laser was over-powerful and the marble would absorb too much heat, this first test gave the opportunity to make OPD more aware of the use of laser.

In 1992, OPD established a collaboration with the Institute of Applied Physics (IFAC) which was initially used for the cleaning of paint, and later extended to stone materials. This experience encouraged OPD to consider as feasible the design of a more proper device. IFAC, endowed with specific competencies in laser technology, suggested that the ideal implementer of such a programme was El.En., a specialist firm in biomedical also located in Florence. To this purpose, the SMART CLEAN project was started and led to the development of a new laser system, whose effects on different materials were also analyzed. The partnership of the El.En. group in the project represented a significant factor in the effort, as the Florentine firm with an internationally recognized know-how in medical ablation techniques using lasers, offered the opportunity to plan a low-cost implementation of the product, which could very well be included in its batch production of biomedical lasers.

Accordingly, in 1996, the physicists started an extensive stage of analysis mostly conducted on stone materials, which allowed El.En. to create a new laser product, modified in both its impulse and duration. The last, but not least, contribution to the innovation process was brought by local institutions, which seized the opportunity offered by the new technology by supporting its application to the restoration of local artworks.

The laboratory tests of laser application were carried out on an assorted typology of archaeological materials in stone and metal, particularly bronzes.[8]

As can be seen, the innovative idea originally emerged from a case of serendipity – the application to holograms resulting in the unpredicted use of laser to cleaning purposes – and later developed through a cross-fertilization between seemingly unrelated sectors like medical diagnostics and cultural heritage. Therefore, this represents a significant case of an open innovation carried out by a creative cluster of economic, non-economic and institutional actors who found in Florence a resourceful environment for its implementation. In this cluster, territorial proximity successfully combines with cognitive proximity, whose positive effects are grounded not only on the interaction between the organizations involved, but also on the crossing and matching of the professional and cultural paths (*human dependence*) of scientists, art curators and historians, as well as firms and institutions.

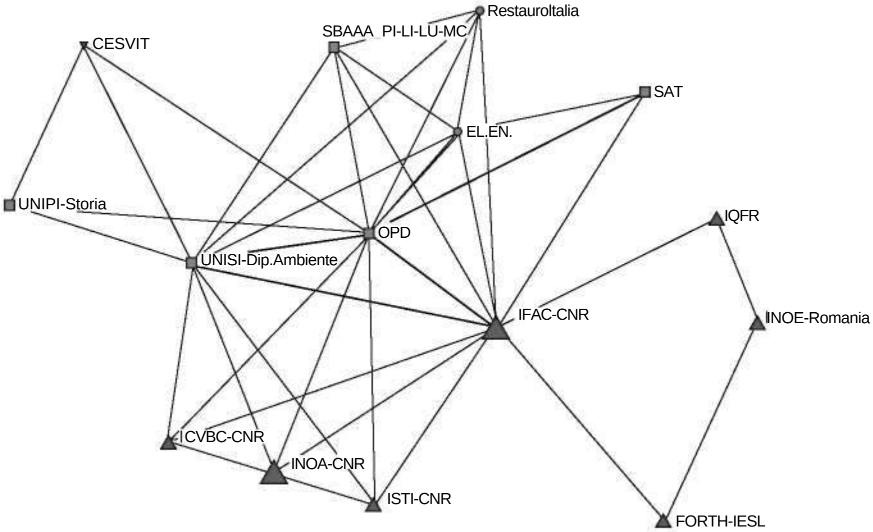

Figure 12.2 The network of actors in laser restoration (c > 4)

Note: The different shades of gray of the nodes indicate the *site* (dark grey for Tuscany, black for Europe); the different shapes of the nodes show the *typology* (a triangle for research centres, a square for universities, a circle for firms); the *dimension* of each node is a proportional representation of the financial resources received. The value expressed by 'c' stands for the minimum number of projects shared by each couple of actors.

Source: our elaboration.

To reconstruct the frame of the partnership system that developed the innovation of laser technologies in conservation, we have selected the 12 financed projects that took the most part in its constitution. The chief contributing creative actors that emerged from the analysis were the El.En. group in particular, together with the conservation-restoration institute (OPD), the Department of Environmental Sciences of Siena University, and finally the IFAC, all of them playing a central bridging role among all the other actors (Figure 12.2).

This innovation, which originated from the tragic events of the Venice and Florence floods, certainly represents an example of a proactive capacity of answering to environmental risk on the part of the city of Florence.

Case of discovery: the Stendhal syndrome

The denomination of Stendhal syndrome represents a state of perturbation perceived by foreign tourists at cities of art, which was analyzed by the Florentine psychoanalyst and art historian Graziella Magherini over more than two decades of observation.

This syndrome, named after the French writer Stendhal, was first described by Professor Magherini as an exceptionally intense and involving aesthetic experience followed by a sense of malaise that Stendhal experienced visiting Florence during his Grand Tour in 1817. As in Stendhal's case, the particular intenseness of the aesthetic experience lived by the visitor of sites charged with deep cultural and symbolic elements – such as Florence – is the factor lying at the basis of a wide array of psychical and psychosomatic disturbances. Through the clinical observation of 106 cases at the Hospital of Santa Maria Nuova in the period from 1977 to 1986 (Magherini 1989), their symptoms were classified within the following categories:

- *disturbances of thought* (66 per cent of the patients), associated with alterations of perception and sense of reality, dizziness, hallucination, delirium;
- *disturbances of feelings and affections* (29 per cent), that is, depressive anxiety, sense of hollowness and precariousness/euphoria, and omnipotent thought;
- *panic attacks and somatized anxiety* (5 per cent) with physical manifestations, such as palpitation and faintness.

As regards the profile of the visitors affected by the syndrome, the whole sample of patients is composed of foreigners (100 per cent), quite fairly split among male (44 per cent) and female (56 per cent), mostly young (76 per cent under 40 years) and single (89 per cent of females and 65 per cent of males). The affected tourists are typically endowed with a lower educational and professional status compared to the average of visitors in Florence and are mostly visiting the city on an individual tour (76 per cent).

According to Magherini (1989), the travel experience, allowing freedom from social obligations and constraints (frequently amplified by the solitude of the individual traveller), makes people both more receptive towards external stimuli and more inclined to introspection. During the trip, the protection afforded by the habits and conventions that regulate the visitor's daily life at home is no longer available and the impact of new experiences can thus be radical: as a result, latent conflicts in personality (for example, senses versuss rationality; Ego versus Superego) rooted in past events are more likely to come to the surface, often bursting in open identity crisis.

In synthesis, the triad *personal history-trip-aesthetic experience* is at the origin of the disturbances. Recurring elements in the reports are the feeling of novelty – partly anticipated through books, but never fully predictable – lived by visitors when staring at the paintings at the Uffizi or the Academy Gallery, alongside with the extraordinarily contemporary appeal of the past. Such intense beauty cannot be rationally dominated or appropriated: therefore, the spectator may feel the urge to immerse him/herself in the artwork in order to penetrate its enigma. His personality, then, may overflow into the painting in a sort of artistic ecstasy, needing to be reorganized by appealing to familiar experiences and 'ancient certitudes' such as in Stendhal's case (Magherini 1989: 589). In this case, the crisis can represent a positive event, allowing the expansion of the tourist's personality by reintegrating previously repressed components. Consistently, the majority of cases resolved with the end of the trip and the safe return home; only acute disturbances of thought have a longer course and often entail the ending of the trip.

The implications of the Stendhal syndrome are manifold and significant, and have opened a new stream of research. Analogous disturbances, namely the Paris (Viala *et al*. 2004) and the Jerusalem syndromes (Bar-El *et al*. 2000) have subsequently been identified, fuelling an international debate among psychologists and psychoanalysts (Halim 2009). The former is a transient psychological disorder encountered by tourists in Paris, which manifests itself through acute psychosomatic manifestations such as dizziness, tachycardia and sweating. Japanese visitors have been observed to be especially susceptible, the main antecedents of the syndrome being represented by cultural distance with the country and the formation of idealized pre-images of Paris.

The origins of the latter are different, as it involves people who feel compelled to visit Jerusalem with severe religious or magic-related psychotic obsessions, such as identification with religious characters. Yet, a group of patients is composed by regular tourists with no personal track of psychotic illness, who suffer from acute episodes while in Jerusalem and recover spontaneously.

Over the last two decades, Graziella Magherini has pursued her studies on the Stendhal syndrome (Magherini 2007) and on the psychological aspects of the aesthetic experience. She has also founded in 2000, and currently chairs, the International Association of Art Psychology, aiming to promote studies on the relationship between psychology and arts and which is now developing into the related fields of art therapy, aesthetic education and study of psychoanalytic aspects in literature.

This discovery may be considered as an answer to the risks of the economic enhancement of art from the point of view of its fruition. An ‘excess of beauty’, that is the aesthetic overload, can indeed have not only positive, but also negative consequences.

Concluding remarks

To conclude, we make some reflections on the resilience of cities of art, by referring to the lesson learnt with Holling’s (1973) definition: resilience is not just the capacity to absorb shocks and still maintain function, it can been from another side that concerns the capacity for renewal, re-organization and development, which deserves consideration for the redesigning of a sustainable future. We discussed this idea with respect to the risks emerging from the globalization process, noting that the creative capacity of culture can turn some of these threats into opportunities. To this purpose, we identified discoveries and innovations that find their common ground in a ‘Renaissance’ path winding between arts and science.

The remarkable resilience of cities of art can first be recognized in the presence of a historical and artistic heritage, and in the capacity of the local milieu to absorb shocks by safeguarding its identity, relationships and history – thus facing the main risk involved in the second modernity, that of losing meanings and authenticity. Second, the creative capacity of the city for renewal, re-organization and development can be traced back to the propensity of creative actors – whether individually or organized in networks or clusters – to develop heritage-driven innovations. The most fitting example of resilience is surely that of laser technologies for the conservation of artworks, an innovation born through serendipity and developed through cross-fertilization in the face of ‘environmental risks’, such as, the 1966 floods, as recalled above.

In some way the ‘partnership system’ identified by Padget and McLean (2006) in Renaissance seems to be still active to a certain extent, in the involvement of a multiplicity of economic, scientific and artistic activities. The occurrence of a social process of innovation is confirmed by the cases analyzed, which can be classified as examples of open innovation, wherein the role of the urban creative milieu is pivotal in activating multiple paths. Nonetheless, differently from Padget and McLean, we have not yet identified a ‘cascade effect’ between different innovations.

The presence of a network of scientific museums as emerged through the study of the ‘Florence and Science’ exhibition is an important signal to be further investigated. It not only demonstrates that culture can produce economic development and innovation – as in the case of the Galileo Museum, which has been recently awarded for its excellence of presentation of exhibits[9] – but it also opens up new ways of performing the traditional task of preserving, producing and spreading knowledge. As in the case of the Museum of Natural History of the University of Florence, the aim is to revitalize the museum as a public space and as a key actor in the *filières* of scientific knowledge, through the organization of a variety of events primarily addressed to families, schools and the citizenry.

Finally, the Stendhal syndrome represents a case in which the ‘multiplicity of knowledge’ stimulated an important scientific finding. Even if this has not produced significant effects in therapy yet – differently from what occurred, for instance, in the case of the Mozart effect (Sacks 2007) – nonetheless it has provided significant advances in research through the potentially fruitful alliance of medicine and arts.

The research path that we have just started is surely complex. We should search for further cases of ‘Renaissance innovation’ and to analyze their possible interrelations. Yet, we believe that the approach to resilience we have just started to take into account here constitutes an important perspective of analysis if we wish to understand whether looking at the past may be an effective strategy to build sustainable models of development for this new millennium.

Notes

1 I wish to thank for the collection of information and some data processing regarding the cases examined here, Nicoletta Leo, Andrea Sartori and Francesco Capone.

2 *Resilience* is defined as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks, including four components – latitude, resistance, precariousness, and panarchy – most readily portrayed using the metaphor of a stability landscape. *Adaptability* is the capacity of actors in the system to influence

resilience (in a socio-economic system, essentially to manage it). There are four general ways in which this can be done, corresponding to the four aspects of resilience. *Transformability* is the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable (Walker *et al*. 2004: 2–5).

3 These three excesses, consisting in a superabundance of events and spaces, and in over-referencing, find their fullest expressions in non-places. The excess of time is a redundancy of events in the contemporary world, which causes the individuals to have difficulties in giving meaning to the imminent past because they are too much applied to overabundant present events. The excess of space consists in a redundancy of places, mainly caused by the revolution in transportation, the shortening of distances and the multiplication of impersonal places. The third excess implies that individual stories are increasingly implicated in collective history, entailing the risks of a personalistic use of history (Augé, 1992: 32–41).

4 The event was promoted by the Foundation of Cassa di Risparmio di Firenze, which networked four Florentine museums for the period 1 November 2009 to 9 May 2010 with the following initiatives: Palazzo Medici Riccardi with the exhibition ‘Florence, 1829. Art, science and society’; ‘La Specola’ Zoology section of the Museum of Natural History of the University of Florence with the exhibition ‘The tribune of Galileo and the Florentine La Specola’; the Science and Technology Foundation – Physics Cabinet, with the exhibition ‘Educational methods for science in the 19th century’.

5 The questionnaire was developed by the Foundation of Cassa di Risparmio di Firenze, and it was then worked out by us. The percentages in the age groups of the sample resulted as follows: 31–50 years, 29 per cent; 51–70 years, 28 per cent; 12–18 years, 15 per cent; 19–30 years, 13.5 per cent; under 12 years, 11 per cent; over 70 years, 3.5 per cent.

6 The original database, used in Lazzeretti and Cinti (2009), was updated and developed in order to apply specifically to scientific museums. The first data are presented here.

7 This section represents a synthesis of our works (Lazzeretti, Capone and Cinti 2011; Lazzeretti and Cinti 2012), to which we refer for further details and bibliographical references.

8 Thirteen items were successfully restored, including masterworks such as the famous Donatello’s David – restored in 2008 and re-exhibited in 2009 – and of Lorenzo Ghiberti’s Gate of Paradise at St. John’s Baptistry, whose cleaning is still ongoing.

9 The Galileo Museum has been awarded by the European Museum Academy in 2011, in recognition of its noteworthy collection as well as of its peculiar way of exposing it, which combines the traditional means with the new ICTs and multimedia tools.

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13 Socio-cultural dynamics in spatial policy

Explaining the on-going success of cluster politics

Dieter Rehfeld and Judith Terstriep

Introduction

In the course of the 2003 election campaign in North Rhine–Westphalia, the designated Minister of Economic Affairs stressed that the old government had one hobby, 'clustering', and she promised to push a change and terminate cluster policies in case of an election victory. Indeed, her party won, yet one year later they initiated one of the most ambitious and far reaching cluster project in Europe. There are many reasons for politicians to be sceptical about the cluster approach: So far, no genuine evaluation clarifying the overall benefits of cluster politics exists, serious doubts arise on whether clustering makes sense for all regions, or simply the political logic of being different in terms of distinctiveness from opposite parties, other regions or countries. It is especially the latter aspect, combined with the European and world-wide prominence of cluster policies, which makes it difficult to elaborate counter-concepts, as the cancellation of cluster policies entails the risks of being uncoupled from the debate, networks and funding. It is argued later in this chapter that such 'concept resilience' is a proximate case of the 'self-organisation' of a policy instrument.

The key definitions are:

- *Clustering* refers to a regional concentration of interacting economic activities and institutions.
- *Cluster management* (or the management of cluster initiatives or projects) aims at unfolding the innovative potentials of clusters at the regional or local level.
- *Cluster politics* provide resources and an institutional frame to initiate and support cluster management.

Against this background, the aim of the chapter is to discuss and explain the on-going success of cluster policies (within the EU with a special focus on Germany) despite the growing scepticism of academia and politicians: Why have cluster initiatives and cluster policies become the leading paradigm in innovation and structural policies? The chapter focuses on the social field of policies and leaves the question whether cluster policies and initiatives are successful in economic terms aside.

In this sense and following societal theories, it is assumed that society is based on different social fields (Bourdieu 1972) which follow their own logic and dynamic. With regard to clusters, it is the ‘economic field’, the ‘political field’ and the ‘academic field’. And although all actors in a specific social field are individuals, social actors and their reputation as well as social capital depend on the reference criteria of the social field in which they are embedded. Nevertheless, social individuals are always interested in general societal acceptance, in quality of life, in friendship, and so on. From time to time situations may occur in which the needs of a social field and an individual do not match. For example, a local authority asks a researcher from a local university to prove the existence of local clusters saying that otherwise they will not receive subsidies from national or European funds. We faced similar problems during our first cluster studies in the early 1990s in Dortmund, Gelsenkirchen and, more generally, North Rhine-Westphalia (NRW). The attempt to overcome this dilemma by developing alternative, more sophisticated and well-defined analytic concepts such as ‘fields of innovation’, ‘economic cores’ or ‘fields of strategic action’ failed. Irrespective of our endeavour, the public debate simply ignored these concepts and quickly reverted to the cluster idea. Ultimately, it was the demand for rather superficial studies which essentially contributed to the recent weak and fuzzy (Markusen 1999) understanding of clusters and cluster policies. It is the ‘conceptual elasticity’ (Moulaert and Sekia 2003: 289), which so far has prevented the development of a consistent cluster theory. Table 13.1 summarises the different types of embeddedness of the cluster idea in the economic, political and academic field, along with the key aspects of definition, spatial understanding, and time horizon, modes of interaction, dynamics and activities, which will be discussed in the following sections.

In the economic field, a cluster is defined by spatial and sectorial concentration that is not by chance but rooted in specific regional advantages and related

Table 13.1 The cluster idea in three social fields

	Economic field	*Political field*	*Academic field*
Key feature of definition	Concentration and interaction	Concentration, equal distribution	Concentration
Space	Functional (density)	Administrative	Statistics (administrative)
Time horizon	Short-term benefits and long-term development	Election period, programmed schedule (EC)	Long-term project
Mode of interaction	Cooperation and competition	Competition (difference), up-coming cooperation	Discourse in disparate disciplines
Mode of knowledge	Tacit	Symbolic	Explicit
Dynamics	Evolutionary	Social process	Collective learning
Key activity	Valorisation	Implementation and representation	Explanation

interaction (competition as well as cooperation, cf. Porter 1990). The political field emphasises concentration, especially in spatial policies, but complements it by a strong focus on the economic potential of regions and technologies. Accordingly, spatial policies are committed to equality and are basically future-oriented. Referring to ‘potential clusters’, allows for broadening the scope of cluster policies towards less-developed regions lacking reasonable levels of sectorial concentration and interaction as a base for accruing clusters. As in the economic field, the majority of academic studies focus on spatial and sectorial concentration. This may, however, be due to the fact that data for sectorial analysis is available, whereas the investigation of modes and intensity of interactions would require sophisticated long-term research.

In spatial terms, economic clusters are not restricted to administrative boundaries but rather functional spaces defined by density and interactions. The political field, in contrast, is organised by administrative units. Notwithstanding the broad acceptance of functional spaces as an ideal unit of cluster analysis in academia, the majority of cluster studies still focus on administrative units, as public statistics are based on these. As a result, the Ruhr Area, one of the most dense and traditional industrial regions in Europe, for instance, does not appear in European cluster surveys as it does not fit with the given spatial categories (NUTS categories).

Considering the time-line of cluster development, a further discrepancy becomes obvious: cluster development is a long-term process that mostly takes decades and depends upon unique and specific actions. Politicians – in contrast – have substantially shorter time horizons based on election periods or programme timelines. And the academic field is driven by long-standing academic discussion and progress, always punctuated by project milestones, conferences and project deadlines.

Interaction in economic clusters is driven by a mix of cooperation and competition. In politics, competition between parties as well as between regions is the dominating mode of interaction, but cooperation as a new mode of governance became more prominent in the last decades. In the academic field, interaction takes place by discussions among disparate disciplines and, behind this rational surface, very different modes of interaction can be found: competition on resources and funds, cooperation in research teams as well as strong hierarchic traditions within institutes.

Likewise, one can distinguish varying dominating modes of knowledge, each indicating different mixtures of scope (individual/collective) and/or codification (tacit/codified). First, *embedded knowledge* (that is, implicit collective knowledge, Moodysson and Jonsson 2007) within clusters is based on routines, habits and norms resulting from continuous interaction. In contrast, academia is based on *embrained knowledge* (that is, explicit individual knowledge) which is formal theoretical knowledge. Finally, politics – in times of mass media – is more and more driven by *symbolic knowledge* (for example, knowledge related to images). These different modes of knowledge are related to the key activity within the social fields: Clusters, or rather companies embedded in clusters, combine knowledge from a broad range of different sources, including clusters' embedded knowledge to maintain their competitiveness. Whereas politicians responsible for programme implementation have to showcase successful activities best achieved by making use of symbolic knowledge, academics need to publish their knowledge to gain scientific reputation.

Although these arguments are rather abstract and simplified (for further details see Rehfeld 2006), the distinction illustrates that the different social fields function in very specific ways, having their own rules, own reputation and success criteria, as well as specific trajectories of dynamism. In market-driven economies, based on a large number of (formally) independent actors, it proved useful to study dynamics from an evolutionary perspective (Boschma and Frenken 2006). One can clearly distinguish dynamics in politics form those in other fields as they are not intentional in any case but are strategic and – according to theory – targeted at general rules, not at private benefits. Hence it is reasonable to critically reflect on politics as social processes even if the related theoretical base (cf. first of all, the work of Elias 1976 that focuses on the centralising–decentralising dynamic) is much weaker than the evolutionary one. Finally, contrary to the allegation of science, solely based on a rational discourse and collective learning, Kuhn (1962) illustrates that social factors such as power and influence are crucial, too.

The above distinction is of primary importance for unveiling the specific logic of the cluster idea in policies. It is this specific logic which sets it apart from the logic in the economic and the academic fields. 'Cluster' act as a nexus bringing different institutional path dependencies (as 'innovation' does for university–industry relations in city-regions, see Kitagawa's Chapter 16 in this volume). Accordingly, it is useful to study cluster policies in the specific logic of their respective political dynamics. Investigating clusters from this perspective, and this includes 'framing' through theories and categories from political science, is little established, so far. In this respect, four types of studies are of interest.

First, the analysis of political actors from the new political economy frame (cf. Wrobel and Kiese 2009). The authors' basic assumption is that political actors are driven by self-interest and by broadening their own field of responsibility and, therefore, contribute to the widespread diffusion of cluster politics. Although this is an important aspect, we argue that it is not only self-interest but political pressure rising from the dynamics in the multilevel governance architecture that drives actors' motivation to jump on the bandwagon and focus on cluster politics.

Second, studies on cluster politics in the European multilevel system focusing on learning processes (cf. Borrás and Tsagis 2008). The authors present a comparative study of cluster policies in Europe, focusing on the extent to which the dynamics of multi-level governance are responding to the problems and challenges faced by clusters, especially how governance supports learning processes in clusters and in governance itself. We too, study learning processes, but shift our interest to the dynamism resulting from a mix of institutional innovation (based on learning), path dependencies and pressure from the political processes.

Third, studies on the evolution of cluster politics and implementation of cluster policies. Referring to concepts such as path dependence and varieties of capitalism, it is argued that policies vary according to their regional and national institutional context (Sternberg, Kiese and Stockinger 2010; Voelzkow, Elbing and Schröder 2007). Unlike these authors, we have identified different paths within the different levels and sub-politics of the multilevel architecture.

Fourth, studies taking a general discuss on the cluster approach and its dynamics as starting point followed by a debate on politics and its impact on clusters' success (cf. Martin and Sunley 2011; Duranton 2011). Following this line of reasoning is resulting in doubts as to the success of cluster politics. Again, our approach differs: instead of beginning with the political economy of clusters, we choose social dynamics of the political process surrounding the cluster idea as point of origin. Hence, we do not ask what the economic impact of cluster politics is, but ask for the impact on politics in respect of the political system.

The remainder of the chapter is structured as follows: the next section discusses the way in which the development trajectories of uncoordinated bottom-up cluster initiatives result in a dynamic process, which in turn leads to institutionalisation and path dependence. The second section elaborates on the reasons for and the paths of the anchoring of the cluster idea in the political field. The fourth section analyses the division of labour within the European multilevel system. The chapter concludes with a summary and outlook on the impact the cluster idea's embeddedness in the political field.

From uncoordinated bottom-up activities to societal dynamics and institutionalisation

Economic and political background of cluster dynamics

Clusters are by no means a new phenomenon. In the nineteenth century, spatial inequalities and regional concentration have already been broadly discussed in economic studies (Scheuplin 2006), and Alfred Marshall's publications in the late nineteenth century are a common point of reference in recent cluster studies (Porter and Ketels 2009). It is widely acknowledged that clusters have been crucial in the spatial division of labour in the course of the twentieth century. For example, in the automotive industry, clustering came about at a very early stage of value chain formation in the 1930s (Rehfeld 1999). In Germany such clusters are still studied today. Nevertheless, it is evident that in the course of mass production, standardisation of value chains, internationalisation and global diffusion of production technology, the local environment lost its strategic importance as regards management decisions as well as in academic studies. As a consequence the concept of clustering fell into oblivion.

With the end of standardised mass production, differentiated patterns of spatial division of labour reappeared on the global map. In this vein, Piore and Sabel (1984) underlined the importance of regional networking for the rise of more flexible production systems and in regional studies (cf. the retrospective view in Cooke 2008), about successful regional innovation systems (the 'holy trinity' of regional studies refers to Third Italy, Silicon Valley and Baden-Württemberg).

Porter's research on the competitive advantage of nations (1990) gave a decisive impulse for the revitalisation of the cluster concept and, significantly, coined the term cluster. It was his 'hands-on approach' in combination with the Competitive Diamond as a tool for describing the competitive advantage of clusters which laid the ground for on-going policy fascination (cf. Bode *et al*. 2010: 96).

Notwithstanding the broad diffusion of the cluster concept, the relevant literature on clusters offers a wide variety of diverse definitions (see Martin and Sunley 2003). However, two common aspects of the different cluster definitions are crucial: *Networking* as a mode of interaction between companies and *spatial concentration* as its industrial form. Taken together, these two aspects can be considered as essential in the global economy from the late twentieth century until today.

With regard to *networking*, various studies highlight the fundamental change in companies' culture towards inter-firm collaboration and partnering during the course of the last two or three decades (Boltanski and Chiapello 2003, studying management documents; Castells 1996, studying the consequence of digitalisation). Castelles (2010: 176) summarises as this shift in firms' organisational structures as follows: 'The main shift can be characterized as the shift from vertical bureaucracies to the horizontal corporation.' The ever increasing importance of networking is mainly driven by the following factors:

- The increasing embeddedness of companies in global and transnational value chains resulting in a new balance between market relations and network relations.
- The growing uncertainty caused by acceleration of innovation cycles and increasing complexity; networks are helpful in reducing several of these insecurities.
- The increasing importance of different types of knowledge along the entire value creation process due to the steady integration of technology, production and service functions requires internal and external cooperation with multiple actors; provided companies have the capacity to absorb external knowledge, networks can be considered as knowledge hubs which facilitate the transfer of tacit knowledge through face-to-face and personal interaction.
- Globalisation requires a deep understanding of the specific impacts of different markets and the interaction of different cultures.

In summary, the lonesome rider culture is replaced by a network culture that influenced and partially changed the whole companies' culture in order to stay competitive. Although this change does not have its origin in clusters, it raised companies' awareness of such locations and encouraged companies' embeddedness in clusters.

In parallel with the rising network economy, the spatial division of labour has gone through a remarkable transition leading to *spatial concentration*. The relationship between national state and local or regional levels is rebalancing (Sassen 2008; Rehfeld 2009). From the business point of view, regions (in their function as locations) are of higher importance than the national environment.

Even if this is studied by different concepts (agglomeration, cluster, metropolitan areas, or world cities) there is a strong focus on the reasons for and impacts of spatial concentration of business activities.

These trends in global economy went hand in hand with shifts in the political system. *Re-regionalisation* and *decentralisation* were at the core of policies all over Europe during the early 2000s (Benz *et al*. 2000; Hooghe *et al*. 2010). Nearly all European countries initiated a reorganisation of their political institutions driven by the idea of decentralisation. The EU structural policy was one of the driving forces in this context, nevertheless, the implementation of decentralisation has been divers, depending on the national political settings and paths. Furthermore, decentralisation moves far beyond a new division of responsibilities between the different political and administrative levels. It refers to the search of new modes of governance, especially to public–private partnerships, to activation instruments and learning processes.

As Figure 13.1 illustrates, the new spatial division of labour coincided with the rise of the network economy. Related decentralisation and regionalisation in the political-administrative system gave space for new activities that corresponded with the economic change. Clusters are of importance in all three aspects. We argue that they work as the missing link, giving policy the chance to reorganise in institutional and strategic terms and face economic change in a more successful way. Before discussing this in more detail in the next section, it is helpful to provide a brief overview of how clusters gained their popularity as a driving force in handling meso-economic and spatial change.

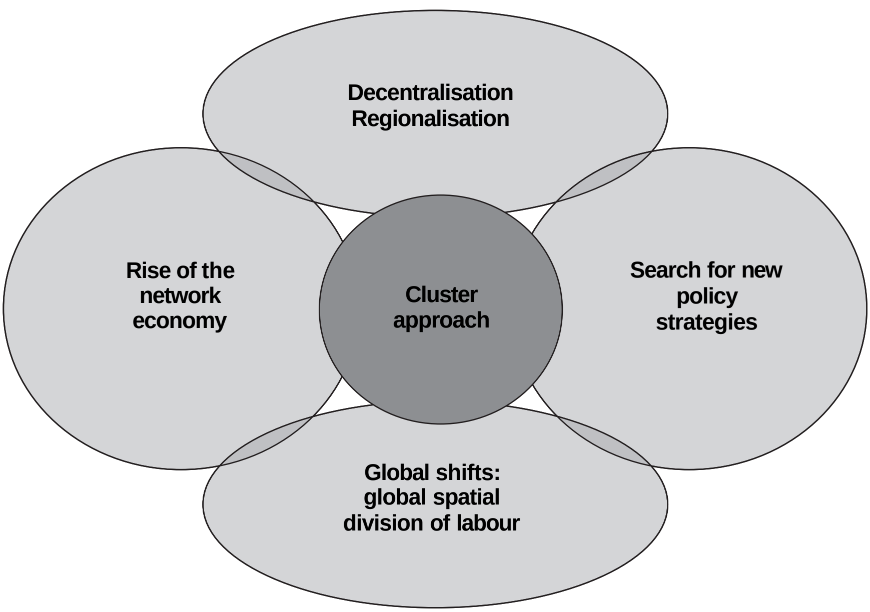

Figure 13.1 The economic and political background of the cluster approach

Trajectories of a new concept in structural policies

Following Chiapello (2010), four conditions are necessary for a new idea to be institutionalised in a way that it becomes a societal frame. First, it takes experience and knowledge that functions as good or better practice. Without doubt, Silicon Valley is in this position today. In the early years of adaption, the focus was on microelectronics and related software and 'xxx-valleys' spread all over the world. Looking back, most of the imitators failed and the lesson learned was that clusters and local economies are not limited to microelectronics. Stories of successful regional restructuring, such as, Baden-Württemberg (renewing the automotive sector and mechanical engineering by integrating electronics), the Third Italy by becoming the leading edge in textiles and clothing based on small family companies, the Ruhr Area by changing from metal working and mining to environmental technologies, and so on, illustrated that the regional base and its embedded competences are superior to a broadly spread sector diversification.

Not surprisingly, regions tried to exploit these ideas. The early successful cluster initiatives had been established bottom-up, sometimes financed by national or European funds but not driven by central policy programmes. Lower Austria, Grenoble and Rhône-Alpes in France, Tampere in Finland functioned as early birds. West-Midlands in the UK, Wolfsburg and Dortmund in Germany, or Catalonia in Spain were some of the most prominent followers. Today, nobody knows exactly how many cluster initiatives exist in Europe. The European Cluster Organization Directory (2010) lists 1,205 cluster organisations in 216 regions. However, more initiatives – not least the privately funded initiatives and those without a formal organisation, both of which are not listed in public documents – are missing from this list.

Second, actors are needed who take up this experience and communicate it into the political process. Due to this aspect, the 1990s was the high-point of studies on regional clusters, most of them best practice studies, often initiated and financed by the European Commission or the OECD. On the one hand, these studies helped to spread the cluster idea (the way it was adapted and changed by the political actors will be discussed in the next section) as there was a strong bias towards success stories resulting in policy recommendations. On the other hand, the bottlenecks and limits of implementation of the cluster approach were ignored and it took some time before academic research on clusters shifted towards sound theoretical and systematical approaches.

Third, a frame needs a *guiding idea* and a *conceptual base*. As outlined in the previous section, networks and spatial concentration are key components and shared aspects of virtually any cluster approach. Academics failed to give a coherent conceptual base because cluster research became highly fragmented in disciplinary terms. This gap was filled by international activities committed to the dissemination and the conceptual integration of the cluster approach. The World Bank conference in Mexico in 1997, strategic papers organised by the OECD, the institutionalisation of the Competitiveness Institute (TCI) and the related Cluster

White Book (2003) and the Cluster Green Book (2004) are some of the milestones in framing international cluster discussion.

In the European Union, cluster policy became a strategic key issue in the context of the Lisbon Strategy. Programmes such as PAXIS, ProInno, Europe INNOVA or KIS-IP, aimed at disseminating good practice, supporting networks of European clusters to organise shared learning processes and to improve capacity building in emerging clusters, later moving towards strengthening world-class clusters (EC 2008).

In parallel with this framing, the fourth aspect, *institutionalisation*, came into life. Institutionalisation has different facets and the most important are:

- European, global and regional conferences, especially organised by the EC-DG enterprise and the TCI, became places for communication and exchange, for presenting best practice and in the course of time for a debate on obstacles and new ideas;
- the European Cluster Observatory and European Cluster Platform, both initiated by EU DG Enterprise and Industry, began presenting and discussing cluster initiatives in terms of 'platforms';
- some cluster qualification programmes at the global level arose from the Harvard concept of cluster training (Kennedy School) based on Porter's approach followed by a dispersed range of regional and national courses (for example, REG-X in Denmark and REG LAB in Sweden);
- probably the most important was the integration of the cluster approach in key European and national programmes – the Lisbon strategy first of all – that diffused further programmes of innovation, regional policy and 'competitiveness' based on clustering.

This does not mean that all such standards are accepted, and the question of evaluation of cluster initiatives and programmes, especially, so far remains unsolved. Many different approaches exist, mostly focusing on single programmes and initiatives. Also, the variety of implementation approaches means the underlying ideas and models of intervention are very heterogeneous. This variety, corresponding with the differences that result from the way the cluster approach is adapted in the political field is discussed in the following section.

Adoption in the political field

In the sub-section 'Economic and political background of cluster dynamics', we argued that the key aspects of the cluster approach reflect real changes in global economy. However, this neither explains why it was adopted in policies in such a broad way, nor why it was this concept and no other. Reflecting studies in regional economy in the 1980s and early 1990s, different concepts had been candidates to become leading ideas in the face of global change: global cities, regional innovation systems, the innovative milieu or regional networks are the most prominent. The difference between these concepts and the cluster approach is that the cluster approach became the focus of a framing process discussed in sub-section 'Trajectories of a new concept in structural policies' and the key elements of the other approaches (especially the learning region and the regional innovation system approach) had been integrated in the overall cluster frame.

Following Kingdon's (1995) research on agenda setting and policy streams, the first condition for a new concept for diffusion into the political field is that there are various problems that capture the attention of people in and around government. In the case of cluster policies, three problems within the political field had been on the agenda and the cluster approach promised to solve these problems.

The first was a gap in economic policy. The concept of a support driven macro-economic policy as the leading idea in the 1980s and 1990s, in combination with the hope of rising service industries that compensate the growing weakness in productive industries, was out-dated with the crisis of the new economy around the turn of the century. The cluster approach provided ideas to fill both gaps, the reinvention of meso-economic policy by combining regional and sector issues and the renewed interest in productive industries in a future-oriented way. Moreover, the cluster concept was compatible with the concept of endogenous development in regional and global development policies and filled this rather vague concept with concrete plans for implementation.

The second problem was that, in institutional terms, the traditional economic aggregates – first of all administrative regions and statistically defined industrial sectors – decoupled from real world change. Branches of the different ministries had been complementary with industrial associations that often represented a sector and not a value chain. Regional activities focused on a small local level with strong administrative borders. Bottom-up cluster initiatives illustrated that it was possible to overcome these institutional limits and cluster policy promised to renew the institutional setting for economic policy.

Economic policy facing ever-growing implementation restraints was the third problem. Many programmes failed because companies, especially small and medium-sized, did not make use of them. Cluster initiatives indicated possible solutions in three aspects:

- first, cluster initiatives function as a mediator and communicator as they do not address the single company but networks of companies;
- second, cluster initiatives proved that companies are willing to actively participate when the topics on the agenda match their interests (and thereby contribute to implementing the idea of the activating state);
- third, they provided feedback to policies on future tasks, needs and support policies by pooling efforts and resources on the most promising topics and regions.

While in the first years, cluster policies supported regional cluster initiatives in an experimental way, in the course of the 1990s and, most recently, with the EC Lisbon Agenda, the support of cluster initiatives spread over national policy agendas. At this stage the cluster concept's fuzziness was quite useful as it allowed adjustment to different philosophies in economic policy. The cluster idea was not a concept to be adopted in a coherent way and therefore offered space for context-specific adoption according to different political paths, sector policies as well as national policies (for further typologies and systematisation see, for instance, Nauwelaers and Wintjes 2008).

In most German federal states, for instance, the roots of cluster policy are in the field of regional policy (framed by EU structural policy). As a consequence, clusters were funded in regions that are lagging behind the average in economic performance or in regions that faced major sectoral restructuring, which is in regions with weak clustering potential. At the same time and without any coordination, the central state focused on technology-driven clusters. With the shift in European structural policy towards the Lisbon strategy and a broad spatial frame that includes and promotes strong regions, the framework changed and, today, cluster policy in Germany is basically linked to technology policy. Another example is the German federal state of Brandenburg, where cluster policy was part of regional policy but the instruments (incentives on the one hand, network projects on the other hand) started in different contexts resulting in coordination problems.

On the contrary, in Finland, cluster policy had a strong beginning in the context of Finnish technology and innovation policy. But today there is a shift to strategy centres that are driven by the most important Finnish industrial value chains. In the Netherlands the ‘Peaks in the Delta’ approach was a very promising combination of spatial policy, regional development activities and technology policies. However, the programme ended without any evaluation and cluster policies were dropped from the agenda of Dutch economic policies. In France, we find a combination of traditional planning approaches rooted in the 1950s, on-going decentralisation strategies and a strong technology-driven focus. In Switzerland, cluster initiatives are predominately bottom-up initiatives and central policy is in its emerging phase. In the Czech Republic, one found the combination of central state-driven planning strategies and market-driven instruments.

These are only a few examples. They illustrate that cluster policy is often embedded in national traditions and the related fields of economic policy. Accordingly, the adoption of the cluster concept in different political fields shows strong elements of path dependence and results in variation. Furthermore, practice illustrates that there is little coordination of different fields of economic policy and especially labour market policy has very few links with cluster policy. Beyond this variation there are common dilemmas that arise from the basic aspects of cluster development.

To start with, the success of clusters relies on concentration. Or put simply, the higher the concentration of related variety (Boschma and Frenken 2006) of economic activities (including research, education, qualification, and so on), the denser the interaction (internal as well as external) and the higher the chance of dynamic cluster effects. Therefore, ideally, cluster policies should rather focus on a small group of promising clusters instead of supporting as many clusters as possible. This conflicts with the European welfare states as well as with the basic consensus-driven European integration, which implies a very strong commitment to regional equality, specifically supporting equal conditions of welfare and quality of life in all European regions. This commitment impedes being selective – and in most cases well-functioning regions benefit from the cluster policies.

In addition, cluster policy is always future-oriented, making it difficult if not impossible, to predict the technology, sector or lead market in which any region will be the winner in the long run. So the solution is not to emphasise clusters, but cluster potentials and thus, opening the door to find potentials and implement related cluster initiatives in nearly any European region.

Division of labour in the system of multilevel governance

As pointed out, cluster policy is multilevel policy. As such it is characterised by the following features (cf. contributions in Tömmel 2007; Benz *et al*. 2007):

- complex institutional and actor patterns;
- no clear definition of borders between the levels resulting in weakly defined responsibilities;
- interdependencies between single actors;
- negotiation processes on policy aims and implementation as interplay between public and private actors and mainly about self-regulation rather than classical state intervention;
- this is why steering techniques that do (and can) not fall back on authoritative instruments are characteristic for cluster policies.

Table 13.2 presents the most important aspects of cluster policies at different political levels in the European Union with Germany and North Rhine–Westphalia illustrating the national and sub-national level.

At the European level, three instruments are of specific importance as regards cluster. Following the Lisbon Agenda, cluster development is a key issue in European cohesion policy. There is a broad range of instruments to put it into practice and the implementation is driven by the national state or sub-national states. In this context, the cluster approach is supported very broadly, while the conditions for financial support vary according to the national or sub-national economic philosophy. In contrast, DG Enterprise and Industry works as a promoter of new ideas and best practice in cluster policies. The detailed programmes change over time: from European networks of clusters with a broad sectoral and technological base over cluster networks to strategic fields such as service industries, financing or sustainability to the promotion and global profiling of world-class clusters. Joining these programmes requires well-functioning cluster initiatives, involving new and learning clusters. Under the umbrella of DG Research the sub-programme Regions of Knowledge (RoK) is most important. It aims at funding the cooperation of knowledge-driven clusters in accordance to the strategic fields defined in EU 2020 strategy. The programme focuses on actors from the triple helix (state, private industry, research, which needs to be proven to participate in the programme) to develop joint regional and European research agendas.

Table 13.2 Characteristics of cluster policies on different political levels under the Lisbon Agenda

Policy level	*Administrative unit*	*Concept*	*Policy field*	*Instruments*	*Implementation*
EU	DG Region	Cluster	Cohesion and structural policy	Broad range of instruments	Dispersed (covers nearly all regions)
	DG Enterprise	World Class Cluster	Innovation	Cooperation between clusters, certification	Selective (only few regions with quality standards)
	DG Research	Cluster	Research & Development	Cooperation between clusters (RoK)	Selective (only few regions with quality standards)
National (Germany)	Ministry of Economic Affairs	Networks of Excellence	Innovation	Certification	Broad range
	Ministry of Research	Leading edge clusters	Research & Development	Co-financing cooperative innovation projects	Highly selective
Sub-national (NRW)	Cross ministry Activity	Fields of competence, clusters, lead markets	Technology and research and development	Basic funding cluster management	Covers nearly all value chains
	Ministry of Economic Affairs	Regional networks	Structural policy	Basic funding of cluster management	Occasional
Local/ regional	RDA, Technology Parks and so on	Cluster, sector network, field of competence,	Economic development policy	Resources for cluster management	Dispersed (filling the gap)

In Germany, several specific programmes at the national level are committed to the cluster idea. For example, the InnoRegioProgram aimed at strengthening innovative networks in Eastern German region, the BioRegio competition focused on the leading biotechnology clusters. Next to these programmes, two instruments are of relevance: the *Networks of Excellence initiative* brands regional innovation networks in all industrial sectors or fields of technology. Its roots are in the Ministry of Research and Development and the benefit is branding by certification. Up until 2012, about 140 networks exist and an evaluation is a prerequisite to remain a member of this prominent label. In contrast, the *leading edge cluster competition* launched by the Federal Ministry of Education and Research is highly selective. So far, fourteen clusters have been selected and will be funded with a total amount of 200 million euro. The entry conditions are very high and comprise a well-functioning network and actors, first of all private companies, who commit to co-finance innovate projects counting for 40 or 50 million euro (up to 50 per cent are financed by the government) are required.

This highly selective programme at the German national level is possible because structural policy is implemented by the sub-states in Germany. In North Rhine–Westphalia, 16 cluster initiatives are funded which cover most industrial sectors. In addition, there is a programme that funds regional networks in fields that are not covered by the North Rhine–Westphalia cluster initiatives.

The local and/or regional level is where cluster policies are implemented. Accordingly, this level is crucial for the successful implementation of cluster policies. Nevertheless, we find a lot of cluster initiatives managed by regional development agencies, technology parks or universities, mostly equipped with very limited resources.

Reference to the five features of multilevel governance mentioned at the beginning of this section, indicates that cluster policy indeed covers complex institutional and actor patterns. All levels of the vertical dimension are involved with different instruments and programmes, first of all in the context of cohesion and spatial policies with innovation and research policies. Hence, cluster policy is no longer coherent or integrated but a political frame that structures the activities of many sub-policies.

In addition, multilevel studies point out that the borders of the levels and the actors are not clearly demarcated, so responsibilities are not always clearly defined. This is especially true for spatial policy where all levels have to work together with different functions. But then the story becomes more complicated: at first sight the single programmes have different criteria. Thus German networks of competence focus on networks, not on clusters in a strong sense, the regions of knowledge focus on clusters that are committed to the triple helix approach, or the North Rhine–Westphalia clusters cover a broad range starting with technology networks and ending in more traditional sector orientation. So, all levels have a specific focus and specific criteria of funding and evaluation. But in the end they depend on each other: especially the highly selective programmes that need a broad range of professional competence as well as established clusters. This is the third feature mentioned above, the levels and programmes work together and in certain terms they do it in a self-organising way: when most levels base their strategies on networks and no longer on single actors, those regional or thematic levels that have no networks run the danger of losing contact and cannot adapt to other activities. Due to the new political economy approach mentioned in the introduction, this means that policy actors engage in their own interests but face the self-organising dynamic of the diffusion of the cluster approach as a policy and politics in which they have little choice but to act differently.

The fourth feature refers to the various governance modes and the potential for learning and experimentation. If we take key categories from the governance discussion (steering through market, hierarchy and networks) as a point of reference, almost all possible fields are covered in this triangle (Figure 13.2). The proceedings of states (including federal states) with extreme restructuring problems (for example, Eastern and Central European states or, in former DDR, Brandenburg) or states with a strong planning tradition such as France, are influenced by a more hierarchical steering philosophy. Here, the challenge is to align the central state impulses with the initiation of societal self-organisation. At the other end – this is often disregarded – there are activities of regional self-organisation of companies that do not depend upon and may even reject public funding, as they wish to remain independent from political requirements and public attention.

In-between, there are all sorts of hybrid forms: initial financing aimed at a societal self-organisation progressively replaced by self-support or the promotion

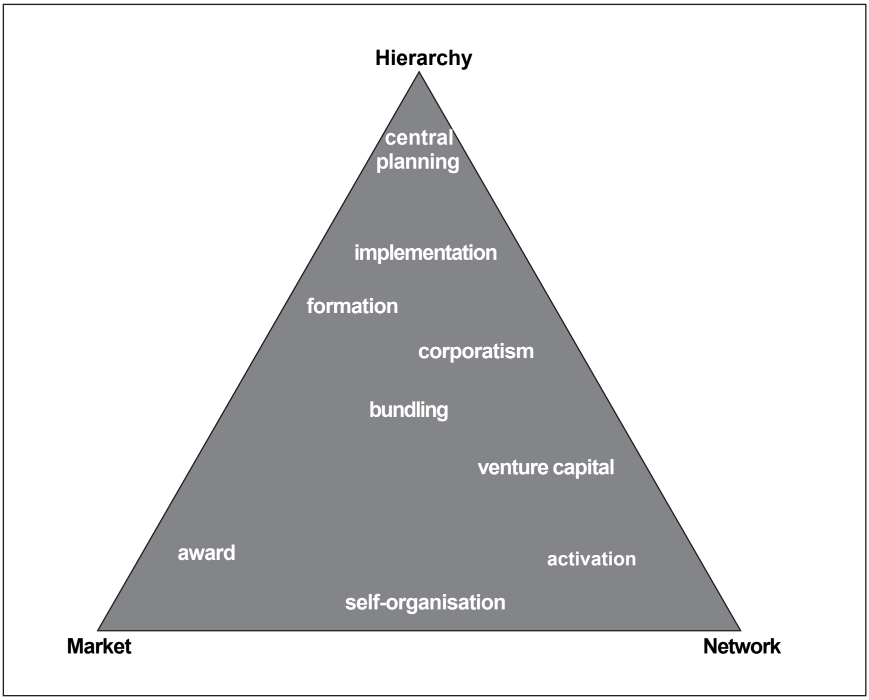

Figure 13.2 Modes of governance in cluster policy

of extraordinary cluster projects which won a competition and remain closely linked to markets and networks. The bundling or formation of national resources through an intensive technological cooperation or cooperation comparable to classical corporatism between state, unions and companies is yet another form linked closer to public interests.

In a certain way, such different models will always be found, depending on the economic starting position, the readiness of social actors to participate in the provision of collective goods or national political-administrative steering philosophies and regulation systems. However, all these different approaches have in common that, starting from a certain point in time, they all rely on the active participation of those addressees. This is especially true for the participation of companies.

This leads to the fifth feature to be discussed, the failure of authoritative steering instruments. Whatever the context is, cluster politics depends on the active involvement of private actors, companies first of all, and they have to balance bottom-up and top-down approaches, in other words, cluster policy and cluster initiatives.

Figure 13.3 illustrates the position of cluster policy and initiatives in selected countries with federal states high on the axis of 'funding' and 'strategy'. 'Funding' means whether public funds are involved or not; 'strategy' refers to the direction of the impulse bottom-up or top-down. The expected time-line (dotted arrow lines) illustrates that all top-down strategies strive for an active involvement of companies by decreasing public financial support in the middle or long run: that is, in the

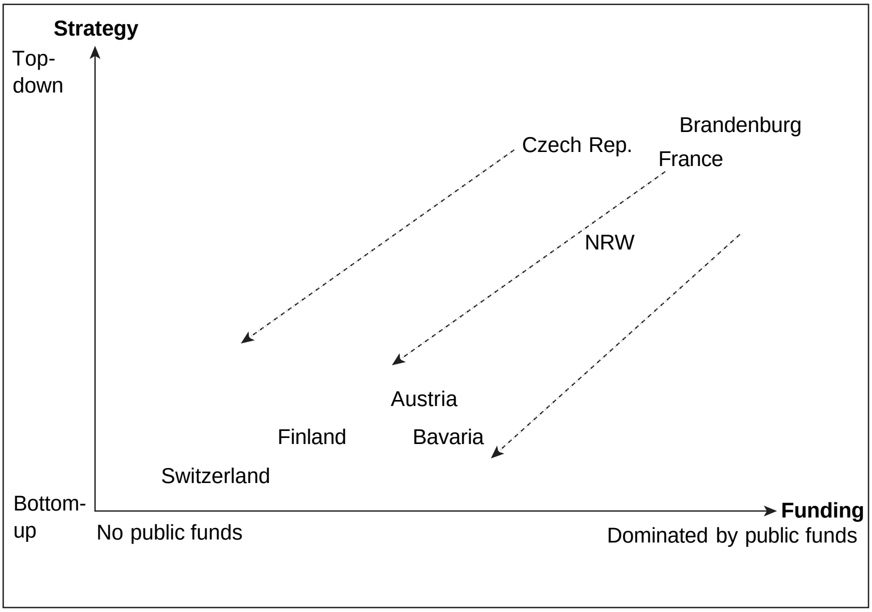

Figure 13.3 Balancing top-down and bottom-up activities

course of time it attempts to change direction from top-down to bottom-up. The more strategy and funding are driven bottom-up with cluster policy as a framing institution, the less problems occur. Most strategies in cluster policy result from a strong impulse from top-down by aiming at self-organisation. Major problems arise when new activities in cluster policy meet long-standing bottom-up initiatives. This is the case in most German federal states, in certain French regions and in some parts of the Czech Republic. The dilemma is that, if policy intends to initiate self-organisation, it must accept the risk that the priorities of the societal actors vary from those of the central state. In summary, the vast majority of cluster policy strategies have a strong top-down orientation while striving for self-organisation. But self-organisation works best with ‘no global controller’ (Arthur *et al*. 1997).

Rethinking the effects of cluster policy

The ‘new’ logic of the economic field, with interactions and functional spaces at its core, asks for new modes of governance. Hence, it offers high potential for cluster policies but requires policy innovation, especially as regards multilevel governance. This means rethinking the administrative setting, instruments and the division of labour between private and public actors.

As highlighted in the section ‘Adoption in the political field’, policies’ innovative potential comes into life in the course of adoption in the political field in a complex way. Its success is driven by a very specific mix of learning, path dependence and self-enforcing processes (see Table 13.1), which varies from country to country. In this context, the space for experimentation and learning opens for different levels in the multilevel architecture. The best examples in our study are the German leading-edge competitive call and the initiatives of DG Enterprise and industry. So far, the key impact of the adoption of the cluster approach in the political field is institutional innovation, which enables institutions of the political field to respond appropriately to changes in global economy. Summing up, the key aspects of institutional innovation are:

- challenging and, from time to time, breaking path dependencies (sector and regional);
- strengthening the local/regional implementation system by overcoming administrative borders;
- mobilising additional resources, especially from the private sector (activating state);
- institutional spill-over (beginning in spatial planning and research policy, but the key ideas get adopted in further sub-policies like education, sustainability or infrastructure.

Nevertheless, there remain tensions resulting from the specific logics of the social fields. As far as the relationship between the political and the economic field is concerned the key problem is the need for concentration in economy and the commitment to equal distribution in the political field. There is a basic lack of information about the future and, as long as this is the case, it is nearly impossible for politics to decide which regions have the potential to develop a self-enforcing cluster and which regions do not. The problem is that there is no strategic option for regions without a potential for a cluster, because all activities are embedded in the same frame. So, multilevel governance in our case has two faces: it gives a shared frame that is broad but includes no strategic option and it gives space for experimentation within this frame leading to the institutional innovation mentioned above.

As far as the relationship between the academic and the political field is concerned, the different modes of knowledge in relationship with the key activities are most important. Implementation of cluster politics needs more than the explanation given by academics, because there is a gap between the knowledge about the way dynamic processes run and the knowledge of how to manage or guide those processes.

Of course, this is not the end of the story. Politics needs symbols for success and thrives on presenting an image of renewal, and today the cluster approach is challenged by new ideas like lead market initiatives, social innovation or social networks based on ICT. We can suppose that, meanwhile, the cluster approach is strongly embedded so that, by creating its own path, it tends to absorb these new ideas. As far as the cluster approach itself is concerned, four challenges are on the agenda for the forthcoming years (cf. Rehfeld 2009; 2011).

First, if it is true that clusters are selective and that it makes no sense to try to develop clusters in each region, we need further strategic concepts for those regions that have no promising starting points to develop clusters. Clustering is one way of strengthening the innovative performance of regions, but we need different ways to elaborate ‘innovative spaces’ (Rehfeld 2006). This includes the question in which way can regions can make good use of key ideas of the cluster approach, such as networking, linking local-global chains, improving competence, organising collective learning process, and so on.

Second, we need a deeper understanding of how cluster policy is positioned in relation to key trends of global change. It is assumed that many future trends will be highly decentralised. Sustainable strategies or new health concepts are fundamental challenges to improve quality of life in all regions and it is not helpful to discuss these challenges first and foremost from a cluster perspective. In a globalised world, no region is autonomous and access to, as well as exploitation of, global knowledge are crucially important for the future of all regions. Global migration brings about more and more geographical fluidity or borderless spaces allowing for flow of innovation across geographically fixed regions. If clusters succeed in avoiding limiting themselves to traditional geographic levels, they have the potential to work as local nodes in global networks, as knowledge hubs and door openers with respect to the above-mentioned trends.

Third, we need evaluation concepts that are aware of the complexity of cluster policy, especially with respect to the different phases of the life cycle of a cluster. In certain terms, it will be very successful when cluster policy contributes to reorganise the institutional setting of economic policy, when it succeeds in combining private activities and public resources or when it helps to make institutions more flexible. So far, evaluation concepts are focusing on indicators, hard factors as well as weak ones (see the examples on the home page of Scottish Enterprise) but, in order to evaluate cluster policy, we need an understanding of the underlying intervention concept and the related strategy.

Fourth, doing this we cannot expect perfect solutions, but different ways to balance dilemmas. Good practice is always good practice in a specific context of space and time. Clusters develop in an evolutionary way and cluster policy has to do the same. In this vein, cluster policy has always to keep in mind that it is public policy and, therefore, cluster policy has to stand for more than only following the economic evolutionary pathway. Cluster policy has to focus on public goods and benefits, and when it does so successfully, there is a chance for a fruitful co-evolution between public and private interests.

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Part IV

Evolutionary spatial policy

14 Transformation of regional innovation systems

From old legacies to new development paths

Franz Tödtling and Michaela Trippl

Introduction

Over the past 20 years, the innovation system approach has significantly enhanced our understanding of the innovation process, stressing its non-linear, systemic, interactive and evolutionary character. The notion of regional innovation systems (RISs) highlights the regional dimension of new knowledge generation and exploitation and constitutes a powerful concept for explaining regional differences in innovation capacity. RISs can be conceptualised as the set of firms, organisations and institutions which influence the innovative behaviour and economic performance at the regional level (Cooke *et al*. 2000, 2004; Asheim and Gertler 2005). They are shaped by existing industry structures and technology paths, the set of knowledge organisations, and the prevailing institutions and networks. As a consequence, they exhibit a high degree of inertia. This may lead to phenomena of path dependency and 'lock-in' in particular regions and to a certain degree of stability in terms of regional disparities in innovation and economic development.

Regions and their innovation systems, however, are not static entities. In fact, one can observe considerable changes of industry structures, innovation activities and patterns of networking in particular regions in the longer run, often reaching beyond the existing development paths. We find phenomena of innovation-driven catching-up processes in lagging regions, restructuring processes in industrial regions leading to new industries and technology paths, as well as sometimes an erosion of innovation capacity and competitiveness in leading regions. Most research on RISs, however, has so far not dealt with such changes. The RIS literature suffers from a key weakness, that is, its static view brought about by a focus on existing structures and relations. As a consequence, the reconstruction of RISs and their evolution over time remains poorly understood. This chapter seeks to advance a dynamic perspective of RISs by suggesting a framework for analysing their transformation. As noted by Simmie and Martin (2010: 27) 'regional and local economic development is far from a smooth and incremental process but is subject to all sorts of interruptions and disruptions: periodic economic recession, the unpredictable rise of major competitors elsewhere, unexpected plant closures, the challenges arising from technological change and the like'. Moving beyond a static view on RIS and elaborating on a dynamic perspective is thus high in demand. A dynamic view on RIS requires more room for agency (see, for example, Martin and Sunley 2010). Analyses of RISs tend to focus on institutional set-ups, subsystems and the links between them, often paying little attention to individual economic agents (managers, workers, entrepreneurs, and so on) and organisations like firms and universities (see also Gertler 2010). By taking into account key actors of change, we link individual agency and RIS structures in analyses of RIS transformation.

The aim of this chapter is to enhance our understanding of how processes of RIS transformation take place. We will identify key actors and drivers of path renewal and new path creation and we seek to find out to which extent such changes are related to the existing economic and institutional structures. Based on a discussion of relevant theories and a critical literature review, we will develop a conceptual frame for analysing RIS changes. Besides the RIS approach, we will use ideas from Evolutionary Economic Geography (EEG) which provides valuable insights into the long-run regional trajectories and sources of change in regional economies (Boschma and Martin 2007, 2010). We will also discuss empirical examples of such shifts based on evidence from Austria and other countries.

Sources of stability in regional innovation systems

RISs tend to be relatively stable phenomena. Martin and Sunley (2006) identify a set of different sources for regional stability and path dependence, including the existence of natural resources, sunk costs of local assets and infrastructure, regional technological 'lock-in', local external economies of industrial specialisation, economies of agglomeration, region-specific institutions, social forms and cultural traditions and inter-regional linkages and interdependencies. An explicit focus on the key elements of RISs draws attention to the following factors underpinning their stability.

Although the subsystem of knowledge generation and diffusion (made up of the regional research and educational organisations, intermediaries, and so on) is subject to changes (for example, due to expanding universities and new educational programmes), the set of knowledge organisations and their accumulated competences tend to be rather stable over time. The quality of research organisations can only be changed in the long run through hiring new qualified staff or entering new scientific fields. For this reason, we find a relatively high stability of regional patterns of research outputs, patenting and university rankings. The second subsystem of knowledge application and exploitation consists of the set of firms, the industries and dominating clusters of the region. Although individual companies and industries are exposed to market fluctuations and technology changes resulting in an expansion or a reduction of output and employment, the overall economic structure and mix of industries is often rather persistent at least in the short and medium term. This contributes to a certain stability of regional rankings of productivity, per capita income and innovation performance over time.

Furthermore, it is not only the 'hard facts' mentioned above but also the 'soft' institutions which matter (Hodgson 1988; Rodríguez-Pose and Storper 2006).

Informal institutions, such as, common habits of thought, routines, practices, social norms and values are crucial determinants of innovation, influencing the behaviour of actors and the relations among them. A key feature of such institutions is inertia (see, for example, Johnson 1992). Traditions, routines and old patterns of behaviour and thought tend to be long-lived. Institutional persistency thus has a further stabilising effect on RISs. This does not mean that institutional (un-)learning is impossible. However, the question of how institutions change remains still poorly understood (Maskell and Malmberg 2007; Gertler 2010).

Despite a high degree of stability and continuity in general, we may observe dramatic changes in particular RISs in certain periods. Evidence of such processes currently exists for some emerging economies of East Asia or South America. In these world regions, we find a number of regional 'hotspots' (Singapore, Taiwan, Hongkong, Shanghai, Bangalore, Sao Paolo) where not just economic development but also innovation and technology shifts occur quite rapidly (see Dunford and Yeung 2011 for China). In Eastern European countries and regions, there is evidence of catching-up processes, which are partly related to endogenous RIS changes but more often due to incoming foreign direct investment. In Western Europe, regional changes are usually less dramatic, but there, too, we observe a dynamic evolution of some peripheral regions, restructuring in old industrial areas, and shifts in the innovation performance of particular metropolitan regions.

How can we conceptualise changes of RISs? In the following we differentiate between various degrees and directions of RIS transformation. Furthermore, we look at different key actors of change and investigate potential modes of the transformation of RISs. We argue that due emphasis should be given to context conditions when dealing with the issues outlined above. The contextual view proposed here recognises the role of the inherited structuring of the RIS under consideration and the embeddedness in particular forms of production regimes and institutional frameworks, as suggested by the varieties of capitalism approach. These contextual factors have an influence on, but do not determine the directions of change, the group of actors which is likely to take the lead and the key modes of RIS changes.

Directions of RIS changes

Despite their inherent inertia, RISs evolve continuously. New firms, products and technologies are more or less permanently added to a RIS, whilst old ones vanish (Boschma and Martin 2007). Consequently, there is a gradual steady change of RISs. More often than not, these small changes are intra-path changes; they do not modify or alter the overall development trajectory of RISs. In certain periods, however, more fundamental changes can be observed, leading to a major transformation of RISs. In this chapter, the focus is on the latter phenomenon.

RIS changes can be of different degrees, ranging from minor (incremental) to major (radical) ones. Importantly, any determination of the radicalness of change depends on the specific level under consideration. An industry or cluster may experience a radical change through, for example, the invention and diffusion of new technologies. This does not automatically imply a radical change of the RIS, however, because such changes do not necessarily alter the region's overall economic structure. In this chapter, we look at the level of the whole system when assessing whether changes are radical or incremental. Our specific interest is in changes of regional industry structures and their directions. However, the transformation of the region's industry structure (subsystem of knowledge application) is likely to be associated with a reconfiguration of the knowledge infrastructure, the institutional set-up and the region's network structure in the medium and long run.

Recent conceptual work done within EEG on the evolution of regional industries and the mechanisms of regional path dependence, path creation and renewal of paths (Martin 2010; Martin and Sunley 2006, 2010) provides valuable insights in this regard. Based on this literature, we distinguish between three basic types of RIS changes (see also Trippl and Tödtling 2008a; Trippl and Otto 2009):

- rejuvenation of existing clusters or industries (path renewal);
- rise of established industries that are, however, new for the region (path formation in established industries);
- rise of new high-tech and knowledge-intensive industries (path creation in new industries).

Arguably, these three types of change might co-exist within a particular region. A RIS often consists of different industries and clusters, each being at a specific stage of the development path (emerging, growing, declining, renewing). Consequently, this could lead to an overlapping of regional industrial trajectories and different types of change within a RIS.

Path renewal

Path renewal refers to changes which take place within older industries or clusters which have already existed for a long time in the region. Such changes are about an upgrading and the revitalisation of established industries. The transformation of the RIS in this case is modest in nature. Martin and Simmie (2008) identify various reasons that might bring path renewal to the fore, such as, the increase of external competition, or the introduction of radical innovations and new technologies within the industry. Furthermore, the loss of innovative dynamism within the regional industry or the relocation of key organisations to other places might urge the rejuvenation of existing regional industries. Arguably, RIS changes based on path renewal modify the existing development trajectory of a region but they do not alter the industry structure. A renewal of existing industry paths does not necessarily lead to the emergence of a new RIS path.

Path renewal of existing industries embraces different forms, ranging from a shift from mass products towards specialities and higher value products as is has been observed in the Styrian metal cluster (Tödtling and Trippl 2004: Trippl and Otto 2009) to the introduction of new technologies and organisational practices as it was seen for example in the automotive cluster in Ontario (Gertler and Wolfe 2004) or the industrial machinery sector in Tampere, Finland (Martin and Sunley 2006). Importing new technologies or organisational forms from outside the region may also matter. Its success critically depends on the absorptive capacity of the RIS (Martin and Sunley 2006).

An innovation-based restructuring of ancestral clusters is linked to changes in the region's knowledge infrastructure. These might involve the creation of research and educational bodies that support firms to introduce new technologies and to upgrade their products by providing specialised knowledge and highly qualified labour. The metal cluster in the region of Styria (introduction of laser techniques and new compound materials) and the watch industry in the Swiss Jura Arc (introduction of microelectronics into the former mechanically based watch industry) demonstrate the significance of rejuvenating old industries by building bridges to new technologies (Maillat *et al*. 1997: Tödtling and Trippl 2004). In such cases new technological trajectories may be opened up for traditional industries.

Path formation in established industries

Path formation in established industries involves more significant RIS changes than path renewal, broadening the economic base of the respective RIS. The emergence of clusters in established industries, that are, however, new for the region is a well-known phenomenon. Examples include the emergence of the automotive cluster in the region of Styria (Tödtling and Trippl 2004) or the growth of the automobile and electronic industries in Wales (Cooke 2004). The rise of new clusters in such industries can take different routes.

There is the way of exogenously driven development propelled by inward investment. The potential role of foreign companies as key agents of change is highly contingent on the specific nature of their activities. Classical branch plants of multinational companies seldom serve to encourage the birth and growth of innovative clusters in established sectors. Foreign companies, in contrast, that feature high value-added functions and embed themselves in the local economy by creating links to regional actors can give an important impetus to the emergence of a new complex (see the cases of the automotive and electronics clusters in Wales as described by Cooke 2004). Exogenous-led cluster building, however, is not without danger. The case of the region of Wales is instructive to demonstrate that the withdrawal of foreign companies from the cluster often has negative impacts for the region (Cooke 2004).

The rise of new clusters in established industries can also have endogenous sources. In this case, the emergence of a new cluster is based upon sectoral diversification activities of home-grown firms that are capable of moving into new sectors by redeploying existing assets and capabilities. Such processes have been described as 'related diversification' (Frenken *et al.* 2007), that is, path formation builds on competences already present in the region, and can be distinguished from 'unrelated diversification' (that is, the development of new clusters which are not related to those already existing in the region). Path formation in traditional industries could also be the outcome of a combination of endogenous and exogenous factors. This is demonstrated by the case of the automotive industry in the region of Styria where the interplay of the attraction of foreign-owned companies, diversification strategies of home-grown firms (for example, in the metal industry) and the existence of some traditional roots and competencies in the automotive sector has resulted in the establishment of a new growing cluster (Tödtling and Trippl 2004).

The formation of new clusters in established industries benefits from an accompanying reconfiguration of the regional knowledge infrastructure. The Styrian automotive cluster provides a good illustration for the relevance of institution building in order to encourage the growth of new complexes. The establishment of a technical college for automotive engineering and the creation of various cooperative research centres between universities and firms supported the rise of this new cluster (Tödtling and Trippl 2004). It is also important to note that in the Styrian case, the development of the automotive cluster coincided with certain changes and conditions in the international car industry, that is, the enduring trend to reduce the level of vertical integration and to outsource a variety of activities and functions to qualified firms (first and second tiers of suppliers) as well as to research organisations (Tödtling and Trippl 2004).

Path creation in new industries

The most radical form of change is brought about by the emergence and growth of industries based on new technological and organisational trajectories such as knowledge-intensive and high-technology industries, implying a major shift in the development trajectories of regions. How do such new paths come into being? There is a growing recognition that chance, contingent events, serendipity or historical accidents should not be over-emphasised in this regard, because new paths often emerge out of previous and existing regional paths (Martin and Sunley 2006; Boschma 2007; Martin 2010). ‘New paths do not emerge in a vacuum, but always in the context of existing structures and paths of technology, industry and institutional arrangements’ (Martin and Simmie 2008: 186). More specifically, path creation in new industries requires the existence of assets, resources or competencies rooted in the area (Martin 2010). These could include, for example, an excellent scientific base or the availability of a highly skilled labour force. The development of a new high-tech agglomeration might also be the result of a strong local demand.

New path creation can result from the branching out of existing industries into new but related technological fields (Martin and Sunley 2006; Boschma 2007). The emergence of new high-tech and knowledge-intensive industries hinges strongly on the establishment of new companies and spin-offs (Frenken and Boschma 2007). Existing endogenous firms or foreign direct investment may also play a powerful role in ‘seeding’ a new high-tech complex. The rise of the software industry in Ireland, for example, has been triggered by the attraction of foreign companies (O'Malley and O'Gorman 2001). The IT industry in the Finnish region of Tampere exemplifies the importance of home-grown leading firms such as Nokia in stimulating new path creation by acting as sophisticated customers (O'Gorman and Kautonen 2004). The environment protection industry in the Ruhr area is another good example in this context. It has its origins in the old mining and steel complex (Hilbert *et al*. 2004). The leading firms of this cluster and their suppliers were forced by legal restraints and other political measures to reduce pollution and contamination caused by their traditional business by developing internal solutions to the environmental problems. They managed to transfer these competencies and skills situated within the old cluster into new markets, giving rise to the new environment protection industry. Nevertheless, compared to the two other development scenarios discussed here, new firm formation is a crucial element for the emergence of high-technology industries (Feldman *et al*. 2005).

Path creation in new industries preconditions a major transformation of the regional knowledge infrastructure. Taking this road might, indeed, be strongly linked to intensive processes of institution building and institutional change. To create or further develop a relevant scientific knowledge base, to establish excellent research organisations, to upgrade the education and training system, and to establish specialised support structures (science parks, academic spin-off centres, incubators, and so on) are key factors that contribute to developing and sustaining new knowledge-intensive clusters. Often this leads to a neglect of and negative consequences for existing sectors reflecting the downside of Schumpeter's 'creative destruction'. Under certain conditions, however, in particular in the case of promoting generic fields and technologies (such as ICT, new materials, life sciences, nanotechnologies), new education systems and support structures might benefit both old and new industries.

Having identified three types of change, it is important to emphasise that the transformation of RISs is likely to differ strongly across regions. A large body of work has demonstrated that RISs come in many forms. Some of them constitute networked systems whilst others are characterised by fragmentation. Furthermore, they can exhibit 'thin' or 'thick' institutional structures (Tödtling and Trippl 2005). RISs also differ in terms of economic specialisation. The existing structures of a RIS will have an influence on which of the three types of change discussed above is more likely to occur, how changes proceed and which mechanisms of change dominate. In other words: regional transformation is a context-specific phenomenon that varies strongly between different types of RISs. The relevance of pre-existing regional economic and technological structures and competences could be illustrated with a brief example of new path creation based on the rise of biotechnology. Gertler and Vinodrai (2009) investigated life science industries in six Canadian regions and demonstrated that the evolutionary pathways followed by these six regions were far from identical. Differences in local historical, geographical and institutional conditions turned out to shape the pattern of specialisation within the life science sector and influence its subsequent evolution in these places in distinctive ways (see pp. 304–312).

Actors of change and the role of context

The transformation of RISs can be the cumulative outcome of regular and ongoing activities by firms and knowledge organisations, the result of more singular efforts (for example, in response to crisis situations), or it can be the outcome of more strategic actions by, for example, policy makers. Looking at the literature, it seems that, in fact, crisis situations have often been triggering more fundamental changes in innovation systems. Examples here are old industrial regions, such as, Ruhr area or Styria in the 1980s, the Boston region in the late 1980s (break down of the computer industry due to Japanese competition), Finnish regions in the early 1990s (loss of the Russian market for Finnish firms) or crises in Italian industrial districts in the 1990s due to competition from China and other emerging economies. The response to such crisis situations, however, often varies. Whereas, in old industrial regions, crisis situations have often resulted in 'restructuring', implying a severe loss of employment and the closing of plants, other economies such as Massachusetts in the USA and Finland have progressively invested in R&D and education, thus improving their innovation system.

Driving forces and actors of change can be quite different agents, such as, charismatic individuals, leading firms or policy actors. One of the key arguments proposed in this chapter is that different types of capitalist systems and RISs have an influence on how likely it is that certain actors and not others play a leading role.

Varieties of capitalism

The key drivers in the transformation of RISs seem to differ by type of industry organisations and institutional forms (Hall and Soskice 2001; Cooke *et al*. 2007). In liberal market economies, which prevail in countries such as the United States or the United Kingdom, these are often the firms, such as start-ups and fast growing young firms in new industries that collectively shape the development of particular RISs. In addition, venture capitalists and large firms in various industries play a key role. Furthermore, in liberal market economies such as the US and UK, universities are often regarded as influential players, as they often have a stronger focus on the application and exploitation of knowledge than most European universities. This is also reflected in a more prominent role of technology licensing and liaison offices, incubators and the support of start-ups. Policy has an influence on the federal level, for example, through R&D spending, health and military research and at the local level through infrastructure provision.

In coordinated market economies like Germany, Austria and the Nordic European countries we find a stronger role of policy actors and of associative governance (Cooke and Morgan 1998) both at national and regional levels in comparison (Cooke *et al*. 2000). This includes a broader and more comprehensive set of activities and measures for improving the national and regional innovation systems. Besides investments in (mostly public) universities, this includes cluster programmes, RIS strategies, as well as networking activities. In Europe, the governance of innovation has become more complex and multi-level in nature through the EU framework programmes, the Lisbon agenda and efforts to establish a European Research area. This has clearly led to a stronger orientation and earmarking of EU structural funds for enhancing competitiveness, R&D and innovation in the most recent programme period.

The argument advanced here is that different institutional forms of capitalism have an influence on – but do not determine – who is likely to perform as a key actor of change. National institutional forms and modes of production regimes form essential context conditions for RIS changes, although significant differences between regions situated within and embedded into the same wider institutional framework might exist.

Types of RISs

As noted above, the structuring of the RIS shapes regional path renewal and path creation in substantial ways. The rise of the biotech industry is a good example in this context. It has followed very different routes and was triggered by different driving forces. The case of the biotech industry in Canadian regions is telling in this respect. Gertler and Vinodrai (2009) identified a variety of critical enabling factors and triggering events in their analysis of six life-science regions in Canada:

> In some clusters, a pioneering firm sparked latent entrepreneurialism or provided credibility and 'inspiration' for actors in the region (Montreal, Vancouver, Halifax, Toronto). In Saskatoon and Montreal, cluster emergence was driven by policy decisions made at the federal level to locate national laboratories in each city. Yet, in Ottawa, while local associative actors and a lead firm were important, it was an exogenous shock that served to raise the profile of life sciences activities.
>
> (Gertler and Vinodrai 2009: 252)

Consequently, despite being embedded in the same national context, the leading actors and driving forces varied considerably from region to region. Furthermore, existing regional capabilities and resources and the structure of the regional economy had an influence on which type of biotech emerged in the six regions investigated. Saskatoon's specialisation in agricultural biotechnology has emerged from the established agricultural economy in that region, while strengths of Halifax in marine-related activities are reflected in the regions's strengths in marine-related biotechnology (Gertler and Vinodrai 2009).

Pre-existing local economic and technological structures and competences thus essentially matter. Referring once more to the case of biotechnology, recent work confirms the view that new regional path creation in this field is likely to follow different routes, depending on historically evolved RIS structures (Trippl and Tödtling 2007). Regions that already host successful high-technology industries also constitute a favourable environment for the rise of new knowledge-intensive clusters, even if the newly emerging sectors are different from those developed in the past. Prevezer (2001: 18) analysed the emergence of the biotechnology sector in California and showed that the industry in the area 'inherited a great deal from the earlier development of computing'. Several of the prominent preconditions for successfully developing high-technology companies were there, including excellent research organisations, experienced venture capitalists, a pool of highly skilled mobile labour, and good communication networks. Consequently, 'the history of having grown the computing industry in California was relevant to the establishment of biotechnology in the Bay area' (Prevezer 2001: 25). Boston with its transitions from electronics, to computers and software, to biotechnology and where generic elements (research universities, venture capital, networks) have supported this transformation is another prime example for a 'strong high-technology RIS' (Tödtling, 1994). Regions which lack such structures, experiences, and knowledge assets are likely to follow different development paths. The rise and early development of biotech in these areas seems to be less a spontaneous phenomenon and depend much more on the inflow of external knowledge, expertise and market intelligence and a stronger role of policy. In addition, it is inextricably linked to a transformation of the RIS that becomes manifest in the creation of a variety of new organisations, processes of institutional (un)learning and socio-cultural shifts. The evidence provided by Trippl and Tödtling (2007) for three Austrian biotech clusters confirms this view.

Modes of change

How do RIS changes occur and in which areas can we observe major transformations? Table 14.1 provides an overview on different areas of RIS transformation in various subsystems. We distinguish between (1) changes in soft or informal institutions, (2) the creation or disappearance of RIS elements, and (3) the transformation of the network structure. We illustrate the relevance of these areas by providing evidence drawn from our own empirical work on RIS changes in Austria as well as from the literature. It is beyond the scope of this chapter to discuss each area for each subsystem in full detail or to refer to numerous examples. Our aim is to provide a framework and an outlook that might guide future investigations of RIS changes.

The different areas of change are often strongly interrelated. In the academic sector, for example, the rise of a culture of collaboration with industry (change in soft institutions), is a precondition for and is reproduced by the creation of various university-industry links (change in the network dimension). Nevertheless, for analytical purposes it seems to be important to look at these different dimensions separately.

Changes of soft institutions: new strategies, routines and patterns of behaviour

RIS changes can manifest themselves in the emergence of new routines and pattern of behaviour as well as the unlearning of existing ones. Arguably, also formal institutions, that is, laws and regulations (for example, the Bay-Dole act in

Table 14.1 RIS transformation: critical dimensions of change and RIS subsystems

		RIS subsystems		
		Knowledge application system	*Knowledge generation and supporting system*	*Policy system*
AREAS OF CHANGE	New strategies, routines and patterns of behaviour	Focus on new products in traditional fields/ niche markets: metal cluster Styria Diversification strategies: automotive cluster Styria	Emergence of a culture of collaboration with industry and a culture of commercialisation of science within academia ('rise of academic entrepreneurship'): Austrian biotech clusters	Reoriented focus and new approaches: rise of innovation policies, cluster approaches, promotion of networks (or in more general terms: new modes of state engagement): Styria, Vienna, Upper Austria, Tyrol, national initiatives promoting the establishment of competence centres in Austria New policy measures: competition-based policy/picking the winner approach: BioRegio (Germany), innovation policy in Vienna
	New RIS elements	Emergence of new industries / clusters: biotech in Austrian regions Arrival of firms from outside the RIS (as source of new knowledge): automotive clusters Detroit, Ontario; software industry Ireland; automotive cluster Styria; biotech cluster Vienna Inflow of highly-skilled individuals with specialised competences from outside the region: biotech cluster Vienna (inflow of experts with managerial competence)	New research organisations and educational bodies: biotech cluster Vienna; automotive cluster Styria; ICT Saarland New science parks: Software park Hagenberg Upper Austria Implantation of spin-off centres, technology transfer centres, etc: biotech clusters in Austria, Styria (various industries), Upper Austria (various industries)	New funding agencies: Austria regions, particularly Upper Austria, Styria, Tyrol, Vienna New managing units: e.g. cluster management agencies: Styria, Upper Austria

(continued)

Table 14.1 RIS transformation: critical dimensions of change and RIS subsystems *(continued)*

		RIS subsystems		
		Knowledge application system	*Knowledge generation and supporting system*	*Policy system*
AREAS OF CHANGE	New networks and reorganisation of existing networks	Renewal of business networks: from hierarchical interfirm networks to interactive innovation-oriented ones: metal cluster Styria Emergence of new networks: automotive cluster Styria, metal cluster Styria Extra-regional networks: old industrial areas (many examples)	Emergence of various forms of university-industry partnerships such as competence centres jointly run by companies and universities (long-term institutionalised forms of knowledge exchange): various examples in Austria	Breaking-up old policy networks: Styria New modes of governance (multi-actor-governance, interactive governance involving main regional stakeholders): Styria, Tyrol, Upper Austria

the US, environment protection laws, and so on) can trigger RIS changes altering incentive structures and legal framework conditions for innovation activities. Nevertheless, in the following, our focus is on soft institutions.

Behavioural routines of organisations tend to be stable in the short run. Processes of search and learning, however, can lead to changes of such routines, enabling organisations to adapt to new framework conditions or even strategically manipulate their environment (Essletzbichler and Rigby 2007). Looking at firms (that is, the knowledge application system), there is plenty of evidence on the importance of new strategies, routines and pattern of behaviour. The case of large companies in the Styrian metal cluster is telling in this regard. After their privatisation, they developed new patterns of behaviour. By re-shifting their focus from mass products to innovative specialities and by developing niche markets, these companies played a key role in the renewal of the old cluster. The adoption of new competitive strategies, thus, was an important element for the transformation of the RIS. Furthermore, the diversification strategies followed by some of these firms were crucial for the growth of a new cluster in the region, that is, the automotive cluster (Tödtling and Trippl 2004; Trippl and Otto 2009).

Changes of incentives and routines are also observable in the academic sector. The emergence of a new culture of academic entrepreneurship and commercialisation of science in many parts of the world is a well-known phenomenon. The rise and growth of the biotech industry in Austria can only be fully understood if previous major changes in the academic sector are taken into consideration (Trippl and Tödtling, 2008b). The emergence of new attitudes and pattern of behaviour regarding the commercialisation of scientific findings, and the gradual rise of a culture of academic entrepreneurship and collaboration with business have essentially propelled the evolution of Austrian biotech clusters (Trippl and Tödtling 2007). Consequently, the opening of the 'ivory tower' and the move of Austrian universities towards the market place figures prominently in the development of biotechnology.

The emergence and role of new innovation policy strategies and routines are widely documented and discussed in the literature. Referring once again to the case of Styria we have seen a withdrawal of the state as an owner of the large companies and as provider of industrial subsidies, and its re-emergence as promoter of research-industry interfaces, thus facilitating networking and collective learning activities (Tödtling and Trippl 2004). As in many other countries and regions, in Styria, for example, a major shift from a firm-centred approach to a system-centred one (promotion of clusters and networks) has occurred. This is often accompanied by moving beyond direct intervention towards indirect facilitation, reflecting a new mode of state engagement and a new role of public actors (Cooke and Morgan 1998). In Vienna, essential changes of the RIS were brought about by a shift from traditional regional policies towards innovation-oriented ones. Moreover, new policy instruments such as the introduction of competition-based policies favouring a 'picking the winner approach' (see the case of BioRegio in Germany) can imply essential RIS changes.

Changes in RIS elements

RIS elements are defined here as individuals, organisations or more complex units such as industries or clusters. In the following, we concentrate on the role of individuals and organisations. Changes at the level of industries and clusters have already been discussed in the previous sections.

As noted earlier, analyses of RIS transformation should provide room for agency as asserted by key individual agents and organisations. Individual agents can play a critical role in all three RIS subsystems, namely, in the knowledge application system (entrepreneurs, venture capitalists), policy system (charismatic policy agents) and the knowledge generation and diffusion system. Individuals from the academic sector can be an essential engine of change. One of Germany's first star scientists in the field of computer science, for instance, has played a key role in the rise of the ICT cluster in the old industrial area of Saarland (Trippl and Otto 2009). The work done by Zucker and her colleagues (Zucker *et al*. 1998, 2002; Zucker and Darby 2006) suggests that direct involvement of top researchers in the commercialisation of science was an important factor for the development of biotech in specific places in the United States. Focusing on highly cited scientists Trippl (2011a) has shown that the attraction of elite researchers is often highly beneficial for the receiving regions. The stars tend to keep close connections to their sending regions, thus providing access to distant knowledge pools for the receiving region and they engage in regional knowledge transfer and diffusion activities.

The emergence of new firms, research and supporting organisations and new governance agencies can trigger the transformation of regional economies. The latter may include the establishment of new funding agencies and cluster management units as it has been observed in many places around the world. In the following we concentrate on changes in the knowledge application (firms) and knowledge generating and diffusion systems. The foundation of new firms or the attraction of companies from outside the region adds new elements to the RIS. Such processes tend to occur on a regular basis but sometimes they can set in motion major changes leading to a transformation of the RIS. Looking again at the case of biotechnology confirms this view. Our own work on the Viennese biotech cluster (Trippl and Tödtling 2007) has shown that the establishment of Intercell, one of the first successful academic spin-offs in Austria, was critical for cluster evolution, as it served as a role model for other spin-offs, thus, encouraging and stimulating entrepreneurial activity and cluster growth. The arrival of foreign companies can also play an essential role, provided that they possess specific technological or other competences and share them with local actors. Such processes proved to be critical for the growth of the Styrian automotive cluster (Tödtling and Trippl 2004; Trippl and Otto 2009). Arguably, not only the emergence of new, but also the disappearance of established, RIS organisations can have far-reaching effects on regional change (see the case of Wales, Cooke 2004) where the withdrawal of foreign firms had rather negative consequences for the region).

RIS changes can also take place by establishing new organisations in the region's knowledge generation and diffusion system. Establishing new research organisations, educational bodies, science parks or spin-off centres is a well-documented phenomenon in the literature. Our empirical work on three biotechnology clusters in Austria (Trippl and Tödtling, 2007) has shown that new path creation in the regions of Vienna, Styria and Tyrol has been accompanied and facilitated by a reconstruction of their RISs brought about by establishing academic spin-off centres and new research institutes.

Changes of networks

Another important dimension of RIS transformation concerns the region's relational fabric. Changes in the network structure involve the breakup or reconfiguration of existing relations as well as the creation of new ones.

RIS changes can manifest themselves in the creation of networks between hitherto unrelated actors. The case of the Viennese food sector represents an interesting example in this regard. Over the last few years, Viennese food companies have faced the challenge to adopt innovation-oriented restructuring strategies to cope with increased competition from foreign producers. Switching to an innovation-based path, the food firms present in Vienna established links to actors with whom they have never previously collaborated, namely the universities located in the region. By so doing, they gained access to new science-based knowledge which underpins their innovation activities particularly when combined with experienced-based knowledge available in-house or acquired from value-chain partners (Trippl 2011b). The establishment of new networks among firms proved to be an essential factor for the recovery of the metal cluster in the old industrial region of Styria. For a very long time, fierce rivalry among the large companies in this cluster resulted in the absence of market relations and knowledge links. It was only in recent years, partly promoted by policy actors, that these actors started to collaborate intensively, transforming the cluster into a more networked system. Similar evidence is available for the automotive cluster in Styria (Tödtling and Trippl 2004; Trippl and Otto 2009), pointing to the gradual emergence of a culture of cooperation in the region.

Not only the establishment of new networks but also the reconstruction of existing ties can drive processes of regional change. The renewal of business networks by the substitution of hierarchical interfirm linkages with innovation-oriented interactions is often crucial in this regard. Finally, changes in the relational dimension also matter in the policy system. This is well documented for old industrial areas. Ties between the state, firms, and trade unions were often too strong, preserving existing structures and institutions. Evidence suggests that dismantling these petrified policy networks was one key factor, amongst others, triggering the renewal of these areas (see the cases of Styria in Austria and the Saarland and the Ruhr area in Germany as described by Grabher 1993, and Trippl and Otto 2009). Furthermore, RIS changes can manifest themselves in the formation of new policy networks in the context of new modes of governance such as multi-actor-settings involving main regional stakeholders in the formulation and implementation of policies. In Austria there is plenty of evidence on the rise of such constellations in traditional industrial regions like Styria and Upper Austria (Tödtling and Trippl 2004) as well as in metropolitan and peripheral areas (Trippl and Tödtling 2007).

Our discussion on changes in the relational assets of regions was centred on the transformation of existing, and the creation of new ties between regional actors. This does not mean that extra-regional networks do not play a role in the transformation of RISs. On the contrary, there are strong reasons to assume that the most important knowledge sources can be found abroad (Maskell and Malmberg 2007). The importance of inter-regional and international innovation networks and the capacity of RISs to get access to and absorb knowledge from extra-regional sources in order to avoid 'entropic death' and parochial lock-in are widely acknowledged in the literature (Camagni 1991; Oinas and Malecki 2002)

Summary and outlook

Existing RIS approaches so far have been able to highlight the role of key actors and organisations from science, business and policy, and their interactions, as well as the role of hard and soft institutions for innovation processes. Due to their static nature, however, these approaches fail to address the transformation of RISs in an appropriate way. In this chapter we have provided a conceptual frame for understanding transformation processes of RISs by looking at the direction of changes, key actors and areas of change.

We argued that RIS changes often take place within existing sectors or clusters in the form of path renewal. This may imply severe changes of products, processes and organisations, for example, through the application of new technologies in existing industries. However, it does not transform the RIS in a broader way. A second route is related to industrial diversification, that is, the formation of a new regional path in established sectors. This can occur, for example, through the attraction of direct investment in industries new for the region, and respective supply chain development. This might lead to a new cluster in the region and include changes in the knowledge bases and technologies. Finally, path creation in new knowledge-based industries implies a more radical change in the RIS both from a structural and a technology perspective.

RIS changes are driven by key actors from business, science or policy, sometimes as planned rational actions based on exploration and foresight, or more spontaneously in response to crisis situations. Although there is room for agency, the direction and kind of change is shaped by existing structures and contexts such as the prevailing form of capitalist system (liberal versus coordinated market economies) and RIS characteristics. This implies that in particular regional settings we might find quite different outcomes, as a result of combined actions by firms, universities, and policy agencies which are embedded in the contexts of a particular form of capitalism and RIS type.

Regarding the areas of RIS transformation, we have identified the change of 'soft' institutions (change of routines and attitudes), the change of RIS elements (the closure or setting up of research organisations and firms), as well as changes of knowledge relations and networks within the region and beyond. Most visible is usually the setting up of new organisations such as a university or research park. Such measures, however, are often not able to transform a RIS more fundamentally if they are not accompanied by institutional change (new behavioural attitudes and routines) and the creation of networks within the region and beyond. This implies that new elements should offer possibilities for relating to existing structures and for knowledge interactions in the regional economy. A vertical cluster approach might enhance innovation and competitiveness in particular industries, but it seems to be too narrow to enhance the transformative capacity of the overall RIS since it ignores the potential interrelations between clusters and industrial paths. A broader horizontal and related variety based view provides more opportunities in this regard (Frenken *et al*. 2007; Boschma and Frenken 2009; Cooke *et al*. 2010).

In this chapter, we have dealt with the directions, the actors and modes of RIS transformation. Little has been said, however, about the transformative capacity of such systems. Why are some regions and their innovation systems more able than others to promote path renewal, formation and creation, that is, to renew and change their industrial structures? Recent insights provided by scholars working in the field of EEG form a valuable basis for thinking about the transformative capacity of RISs (see for example, Boschma and Martin 2010). A key concept in this context is that of variety (diversity) in economic structures, institutions and knowledge bases. According to this view, the transformative capacity of a RIS is positively affected by the degree of sectoral variety (diversity). Furthermore, it is argued that the broader and more diverse the knowledge bases, the larger the scope for innovation. These insights underline the importance of variety in the knowledge available for innovation as a determinant for the transformative capacity of RISs. Frenken *et al*. (2007) have proposed a refinement of this idea, arguing that certain types of variety are more conducive to regional growth and innovation than others. They distinguish between related and unrelated variety. Although unrelated variety (emergence of a new sector which is not related to those already existing in an area) might protect the region better against asymmetric shocks in demand, related variety may be more beneficial, because in this case the rise of the new industry builds on competences present in an area, allowing for complementarities to existing industries and knowledge bases. This implies that the long-term development of regions depends on their ability to diversify into new applications and new sectors while building on their current knowledge base and competences. Connections to knowledge sources located outside the RIS are acknowledged to be particularly important to ensure variety and new innovation impulses (see, for instance, Maskell and Malmberg 2007; Martin and Simmie 2008).

Finally, it is important to note that the focus of our chapter was more on successful examples of RIS transformations. Arguably, there are many regions, particularly lagging ones, which have shown little capacity to change their innovation systems and upgrade the economic structure. As argued by Martin and Simmie (2008), legacies of old industrial structures, an outdated skill base, restrictive business cultures, and so on, are key factors which limit the scope for enhancing existing paths and the potential for creating new ones in these areas. There are still considerable knowledge gaps and open questions regarding the transformative capacity of RIS such as the following:

- Which types of knowledge variety enhance the transformative capacity of a RIS?
- Why are specific paths selected and not others? What is the relative importance of chance, first-mover advantages and strategic decisions in this regard?
- Do RIS transformations differ, depending on whether they are triggered, (a) by externally generated crises, or (b) by endogenous processes?
- To what extent are RIS changes based on (a) a top-down and anticipatory transformation, or (b) bottom-up and endogenous processes (for example, a self-organised market-based transformation)?
- How does this relate to the magnitude of change of techno-economic paradigms (minor or major)?
- In which ways are changes in different dimensions in RIS subsystems related to each other?

Exploring these issues would enhance one’s understanding of how RISs transform themselves over time and would shed further light on critical factors and conditions for their change.

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15 Path dependence and the state

The politics of novelty in old industrial regions

Kevin Morgan

Introduction

The history of capitalism is the history of uneven development, a dynamic process of ‘catching up, forging ahead and falling behind’ that enthrals or appals, depending on whether we focus on the benefits of success or the costs of failure (Abramovitz 1986). The history of capitalism is also a process of *continuity-in-change*. Despite the post-modern obsession with flux and fluidity, the geographical landscape of capitalism exhibits some remarkable continuities, like the capital city-regions of the global north, where economic success has been the norm for more than a century, thanks to a powerful set of agglomerative forces. And yet the changes are just as dramatic as the continuities, especially at the international level, where the emergence of the BRIC economies is the most compelling example today.

The advent of evolutionary economic geography (EEG) promises to shed new light on the process and mechanisms of uneven development because it specifically seeks to explain the dynamics of the economic landscape, the continuities and the changes that co-evolve in space and time, a process that illustrates both ‘the grip of history’ and ‘the scope for novelty’ (Castaldi and Dosi 2004).

EEG draws its inspiration from two closely aligned theoretical perspectives, the first of which is evolutionary economics, which avers that theories of economic evolution must meet three key criteria: (i) they must be *dynamical*, which means that change rather than equilibrium is the overriding object of analysis; (ii) they must accept that economic evolution is an *irreversible* and path-dependent process in which the legacies of the past condition the present and the future; and (iii) they must account for the emergence of *novelty*, the creative capacity of economic agents that drives innovation, evolution and variety in capitalist economies (Boschma and Martin 2010; Witt 2003). The second inspiration is the complexity perspective in economics, which eschews the concept of equilibrium and instead views the economy as an evolving complex system in which there is continual adaptation, where niches are continually created by new markets, new technologies and new institutions and where the very act of filling a niche creates the conditions for new niches, resulting in ‘ongoing, perpetual novelty’ (Arthur *et al*. 1997).

Because these perspectives are largely aspatial in outlook, EEG is primarily concerned with:

> the spatialities of economic novelty (innovations, new firms, new networks), with how the spatial structures of the economy emerge from the micro-behaviours of economic agents (individuals, firms, organisations); with how, in the absence of central coordination or direction, the economic landscape exhibits self-organisation; and with how the processes of path creation and path dependence interact to shape geographies of economic development and transformation, and why and how such processes may themselves be place dependent.
>
> (Boschma and Martin 2010b: 7)

Although this focus can be criticised for being too focused on the micro-economic realm, paying too little attention to the macro-economic realm of the state, for example, some evolutionary economic geographers are aware of the problem, admitting that what is missing from their work in progress is ‘a systematic view on the state that is well grounded in evolutionary thinking’ (Boschma and Martin 2010: 23).

As we can see, path dependence is a key concept in EEG, though it is not exclusive to this branch of economic geography; indeed, the central idea of a historically structured and self-reinforcing trajectory of development can be traced back to the seminal work of Myrdal and Hirschman in the 1950s, which highlighted cumulative causation as the key self-reinforcement mechanism (Myrdal 1957; Hirschman 1958). Although path dependence has become a ubiquitous metaphor in the social sciences, its fuzziness is such that it is often used to make the rather banal point that ‘history matters’. However, the advent of EEG has helped to clarify and enrich the concept of path dependence, especially through the pioneering work of Martin and Sunley, who have rendered it more robust in three particular ways: by rescuing it from its equilibrium associations in technology studies and placing it on a more secure evolutionary footing; by clarifying its spatial implications, especially the extent to which path dependence is a place-dependent process; and by affording more scope for deliberative social action in the breaking of old and the making of new paths of development (Martin and Sunley 2006; 2010).

The extent to which path dependence is a place-dependent process is particularly germane to the concerns of this chapter, the central theme of which is the role of the state in meeting the challenge of innovation in old industrial regions. Compared to advanced technology regions, old industrial regions are almost, by definition, less capable of generating novelty (which is used here as a shorthand for innovation in the broadest sense of the term). While the former regions are better equipped to engage in *exploration*, which generates novelty, the latter tend to be more engaged in *exploitation,* which involves refining existing knowledge (March 1991). One of the central arguments of this chapter is that the generation of novelty in old industrial regions is more dependent on state-inspired or state-supported action than it is in advanced technology regions, where the evolutionary processes of search and selection are led by knowledge-intensive firms acting alone or in concert with other like-minded firms. Although EEG might be more inclined to study innovative regions, since it is primarily concerned with ‘the spatialities of economic novelty', some excellent evolutionary studies have emerged of old industrial regions, where the central theme has been the role of regional lock-in. In his analysis of the Ruhr steel complex, for example, Grabher identified three different levels of lock-in: (i) *functional lock-in*, where close inter-firm relationships can make suppliers so over-dependent on their customers that they lose the capacity to monitor markets and technology; (ii) *cognitive lock-in*, which is akin to group-think inasmuch as it promotes common world views and lacks the diversity which is associated with debate and constructive challenge; and (iii) *political lock-in*, which is the combined effect of all the institutional actors, particularly governments, trade unions and incumbent enterprises, that seek to defend the status quo (Grabher 1993).

When these three phenomena co-evolve in the same region, then we have a place-dependent form of path dependence that constitutes a more systemic form of regional lock-in (Martin and Sunley 2006). But this is not a purely regional phenomenon because, while a regional lock-in refers to a set of inter-related lock-ins that manifest themselves at the regional level, it is also 'influenced and affected by both intra-regional and extra-regional factors' (Hassink 2010c: 452). Where regional lock-in exists in old industrial regions, it is generally thought that the state must take the initiative for *unlocking* the process, either by orchestrating the restructuring of traditional industries or by attracting new enterprise into the region through regional policy. Although the state's spatial role is invariably reduced to this formal regional policy role, the state actually shapes the structure of the space economy in multiple ways – by what it does *and* by what it chooses not to do.

This chapter offers an empirical examination of these multiple roles by exploring the history of regional economic development in Wales, the birthplace of regional policy and the nearest thing to a 'nationalised region' that the UK ever produced because of its heavy dependence on state-owned enterprises and the public sector. The chapter takes three developmental vignettes, each of which raises key issues about the nature of path dependence and path creation. Each vignette also illustrates a different role of the state, namely: (i) the state as *producer* in the case of the coal industry; (ii) the state as *animateur* in the case of technology-based incubators; and (iii) the state as *purchaser* in the case of positive procurement policy. These vignettes are used to illustrate two wider points. First, that evolutionary geographers need to incorporate the state into the centre of their analysis because, far from being one institution among others, it is the pre-eminent institution at the macro-level which fashions the 'rules of the game' under which all other institutions, including the firm, have to operate (Gertler 2010). Second, that evolutionary geography needs to bolster its engaging theoretical propositions with a more robust empirical evidence base because, at this point in its history, the former has evolved much faster than the latter.

The path not taken: locking in the National Coal Board

Of all the industries one associates with social and economic decline in the global north, none springs to mind as readily as the coal industry. For more than half a century the coal industry has seen its share of the energy market challenged by the growth of cleaner and cheaper fuels, though its relative decline in OECD countries has been more than offset by growth in China, which now accounts for nearly half of world coal consumption (IEA 2011). In addition to rival fuels, the coal industry has fallen foul of ecological forces because conventional coal production is a major source of greenhouse gas emissions, so much so that one prominent climate scientist has characterised coal-fired power plants as ‘factories of death’ (Hansen 2009).

For all these reasons, one might suppose that the coal industry was doomed to decline, leaving coalfield communities few options other than unemployment or migration. But if we take the British coal industry as an example, it is clear that there were other options at certain points in its historical evolution when alternative paths were possible and it is worth asking why these paths were not taken. Alternative paths were identified by miners and managers long before the actual demise of the industry, so this criticism in no way depends on the wisdom of hindsight. To appreciate the context, let us briefly examine the historical record of the state-owned coal industry, a history that formally began on 1 January 1947 (‘vesting day’) when the National Coal Board (NCB), a newly created public corporation, assumed responsibility for some 980 collieries from over 800 separate companies.

The nationalisation of the coal industry was deemed to be one of the essential tasks of post-war reconstruction for political and economic reasons. Politically, the miners were the strongest union in the country and anything less than full nationalisation would have triggered industrial strife and jeopardised the reconstruction effort. Economically, the UK was hugely beholden to the coal industry because, at that time, it was still largely a one-fuel economy and coal was synonymous with power. Although the private companies had resisted nationalisation, preferring compulsory amalgamations under regulated private management, they were overruled because the scale of public investment that was required to modernise the industry was so great, and the social and technical state of the industry so poor, that nationalisation was the only feasible political option.

One of the great paradoxes of nationalisation was that, while it signalled a significant political victory for the miners, who had fought for it since the first parliamentary bill was introduced in 1893, they became progressively more alienated from the NCB as an industrial employer. Far from being a showcase for industrial democracy and public ownership, as the miners had originally hoped, the NCB evolved into an ever more remote and bureaucratic organisation in which area managers as well as union officials were excluded from a decision-making process that was highly centralised in London (Cole 1949; Coates and Topham 1968).

Centralised authority was part and parcel of the ‘efficiency concept’ of nationalisation that won the debate in the Labour Party against more devolved and democratic models of public ownership, a concept that informed a host of other public corporations in sectors as diverse as broadcasting, energy and transport (Barry 1965). But it would be wrong to suppose that centralisation was a structure and strategy foisted on the miners by the bureaucratic NCB. In organisational terms, the nationalised coal industry was structured into four levels – collieries, areas, divisions and the overarching national level, where all the key decisions were made by the NCB Board (in conjunction with its political masters in the Ministry of Fuel and Power). As a matter of fact, many socialists in the National Union of Mineworkers (NUM) and the Labour Party actually approved of a measure of centralisation because they feared that regional devolution would fragment national bargaining power and undermine the viability of the peripheral coalfields in Scotland, Wales and North East England, where the costs of production were much higher than in the central coalfields of Yorkshire and the East Midlands, which were blessed with a more benign geology. Regional cost differentials mattered little while the UK was largely a one-fuel economy, when it was a case of 'coal at any price', but these uneven operating conditions assumed a terrible significance after 1957, when fierce price competition from oil shifted the whole emphasis of NCB strategy to the twin goals of lowering costs and concentrating as much output as possible in the most productive divisions of Yorkshire and the East Midlands (Schumacher 1969).

South Wales was the most vulnerable coalfield in the cost-conscious era after 1957 because of its above-average production costs, one of the defining features of this coalfield ever since it was developed on a large scale in the second half of the nineteenth century. From the histories of the South Wales coalfield, one gets a strong sense of environmental determinism because many of the distinctive features of the industry – in particular its record on productivity, output, innovation, wages, accidents, strikes, industrial relations – are invariably attributed to, or conditioned by, its peculiar and capricious geological conditions. The special qualities of South Wales coal, especially its steam and anthracite varieties, neither of which was widely available in the UK, helped to offset the disadvantages of being a high cost producer because the region could command premium prices for its high quality products.

Socially, the most distinctive feature of the South Wales coalfield was the fact that, under private ownership, it had the worst industrial relations record of any coalfield in the UK, a record that is attributed to a unique combination of factors, including its capricious geology (which made costs difficult to control), an export market bias (which exposed the industry to international trade fluctuations), a peculiar cost profile (in which labour costs accounted for some 70 per cent of total production costs) and a coalowner culture that was obsessed with a narrow and short term economic calculus. Whereas coalowners in the English Midlands assumed a paternalistic attitude to their employees, the Coalowners Association in South Wales was unusual in being overwhelmingly concerned with matters of industrial relations:

> There was fierce resistance to wage claims, safety legislation, reduction in hours, union organisation – anything that was likely to add to the labour cost whether at a general level or at the level of the individual colliery. The resultant antagonism between owners and men was not the product of the personal characteristics on either side – though these could exacerbate any particular

> situation: it was embedded in the economic realities which made labour-cost the most important consideration for everybody and thus continually underlined the inherent conflict of interest between owners and miners.
>
> (Williams 1995: 112)

If the militant reputation of the South Wales miners was originally a response to the militancy of local coalowners, a tradition of union militancy was reproduced in the region after nationalisation because the struggle with private owners was superseded by a struggle with the public managers of the NCB. Another distinctive social feature of the regional coalfield was the political talent that it spawned over a long period of time, from the likes of Noah Ablett, one of the authors of the *The Miners' Next Step* in 1912, the most articulate case for syndicalism ever produced in the coal industry, to Arthur Horner and Will Paynter, the successive leaders of the National Union of Mineworkers from 1946 to 1968. These organic intellectuals of the NUM were among the first to identify the strategic shortcomings of the nationalised coal industry and they sought to transform the NCB into a more innovative and democratic public corporation, a strategy that failed miserably because successive governments remained wedded to the 'efficiency concept' of nationalisation, which rendered the public sector a servant of, rather than a pacesetter for, the private sector.

With the advent of fierce competition from oil after 1957, the NCB embarked on a massive programme of colliery closures in the high cost coalfields of Scotland, Wales and the North East of England, triggering high unemployment in the poorest regions of the UK. The colliery closure programme highlighted two major shortcomings of the NCB as a public corporation: (i) the fact that its *pricing policy* was controlled by the state and consequently it was not allowed to become a financially viable corporation and (ii) the fact that it never sought to use its *powers to diversify* into the cognate engineering sector. These shortcomings need to be better understood because they made it impossible for the NCB to pursue paths other than terminal decline and this constitutes one of the most dramatic examples of *political* lock-in the post-war history of the British economy.

Had the NCB been a private firm it would certainly have charged higher prices for its product in the first post-war decade, when the economy was largely a one-fuel economy, when coal was in short supply and when the market would have borne the increased prices. That this was not done is wholly due to the fact that the Labour government, through a series of 'Gentlemen's Agreements' with the NCB, decided to keep coal prices as low as possible to contain inflation at home and to support private sector exports abroad. The NCB was even compelled to finance the losses, totalling over £70 million, on imported coal in the 1950s, losses that were incurred to meet the nation's emergency fuel requirements. Although there was no statutory limitation on it making a profit, the NCB was rarely allowed to do so because of its national service obligations. In the 1960s, when the market for coal was clearly crumbling, the NCB was told to charge commercial prices for its product, an injunction that came ten years too late. In other words, 'when the Board had the possibility to raise prices it was in effect forbidden to do so and when it was allowed to (after the new directives of 1961) it was unable to do so because it had lost its monopoly position in the growing competition from other fuels' (Barratt-Brown 1969: 124).

The second shortcoming was even more important in shaping the evolution of the NCB because it condemned the corporation to the ultimately fatal path of commodity coal production. There was nothing in the Coal Industry Nationalisation Act of 1946 to prevent the NCB from doing what any private firm would have done in the face of a declining market, which is *to search for and diversify into new product markets*. This is all the more remarkable when one considers two other factors, namely the prodigious engineering expertise within the NCB and the fact that it was spending over £250 million a year in the 1960s buying expensive mining machinery and equipment. Looking back on its plight through the lens of user-driven innovation, the NCB was clearly conducting a lot of the hard work of innovation – as regards research, design and development for example – for which it received little credit, still less any commercial reward. In actual fact the evidence suggests that this was yet another hidden subsidy to its private sector suppliers because it was frequently observed that 'a new technique is developed in a colliery or workshop and then given to a private firm to produce' (Barratt-Brown 1969: 127).

The subordination of public sector corporations to the needs of the private sector was the very essence of the 'national service' conception of nationalisation and there was no better illustration of this unequal relationship than the NCB. What the miners' union found most galling was the fact that NCB purchasing managers, far from objecting to this unequal relationship, actually stood to benefit from it in a personal capacity because they had built up substantial holdings of shares in the private sector suppliers from whom they were procuring mining equipment (NUM 1974).

These systemic shortcomings – with respect to pricing and diversification – totally emasculated the NCB, locking it in to a narrow path of commodity coal production, a path that led to its terminal decline as a public corporation and a major employer in some of the poorest regions of the UK. Conventional histories of the coal industry continue to tell a familiar story about the inevitable decline of an 'old industry'. But what I have tried to suggest here is that, while the market for coal in the UK was in terminal decline, it was not inevitable that the NCB had to decline with it. The NCB could have diversified into high-value-added engineering sectors, embracing production as well as research, design and development, and some of these facilities could have been located in the peripheral coalfields, where collieries were being closed. The NUM consistently advocated sectoral diversification along these lines after 1957, but the NCB showed no inclination to do so.

There are many reasons why diversification was a path not taken, but perhaps the most important was the very nature of the NCB as a public corporation. The political conception of nationalisation developed by the post-war Labour government was one in which public corporations were to be managed as de facto arms of the state; they were therefore obliged to put 'national service' obligations before their own financial viability and discouraged from pursuing any course of action that departed from this unwritten convention. The failures of the NCB – particularly its failure to diversify into mining machinery for example, a sector that was growing worldwide and in which it had enormous technical expertise – become less of a mystery when set in the political context in which the corporation was forced to operate. Although the NCB disappeared with the industry in which it was born, sold off as part of the Thatcher government's privatisation spree, we should never forget that its demise was neither inevitable nor pre-ordained and critical histories of the period should do more to acknowledge these possibilities because the actual path was not the only path, other worlds were possible in other words.

From an evolutionary standpoint, the story of the path not taken by the NCB illustrates the three dimensions of regional lock-in that we identified earlier. The influence of *functional lock-in* can be seen in the incestuous buyer–supplier relations that tethered the NCB to its engineering suppliers, only in this case it was the public sector buyer that suffered from the relationship rather than the private sector suppliers, many of whom evolved into very successful engineering companies. Colliery companies like Powell Duffryn were able to cash their annuities from nationalisation and establish themselves in new and more profitable product markets. Indeed, Powell Duffryn, which had one of the worst industrial relations records when it was a private coal company in the Valleys, even managed to establish itself in the top 50 companies in the country and one of the sectors that fuelled its growth was mining machinery (Barratt-Brown 1969). *Cognitive lock-in* was also apparent in the group-think that enveloped senior NCB managers, who believed that the decline of coal in the UK was cyclical rather than structural. Senior management also uncritically accepted the belief that the division of labour between the NCB and its suppliers was a 'natural' state of affairs, which rendered it unnecessary for them to act as public entrepreneurs who might have deployed their statutory powers of diversification and their internal technical expertise to search out and select new product markets in the way that Powell Duffryn did to great effect. Finally, there was *political lock-in*. But in contrast to the conventional interpretation of political lock-in, where the incumbent institutions are presumed to be lobbying to maintain the status quo, the NCB case presents a radically different inflexion because here the miners' union was the main agent searching for more innovative solutions, including diversification into different but related product markets, a practical example of related variety before the concept was established. Of all the forces making for political lock-in, however, none was as important as the influence of the central state, which exerted de facto control over the NCB's pricing policy and managed public corporations as tools to service the needs of the private sector. Public sector corporations could have played a much more dynamic role in the old industrial regions of the UK, but they were never allowed to do so. In the case of the NCB, it was condemned to a commodity production path which ended in terminal decline because of a combination of decisions and non-decisions on the part of the central state.

Betting on Technium: the perils of state-led path creation

The rapid decline of the coal and steel industries in Wales fuelled the political campaign for a more robust regional policy and this eventually led to the creation of the Welsh Development Agency (WDA) in 1976. Faced with burgeoning unemployment, industrial dereliction and a weak indigenous business community, the WDA spent the next twenty years remediating polluted land, building advance factories and attracting inward investment, particularly from the UK, the US and Japan. However, the limits of a strategy predicated on low unit labour costs became increasingly evident, especially when lower labour cost zones emerged in and beyond eastern Europe in the 1990s (Cooke and Morgan 1998).

To respond to these new challenges, the WDA embraced the regional innovation agenda that was beginning to emerge in a number of less favoured regions of the EU, where it was being trialled by the European Commission as part of a new generation of regional policy called the Regional Technology Plan (Morgan and Nauwelaers 2003). Although there was no single template, the new regional innovation policy agenda enjoined less favoured regions to harness their universities to the cause of regional economic renewal, a more challenging idea than it appeared because, while they were physically co-located, entrepreneurs and academics often inhabited totally different cognitive worlds. This cultural disconnect was most pronounced in less favoured regions, where traditional industries made few demands on local universities and the latter often looked further afield when they sought industrial engagement. Such was the context in which the grand Technium experiment was launched. Let us briefly reconstruct the convoluted history of Technium before we critically examine its fate.

The basic rationale for Technium was twofold: (i) to commercialise advanced academic research and (ii) to create high value jobs so as to retain graduates in and around Swansea, the second city of Wales. The idea of an incubator facility to support new technology businesses was first mooted in the Regional Technology Plan (1996), the first regional innovation strategy ever produced in and for Wales. But the concept would not have been realised had it not met the emerging agenda of the property division of the WDA, which was at that time searching for a flagship project to spearhead the physical regeneration of Swansea Docks. This marriage of convenience spawned the concept of the Technium, which was presented to funders as an alliance between the university sector, which was reckoned to have expertise in *intellectual* property, and the WDA, which was responsible for physical property and business support services. Having secured the backing of the newly created Welsh Assembly Government, to which the WDA was formally accountable, the concept was eventually funded for a two-year period through a £1 million grant under the ERDF programme (DTZ 2009).

The original Technium was opened in Swansea in 2001 in a brand new 21,000 sq ft building, the flagship development in what is now known as SA1 Swansea Waterfront. The aims of the Swansea Technium were: to create a business innovation centre; to support the growth of new and existing knowledge-driven SMEs; to create a one-stop shop for mobile R&D investment projects in the region. As regards what client firms could expect from a Technium location, the chief benefits were threefold: the provision of dedicated office space and state-of-the art facilities; onsite access to specialist business support and access to academic research centres; and networking opportunities with leading national and international companies and academics. After two years of operation, an evaluation of the Swansea Technium found that it had been successful because, on average, the fourteen Technium client firms had seen the following: commercial turnover increased by 39 per cent; staff levels increased by 306 per cent, of which 75 per cent were graduates; and 72 per cent of staff were focused on R&D.

Perhaps the most extraordinary aspect of the Technium experiment was the political decision to have a national roll-out of Technium centres *before* the Swansea Technium had been evaluated. In other words, a new regional innovation strategy was announced in 2002, half way through the Swansea experiment, and the centrepiece of the strategy was a nation-wide Technium network (WAG 2002). In the following five years another nine Technium centres were created in the grant-aided regions of Wales and the development cost of the whole network was initially estimated to be £93.4 million. Of this total, as much as 89 per cent was funded by the public sector, 40 per cent from EU regional aid, 24 per cent from the Welsh Assembly Government, and 18 per cent from the WDA, with the private sector contributing just 10.7 per cent, underlining the fact that this was a state-led initiative in every conceivable respect.

Only one independent evaluation of the Technium network was ever conducted and, notwithstanding the diplomacy of private sector consultants, its findings were nothing short of damning. Among its key findings were the following:

- *No clear rationale.* The most important finding was the absence of a clear rationale for the nine additional Technium centres. The evaluators, DTZ, were surprised to find that there was no documentary evidence to suggest that robust project appraisal or business planning had been carried out to ascertain the need for a Technium in the areas in which they were built. ‘It appears’, said DTZ, ‘that many of the Techniums assumed that their rationale would be the same as that stated for the original Technium in Swansea and specific local circumstances were not adequately considered’ (DTZ 2009: viii). In too many cases ‘the Technium was seeking to create a market, rather than serve a market’ (DTZ, 2009: 15).
- *Lack of explicit objectives.* Few of the Techniums had explicit objectives and, where they were available, they differed between Techniums. The lack of commonality in the way each Technium was managed, meant that the evaluators were forced to call it a ‘network’ rather than a programme because the latter suggests common aims, objectives and governance structures.
- *Poor monitoring.* The evaluation found that Technium managers were unable to provide detailed data on the Technium clients, either current firms or firms that had graduated from the incubator, and therefore a rigorous evaluation was rendered impossible. Although one of the original objectives was to create jobs to retain graduates in the area, monitoring data only measured the

number of 'jobs created' so there was no way of knowing whether graduate jobs had in fact been created.

- *Occupancy rates.* Occupancy rates across the network averaged 46 per cent at the time of the evaluation, which compared unfavourably with best practice benchmarks of 85 per cent. The evaluators refrained from saying that, in private, WDA staff often referred to the worst performing Technium centres as 'Emptium' and 'Desertium' to convey their low occupancy rates (Evans 2010).
- *Business support.* One of the key claims of the Technium concept was that it offered state-of-the-art business support to new technology start-up firms. The evaluation found that, while some businesses had used these services, the level of take-up was not as high as expected and it was not possible to form a view of the value that business attached to these services when such services were also readily available to non-Technium businesses.
- *Sectoral specialisation.* Many of the Techniums had a strong sectoral focus and this was allegedly designed to reflect the strength of local business clusters or academic expertise. But the evaluation unearthed the truth of the matter, which was that it was due to the funding agency, the Welsh European Funding Office (WEFO), which managed EU regional grants on behalf of the Welsh Assembly Government. It was discovered that 'the rationale for sector specialisation appears to have been a response to a request from WEFO rather than clear evidence that the market required sector specific incubation' (DTZ 2009: 15). This is an extraordinary finding when one considers that nine of the ten Techniums had a sectoral focus, a rationale that reflected the bureaucratic requirements of a funding agency, which wanted to differentiate the incubators to satisfy funding procedures, rather than the economic conditions of the areas in which they were created. A network of ten incubators would not have been financially feasible had EU regional funds not been so readily available and, as these funds had to be spent within a specified timeframe, the hasty and injudicious roll-out of the Technium programme may have been driven by the need to comply with these supra-national regulations.

Given all these shortcomings, it was hardly surprising that the Welsh Assembly Government decided to radically reduce the network in 2010 by closing six of the Techniums, a decade after the concept was conceived. What is surprising, however, is the fact that there was no public inquest into the failure of an experiment that cost around £111 million when all the revenue support is added to the capital cost. In the absence of a public inquest, one of the original architects of the Technium concept, Professor Ken Board of Swansea University, reflected on the experience and attributed the failure to three key factors: (i) poor programme management on the part of the Welsh Assembly Government and the WDA, which were too eager to have a national roll-out of the incubators before the lessons of the first incubator had been absorbed (ii) the absence of a regular flow of start-up companies, which meant that a novel regional innovation experiment degenerated into a traditional property development venture and (iii) the lack of leadership in the university sector, where management was more interested in creating intellectual property than exploiting it, with the result that universities were never fully engaged in the process (Evans 2010).

Remarkably, a similarly forthright analysis had been produced for the Welsh Assembly Government by an independent review of publicly funded commercialisation activities, a review that the government had commissioned but ignored. The independent review, published in 2007, captured the key problem with the Technium programme when it said that, laudable though it was, the key weakness was 'the absence of a continuous pipeline of strong technology-based tenant companies' (Gibson *et al*. 2007: 13). It also exposed the fallacy of property-led innovation policy by saying 'one of the key priorities for any programme of commercialisation is not accommodation but the quality of advice and support given to companies which in this case appears more apparent than real' (ibid.).

How are we to explain the fact that the Welsh Assembly Government was fully informed of the problems of the Technium experiment but failed to act on the information? Two reasons help to explain the mystery. First and foremost, the information contained too many inconvenient truths, so it did not accord with the political ambitions of the politicians in charge of the Technium programme. But a secondary influence was also at work because civil servants, who in theory ought to have mounted a constructive challenge to their ministers, quietly suppressed the review because it challenged some of their basic policy nostrums; in other words, suppression met their own bureaucratic agenda as well as serving the interests of their political masters. For these reasons, then, the review barely registered in the public domain – even though it was the first to publicly expose serious weaknesses in the Technium programme, a programme on which so many regional renewal hopes were pinned.

The lack of constructive challenge to the Welsh Assembly Government was further compounded by the growing centralisation of power in Wales following the decision to abolish the WDA in 2004 and the transfer of its functions to the civil service. Although the 'bonfire of the quangos' was rationalised in the name of democratic accountability, it was really driven by the desire for greater political control over development agencies that had hitherto enjoyed some relative autonomy from the inert and risk-averse compliance culture of government, a culture that extolled process over outcome, control over competence. These political innovations rendered Wales a much more state-centric system in which institutional diversity and intellectual pluralism were significantly reduced, a process that further eviscerated the likelihood of constructive challenge (Morgan and Upton 2005). In such a state-centric system, it is exceedingly difficult to expose problems, because the process of fashioning new development paths – which is what the Technium concept was ostensibly about – is invariably subordinated to the political ambitions of politicians whose horizons and metrics are calibrated to short-term electoral cycles. Instead of addressing the problems to sustain the original purpose of Technium as a novel *intellectual property* experiment, the problems were ignored and the programme was allowed to degenerate into a glorified *industrial property* venture, a regional development model that was more attuned to the traditional skill sets of the government and its development agency.

The Technium controversy helps us to understand the scope for, as well as the barriers to, *state-led* path creation, a phenomenon that tends to be much neglected in evolutionary economic theory because the path creation process is invariably assumed to be a *firm-led* process. The Technium experience sheds new light on one of the big debates in the path dependence literature, namely the extent to which place plays a role in the process. The evidence from this regional experiment corroborates the view that pre-existing paths, far from being irrelevant as some theorists seem to suggest, play a profoundly important role in shaping the prospects, either positively or negatively, for new developmental pathways. In other words, it confirms the idea that there is a strong degree of *path inter-dependence* between successive paths in particular places, not least because the presence or absence of competences, resources and institutional support from the 'old economy' can be harnessed by the agents of the 'new economy' (Martin and Sunley 2010; Garud and Karnøe 2001).

The Technium experience embodies both the positive and the negative aspects of *path inter-dependence*. On the positive side, the first Technium incubator was deemed to be a very successful initiative largely because it evolved organically out of a local environment where the university, the development agency and a small network of technology-based firms had found a common solution for their different problems in the shape of the Swansea Technium centre. Most of the subsequent Technium centres illustrate the negative side of the argument inasmuch as they were over-specialised cluster-based incubators in areas that had little or no pre-exisiting corporate competence in the chosen technologies. On the contrary, the selection process was a political process that enlisted the rhetoric of 'clusters' to create cathedrals in the desert: the main rationale for the locational choice was that all the sites conformed to the map of EU regional aid.

The Technium experiment should not be misconstrued. While it does not mean that state-led path creation is doomed to failure, it does mean that the state, when it seeks to nurture something as complex as a local knowledge ecology, needs to act in association with agents that are better placed to search and select which technologies are best suited for area-based innovation initiatives. As it is, the Technium experiment serves as an expensive reminder of the perils of state-led path creation in old industrial regions, where an experiment in path creation (that is, *intellectual* property) degenerated into an old form of path dependence (that is, *industrial* property), a path that was more attuned to the skills sets of the development agency and the mindsets of regional politicians.

The power of purchase: exploring the path of positive procurement

One of the great paradoxes of British economic policy is that successive governments have shown least interest in a policy which has the most direct influence on innovation and development. The source of this paradox is *public* *procurement policy* – the power of purchase – the medium through which the state purchases goods and services and where it interacts directly with thousands of private sector suppliers. As in other countries, the public procurement market is big business in the UK, a market that was worth more than £230 billion in 2010/11. But in contrast to France, where the state deployed its power of purchase to great effect in such sectors as energy, telecommunications, mass transit and defence for example, the history of public procurement in the UK is essentially a story of untapped potential across a wide array of sectors, from high technology to public sector food provision (Morgan 2008).

Public procurement policy began to attract serious political attention in the UK when the Gershon Review exposed a woefully inadequate state of affairs in the world of public sector purchasing, not least because of a totally anachronistic skill set (Gershon 1999). Although some of these weaknesses have been addressed in the past decade, two parallel worlds of public procurement have also emerged: the high-level rhetorical level, which refers to state-of-the-art procurement policy based on whole life costing methodologies to ensure the sustainability of goods and services, and the prosaic world of public procurement managers who are under constant pressure to cut costs.

The parallel worlds of public procurement are especially pronounced in Wales, where the Welsh Assembly Government was one of the first devolved governments in Europe to consider the use of whole life costing in its public tendering criteria, driven by the fact that it was the first devolved government to have a statutory duty to promote sustainable development in all its activities and policies. Despite these formal commitments, the WAG has been less successful at translating these promising developments into action because it has little direct control over the actual procurement process and because the public sector in Wales is chronically short of skilled procurement managers.

Despite these barriers, a positive procurement path has begun to emerge in Wales thanks to the combined efforts of civil society groups, progressive government ministers and unconventional civil servants. These efforts produced two important breakthroughs in the form of the CAN DO toolkit, which is essentially a professional guide to positive public procurement, and the ARBED programme, a green energy programme that was primarily designed to reduce the energy bills of the poorest households, the first programme in the UK that managed to build social justice into a low carbon transition strategy.

The CAN DO toolkit was in part a reaction to the fact that poor communities were not getting any social or economic benefits from the public contracts that were being let in their areas, a problem that local regeneration experts characterised as the ‘leaky bucket’ syndrome. But the advent of a new investment programme – the Welsh Housing Quality Standard – presented a rare opportunity to deploy the power of purchase on a scale that was unprecedented because it involved the expenditure of some £3 billion to meet the new housing standards set by the Welsh Assembly Government. The WHQS signalled the beginning of a radically new housing-led regeneration strategy for the poorest communities because, in addition to the new investment that was coming on stream, local councils also decided to transfer their social housing stock to local social enterprises. Less bureaucratic than local government departments, these social enterprises were eager to explore new ways of leveraging their housing investment to deliver wider community benefits, especially to enhance local employment prospects for unemployed young people and enable locally based small firms to secure a share of the housing investment programme, neither of which figured in conventional public procurement culture in the UK.

Securing stronger local multiplier effects required a totally different kind of procurement policy, a positive rather than a passive procurement policy. Fashioning a positive procurement policy was one of the core aims of *Inform to Involve* (i2i), a small task force of innovative housing experts that was introduced into government to help to maximise the community benefits of the WHQS programme. Although it was *in* government, the i2i task force was not *of* government, and therefore it was less encumbered by the habits and routines of the civil service; where the latter was invariably inclined to ask ‘why’ in the face of novelty, the natural instinct of the task force was to ask ‘why not’. The real novelty here, according to one member of the i2i team, ‘is having one foot in the Assembly Government and having one foot out’ (Fox *et al*. 2011). Whereas civil servants are largely tied to their desks, servicing their minister, the i2i task force was also out in the field, helping the new social enterprises to design and deliver housing-led regeneration strategies. This is the context in which the CAN DO toolkit emerged.

In essence, the toolkit is a practical guide to help public procurement managers to generate more community benefits from their public contracts. Far from being a simple task, the toolkit had to surmount two significant hurdles. First and foremost, it had to condense a bewildering set of EU rules and regulations to prove that its positive procurement message was fully compliant with these legal requirements, because the fear of acting illegally has been shown to deter public procurement policy innovation (Morgan and Sonnino 2008). The second hurdle was to convince the Welsh government’s own public procurement agency, Value Wales, that the core requirements of the toolkit were viable and effective. The civil servants’ first response was to query the legal veracity of the toolkit because their solicitors had major concerns as to whether it was contrary to EU procurement regulations. According to the i2i task force, the civil servants actually went so far as to commission external legal advice to test the legality of the toolkit, a move that suggested that ‘they wanted to trip us up’ (Fox *et al*. 2011: 35). Although the legal opinion pronounced in favour of the toolkit, the civil servants in the Value Wales agency were never fully won over, with the result that they became reluctant partners at best. But it seems that the main reason for civil service resistance was the sheer novelty of the CAN DO toolkit. A senior civil servant in Value Wales conceded as much when he said ‘there were people who weren’t comfortable with it because we hadn’t done anything like it before’ (Fox *et al*. 2011: 40).

Originally designed to generate community benefits in the social housing sector, the CAN DO toolkit is now being rolled out across the whole public sector and Wales is believed to be the first government in the UK to use community clauses like Targeted Recruitment and Training as a core requirement of contract to recruit the long-term unemployed into the formal economy and equip them with a skill set that is relevant to their local labour market. Though it was modest social innovation, this little victory took an inordinate amount of time and effort, illustrating in microcosm why innovation in the British public sector is such an uphill struggle. But the most important point to make about this positive procurement process is that the CAN DO toolkit would never have emerged had it not been for the unconventional role of the i2i task force, which was in, but not of, government. Its role was akin to a corporate Skunk Works, an officially sanctioned breakout space where a team of innovators is allowed to circumvent the habits and routines of the firm to excavate a novel path (the route through which IBM developed its first PC). Perhaps there is a wider lesson here for public sector strategies that aim to marry innovation with a social purpose. A positive procurement path was opened up for the public sector by harnessing the energy, passion and the knowledge of professionals from civil society and implanting them in a Skunk Works in government on a task and finish basis. Although this provoked deep tensions with the conventional civil service, which is professionally disposed to extol process over outcomes because of its risk-averse compliance culture, the government ministers in charge of housing and regeneration believed this was a price worth paying for a policy innovation that secures more community benefits from public sector contracts.

Designing positive procurement policy is one thing, but successfully delivering it across the whole public sector is another matter. The greatest barriers to a national roll-out in Wales are the lack of positive procurement skills in the public sector (especially whole life costing skills) and the uneven political commitment to procurement among local government leaders (Morgan 2010).

Notwithstanding these limitations, the CAN DO toolkit was used successfully to roll out the ARBED programme, which is widely regarded to be the most ambitious project of its kind in the UK (De Laurentis *et al*. 2011). The main aims of the programme were threefold: to tackle fuel poverty, deliver carbon savings and create local business opportunities (WAG 2011).

ARBED (which means 'save' in Welsh) was designed to address sustainability in the capacious sense of the term by identifying social and economic targets as well as the carbon reduction targets that tend to dominate green transition policies. The programme initially targeted low income households in the Heads of the Valleys region, the first low carbon zone in Wales and the site of the former coal-field communities, which are now among the poorest in the EU. Although it is scheduled to run from 2010–15, a Phase 1 trial ended in March 2011. In Phase 1 around £30m was invested in the energy performance of some 6,000 homes through social housing providers in Wales' Strategic Regeneration Areas (SRAs), the priority areas for area-based regeneration investment. The funding paid for energy efficiency measures and renewable energy/heat technologies in specified homes within the agreed priority areas. The strategic use of this investment enabled the government to coordinate and leverage additional monies into Wales from other organisations, including energy companies, UK government and social housing providers. ARBED aims to integrate this investment with targeted supply-side interventions around employment, skills, enterprises and business support services to help to nurture a renewable energy sector that can outlive a finite programme designed to retrofit the social housing stock in a low carbon fashion (WAG 2010).

The Phase 1 trial made a tangible contribution to these longer-term targets, creating new training places for the long-term unemployed, a process that would not have occurred without the Targeted Recruitment and Training clauses that were required as part of the positive procurement policy developed by the CAN DO toolkit. Overall, the Phase 1 trial generated a number of key lessons as to how all the actors – across public, private and third sectors – can better calibrate their actions in space and time to deliver the social, economic and environmental objectives of the programme (WAG 2011).

Sufficient progress has clearly been made already because ARBED won the British Renewable Energy Award in 2011 for the most innovative regional initiative in the UK. What really distinguishes the ARBED programme, however, is the fact that it is the most ambitious *pro-poor* renewable energy project in the country, which is highly significant because so many so-called sustainability strategies are little more than glorified carbonist strategies. That is to say, they are narrowly focused on reducing carbon footprints, which is just one dimension of the multi-dimensional value set that constitutes sustainable development (Morgan 2012).

The CAN DO toolkit and the ARBED programme highlight the role that a positive procurement policy can play in fashioning a *socially just* transition to a low carbon economy. This is especially pertinent in Wales because, of all the nations and regions of the UK, the Welsh economy is most at risk on account of its above-average share of carbon-emitting industries, such as, iron and steel. One analysis of the coming challenge estimates that some 18,000 jobs are immediately at risk from low carbon regulations, while another 100,000 jobs could be significantly affected, highlighting the need for a 'just transition' to a low carbon economy (Winckler 2009).

The emergence of the CAN DO toolkit also calls into question a tacit assumption in research and policy-making circles, which is that regional governments and their agencies are presumed to want to innovate. But as we have seen, the toolkit would never have emerged had it been left to the conventional civil service, which was locked into conventional procurement, a policy that made very few demands on private sector suppliers and generated little in the way of a lasting legacy for the communities involved. The *positive* procurement path was excavated by a special purpose task force that was in, but not of government: that is to say, while they were clearly 'outsiders', they were also 'insiders' with a license to innovate. Without this novel public policy vehicle, the innovative CAN DO toolkit would never have seen the light of day.

This vignette suggests that the concept of path dependence is just as applicable to the state as it is to firms, industries and regions, the units to which the concept is normally applied. Path dependence in this context refers to the low-cost contracting culture that is deeply ingrained in the British public sector, a culture that has been fashioned by anachronistic skills sets, especially in procurement management skills, and by an obsession with compliance protocols that leads it to extol processes over outcomes. Conventional public procurement policy followed a well-honed path of low cost and low risk contracting, a path that was buttressed by conservative legal interpretations of EU procurement regulations, breaches of which incurred severe financial penalties. In short, the conventional public procurement system exhibited all the lock-ins we encountered earlier: functional lock-in stemmed from the fact that the public sector was inordinately dependent on the low-cost suppliers who satisfied its narrow cost-based metrics, making them mutually dependent on each other; public procurement managers were cognitively locked-in to the low-cost contracting model because they did not have the whole life costing skills to generate more innovative and more sustainable contracting models; and political lock-in pressures arose from the fact that most public sector managers and their political masters were content to reproduce the status quo of low-cost contracting. Clearly, this was not an environment that was conducive to policy innovation because novelty, far from being encouraged, was actually frowned upon.

Although the CAN DO toolkit is a modest public policy innovation, the fact that it emerged at all is a major achievement in a civil service culture that is instinctively hostile to exploration and experimentation. The stimulus for change came from outside this civil service culture, in the form of novel agents from the social housing community, all of whom were firmly rooted in and aligned with practice-based professions in civil society. Being in but not of the state was the critical factor because the i2i Skunk Works (an innovative governance arrangement in its own right) functioned as a creative space within the public sector, where it was able to combine the energy of a civil society organisation with the policy-making role of government. Although the community benefit clauses were originally designed for the social housing sector, they were rolled out in the ARBED programme, which is thought to be the first pro-poor low carbon transition scheme in the UK, a programme that overcomes the narrow 'carbonist' character of most green transition strategies because it affords parity of esteem to social and economic benefits as well as environmental dividends.

The CAN DO toolkit charts a new path of positive public procurement, signalling a genuine break with the low-cost/low-risk contracting culture that has been the default position in the British public sector until recently. But new paths have to be nurtured and maintained and the greatest political challenge in the near term is to preserve the gains of positive procurement in the 'age of austerity', which could rehabilitate the low-cost contracting culture and the worst features of the past.

Conclusions and implications

The main aim of this chapter has been to explore the multiple roles of the state to gain a better understanding of the manifold ways in which it is implicated in shaping the economic landscape of old industrial regions. Through the prism of three vignettes from Welsh economic history we have seen that the state's involvement in regional development was highly contradictory because it was actively involved in reinforcing *old* developmental paths (by locking-in the NCB), whilst also trying to fashion *new* developmental paths (by betting on Technium centres). Furthermore, in the case of the procurement vignette, we saw that path-dependent processes were at work *within* state institutions, such was the dominance of low-cost/low-risk contracting routines, a contracting culture that only began to change when civil society ‘outsiders’ were allowed to work as policy-making ‘insiders’ through the innovative mechanism of a Skunk Works, an institutional medium explicitly designed to inject novelty into the system.

The study of old industrial regions could be inadvertently sidelined by the advent of evolutionary economic geography because the latter is primarily concerned with the ‘spatialities of economic novelty’, the economic phenomena of new firm formation and the like that tend to be overwhelmingly associated with dynamic and prosperous regions. However, the three vignettes in this chapter will hopefully alleviate this bias because they demonstrate that the problem is not that old industrial regions cannot generate economic novelty, but that they lack the innovative agents – be they private sector firms, public sector bodies or third party intermediaries – to transform such novelty from the demonstration phase to the widespread diffusion stage, a challenge that some researchers have called the ‘valley of death’ (Auerswald and Branscomb 2003).

Regional development theorists sometimes forget that the models of innovation that dominate our theoretical and policy landscapes are often predicated on the experience of a frightfully small number of advanced regions, the ‘Silicon Valley Effect’ writ large so to speak, such is the emphasis on firm-led search, new firm formation, breakthrough innovations, the entrepreneurial university and so forth. What is conspicuously absent from this totemic model of innovation is any explicit reference to, or acknowledgement of, the role of the state in creating the commercial and technological conditions for this private model of innovation to dominate the economic landscape, an ideological elision that was apparent in the earliest narratives of the digital era (Morgan and Sayer 1988).

Although old industrial regions are more internally diverse than the collective stereotype suggests, one thing they have in common is the fact that the state looms large in their economic and social affairs and the multiple roles of this key institution need to be better understood. Evolutionary economic geography tends to have little to say about this phenomenon because (thus far at least) it has been inordinately concerned with the micro-economic world of the firm, a focus that leaves it open to the charge that it neglects the macro-level forces, especially the role of the state, that shape the economic landscape. Sympathetic critics have rightly argued that the evolutionary perspective can be enriched by a dialogue with a renewed geographical political economy to connect economic, social, cultural, ecological, and political concerns and to examine the dynamics of uneven development within a spatially sensitive approach that respects the micro-worlds of the firm without sacrificing the macro-worlds of institutions like the state (Pike *et al*. 2009).

Far from being confined to old industrial regions, the implications of this analysis apply to the realms of innovation and development more generally, in core regions as much as in less favoured regions. When the multiple roles of the state are more fully appreciated – particularly its roles as producer, regulator, animateur and purchaser for example – it becomes crystal clear that the state has an enormously important part to play in nurturing the transition to more sustainable pathways. Although the state's role is denigrated and downplayed in neo-liberal narratives of development, except when it is summoned for crisis-management duties, it is instructive that the state has been allotted a pivotal role in recent theories of 'transition management' and 'transformative innovation', where the challenge of innovation is framed not in the micro-economic terms of the individual firm, but in terms of socio-technical systems (Geels 2002; Geels and Schot 2007; Steward 2008; Scrase *et al*. 2009).

According to influential researchers at SPRU, for example, the state is expected to nurture transformative innovation by building pathways, enabling markets and fostering new forms of strategic governance to promote the transition to a greener, more sustainable economy (Scrase *et al*. 2009). If the evolutionary perspective can be criticised for neglecting the role(s) of the state, the socio-technical system theorists tend to err in the opposite direction by making some heroic assumptions about the state as a competent and benign actor in the innovation process. The scope and limits of the state as an animateur in the innovation process were documented, albeit in microcosm, in the Technium case study. The failure to calibrate supply and demand, the lax administration of grant aid, the inability to learn from mistakes, and the hubris of ambitious politicians who rolled out the centres before they had been properly evaluated all played their part in the demise of the Technium experiment. But these factors are not confined to Wales. In actual fact, there is a good deal of evidence to suggest that the capacity for organisational learning in the British state system – particularly in central government departments – is woefully inadequate, not least because learning from mistakes is not a political priority and there is little space or time devoted to reflexivity (NAO 2009).

Theorists of transformative innovation may have crafted some compelling narratives of evolution and transition – involving greener, more sustainable and more deliberative ways of working and being – but these narratives pre-suppose a *smart* state not the shrunken state that populates the neo-liberal vision of austerity capitalism (Morgan and Price 2011). Reforming the state, to render it more competent, more transparent and more democratic, has been a perennial struggle in the past and it will remain so in the future.

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16 City-regions, innovation and universities

The evolution and transition of UK urban governance institutions

Fumi Kitagawa

Introduction

In order to investigate innovation strategies for regions and city-regions, a set of conceptual frameworks to identify factors that determine the dynamics of evolution, innovation and transition processes within a specific *place* is needed. Recent studies illustrate various institutional processes and contexts in which *innovation* and *place* remain "inexorably connected" (Shapira *et al*. 2009). The concept of 'city-regions' has gained popularity in both policy and theoretical discourses internationally over the last decade through the interactions of multiple 'scales' (for example, Boudreau 2003; Hall 2009). In the UK, this is accelerated by the recent new government policy landscape and 'scalar' shifts in economic and social developments, particularly in England since 2010. The abolition of the Regional Development Agencies (RDAs) and the establishment of sub-regional Local Enterprise Partnerships (LEPs) have led to a redefinition and renegotiation between sub-national authorities of the roles and responsibilities in various policy areas including the planning, co-ordinating and delivery of enterprise and innovation support (Sadiq *et al*. 2011).

This chapter illustrates the recent transition and evolution of regional governance in England, being replaced by new private–public partnerships emerging at a city-region level. By observing recent scalar shifts and a series of 'institutional shocks' to regional and local economic governance, this chapter highlights the regional and urban adaptation as a multi-scaled process (Martin and Sunley 2006), including political and institutional 'lock-in'. The chapter highlights, in particular, some of the recent evolution of partnerships at city-region level, and illustrates how they have been negotiating and adapting innovation agendas in the transitory space with new urban governance institutions, including universities/higher education institutions (HEIs).

There is not a clear understanding of the influences of spatial transition processes in the city-region innovation agenda, including universities' role in promoting knowledge flows between the university and the city-region, and from there, what this might mean for policy at the level of the city and the university. Recent work has also begun to question the high level of policy expectations, with little understanding of the actual processes of knowledge flows, and the extent to which regional economic or city-region development can be actually achieved through the utilization of university knowledge (Benneworth *et al*. 2010; Power and Malmberg 2008; Huggins 2008). Whilst the roles of universities in connecting knowledge and spanning boundaries to foster innovation (Youtie and Shapira 2008) are increasingly acknowledged, the theoretical development of the concept of ‘city-regions’ and a growing political and cultural space for universities in the territorial development processes have to be seen as the product of a particular set of economic, cultural and political projects, “each with their own logics” (Jonas and Ward 2007: 176). In this light, this chapter addresses the following research questions: *under what conditions does the city-region become a space to meet broader innovation agendas so that new urban governance institutions can work together?* And, second, *what roles could be played by universities in this process under the new financial regime?*

Following this Introduction, the second section examines ‘city-regions’ as an analytical concept in light of broadened scope of innovation. The third and fourth sections present expectations on the role of universities in their regions and ‘city-regions’ and models of institutional governance and debates on the role of higher education in regional and urban development as observed in the UK, particularly in England over the last decade. The fifth section illustrates two cases of city-regions in England, delineating the formation of the city-region political boundaries, institutional partnerships and spatial identities with distinctive roles played by universities in the formation of the innovation agendas. The chapter concludes by identifying issues, constrains, challenges as well as opportunities within the city-region as a political, economic and socio-cultural project, whilst under the current funding regime, universities’ possible roles for innovation agendas through the evolution and transition of urban governance institutions at the city-region level remains unclear.

‘City-regions’ debates, evolutionary perspective to innovation and governance

The city-region is a “fuzzy” concept that indicates a “stretched out or relational space that does not always correspond to administrative city boundaries” (Etherington and Jones 2009). Although the academic literature on regional and urban competitiveness has been rapidly expanding, there is still no generally agreed theoretical or empirical framework for answering what makes some places grow while others do not (see Simmie *et al*. 2008). There has been an evolution of geographical literature on urban and regional concepts swinging between the ‘city’ and the ‘regional’ levels, with growing recognition of local-global linkages. Recently the focus is shifting to the ‘city-region’ concept with authors renewing the arguments that policy making ought to be organized around ‘city-regions’, which Jonas and Ward (2007: 171) call ‘new’ *city-regionalism*. The ‘city-region’ concept has been linked to the idea that large cities are dynamic centres of economic innovation in global space (Hall 2009; Jonas and Ward 2007).

The city-region concept can be defined in different ways. According to Turok, the city-region is “a city or group of cities within a wider territory that have a close, interdependent relationship, often with complementary functions interacting through commuting, trade, information or other flows" (Turok 2009). City-regions are seen as "important sites of policy experimentation around new regulatory structures and spaces of governance" (Brenner 2002). In this light, city-regions can be, first, seen as '*economic territories*' because of their role in stimulating trade, creativity, innovation and entrepreneurialism and, second, '*political territories*' because within them can be found autonomously developed regulatory and decision-making capacities (Jonas and Ward 2007: 171). Third, the city-region is made up of as '*social and cultural territories*' where the relationship between the place and innovation agenda is shaped, and constituencies are negotiated and boundaries are formed.

Lakshmanan and Chatterjee (2009) emphasize issues concerning "urban governance" in the formation of city-regions. It is argued that joint creation of urban dynamic competitiveness is made possible by "new urban governance institutions", which build "consensus or obtain consent in a context where many different urban interests are in play" (p.371) within a set of hierarchical relationships. Lakshmanan and Chatterjee (2009) argue that when urban public, private and social economic actors (including social entrepreneurs) endeavour to cooperate to create urban value, two prior conditions must occur (p.381). First, the actors need to "acquire new economic and political capabilities" in order to engage in strategy formation for city-regions as "new state space"; and second, these actors need to develop "a framework or institution for governing their interactions and their mutual commitment, and for enabling horizontal cooperative relationships between them".

This focus on governance and actors resonates with the recent development of concepts and theories in evolutionary economic geography about regional adaptation – it is not only firms and industries but local and regional development policy and institutional environment condition adaptability of regional economy (Hassink 2010). We need to understand the institutional environment and capabilities of firms, industries and other actors, and how the policy agenda conditions and affects the dynamism and adaptability of regional and urban economy. In this light, the variation of the concrete contents and scope of the innovation policy need to be identified in relation to the economic and institutional profiles in individual regions and city-regions. It is pertinent to examine this process especially when the system is facing multi-scalar 'shocks' through the scalar governance shift and to identify how *the place* adapts to these shocks. According to Swanstrom (2008: 10), a resilient region is characterized as one where "markets and local political structures continually adapt to changing environmental conditions". The policy and institutional dynamics examined in this chapter provides interesting empirical case to investigate this process.

Identifying innovation agenda set in a particular city-region context is a contested process. According to Etherington and Jones (2009: 251), one of the challenges for innovation agenda in city-regions is in finding the right balance between "social inequalities as well as promoting competitive advantage" in light of distributional consequences of competitive policies (for example, Krueger and Savage 2007). This leads to a recognition of a "variety of new actors and agencies in enabling innovation, including public-private partnerships, intermediaries, development agencies" (Shapira *et al*. 2009), and broader range of sectors involved in innovation processes (NESTA 2007). A wide series of developmental and social problems and various interests of actors are negotiated, and sometimes included and other times excluded within institutional boundaries. On one hand, cities are well positioned within the global knowledge economy but on the other hand, the urban institutions exclude a number of community types, as 'holes' adjacent to, and within, cities. Issues of social inclusion and developmental problems, such as environment and transport infrastructures surrounding city-regions, need to be raised and re-conceptualized in the concept of *innovation* and what it means for its "uses and sources at the level of a city region" (Shapira *et al*. 2009).

Universities and the innovation agenda in regions in the UK

This chapter specifically focuses on the changing roles played by the higher education sector in regional *and* city-region innovation processes through the transition of local governance and under the current funding regimes. The contribution of universities to the development of their regions and city-regions is not a new phenomenon. Universities have historically played an important role in the regional and/or city-region space, though in the recent policy discourse, they are certainly given increased political importance (Benneworth and Hospers 2007). Promoting the relationship between the university as a producer of knowledge for high-tech innovation leading to wider regional/city-region development has become one of the stronger policy aspirations in the knowledge economy. However, universities can be seen as "an overstated ingredient" (Lawton Smith 2007: 111) in territorial development unless they are integrated as part of wider territorial economic growth strategies (see Webber 2008).

Under the former Labour government (1997–2010), the UK witnessed "an asymmetric system" of economic governance (Bentley *et al*. 2010) with devolution for Scotland and Wales, and decentralization to the Regional Development Agencies (RDAs) in England, which were charged with the economic development of nine regions. The RDAs were seen as a prime scale of delivery for sub-national economic development policies in England while the situation of economic governance for the English regions – without an elected regional government structure – remained "fluid and variable" (Perry 2007). In England, this is characterized as "central government-sponsored regionalism" and "politicization of economic governance" (Jones *et al*. 2005), which co-existed with processes concerning the "territorialization" of higher education, specifically at the regional level (Kitagawa 2004; Lawton Smith 2007; Warren *et al*. 2010). This has also corresponded with regional development policies and funding mechanisms at the European level (for example, European Regional Development Fund; European Social Fund) and the development of regional innovation policy networks.

The effects of 'regional devolution' on higher education, research funding and the management of knowledge transfer are a growing area of policy concern (Universities UK 2008). The institutional dimensions of devolution processes are conditioned by different forms of “economic governance” (Cooke and Clifton 2005). The economic and social contribution of universities were seen to be public goods, supported by a number of regional bodies (for example, RDAs, Regional Government Offices) and higher education funding bodies through the so-called ‘third stream’ funding: Higher Education Innovation Fund (HEIF), funded by HEFCE (Higher Education Funding Council in England); Third Stream Fund funded by HEFCW (Higher Education Funding Council in Wales); and the Knowledge Transfer Grant (KTG) and Horizon Fund for universities funded by SFC (Scottish Funding Council); and Northern Ireland Higher Education Innovation Fund.

In England, nine regional associations of HEIs were created in each region around 1999–2000 at the time when the RDAs were established, and HEFCE contributed funding to the associations to promote the role of HEIs in each region. The associations placed a particular emphasis on fostering collaboration between HEIs, and building partnerships between higher education and other organizations within their regions. Based on such regional institutional infrastructure, during the 2000s, a number of regional frameworks were built supported by both third-stream funding and RDAs, where different types of universities – with different strengths and weaknesses – *supposedly* worked together with a range of regional policy and industry players and helped regional innovation, economic growth and well-being through workforce development, knowledge exchange and outreach activities (see Kitagawa 2004). Series of funding initiatives were developed, which were jointly funded by higher education funding councils and RDAs, involving regional HEIs and an array of regional innovation and skills intermediary bodies. The wide range of institutions involved in the series of jointly funded projects at regional level led to the “high levels of regional ownership” (Dickinson 2008). This policy process exemplifies regional adaptation and development where universities were embedded as part of the regional innovation architecture.

Arguably, different roles are played by pre- and post-1992 universities in the UK – reflecting differences in institutional priorities, cultures and governance structures between the old universities (pre-1992) and former polytechnic universities (post-1992). It is true that for some universities, especially research-oriented institutions, the development over the last three decades has resulted in them being more cut off from their local area as they negotiate their roles as more ‘international’ players. For post-1992 universities, their core business includes activities such as professional or vocational training and placements, applied research and consultancy in a number of areas. Such institutional diversity, as an eco-system of innovation and learning institutional structures, could be viewed as providing the opportunity to meet the “needs of specific regional and local economic and social contexts” (Little and Williams 2009).

There is also a shift of policy expectation in terms of *scope*, from that on a narrow economic focus to a wider interactive model. The scope of policy expectation has been broadened to respond to the perceived more interactive nature of innovation, and there is also an increasing understanding about different roles that universities can play, and also different relationships universities establish with other actors (Abreu *et al.* 2008). For example, universities contribute to their regions not only through research and teaching, but also by cultural and civic engagement. The social role of universities has recently been the subject of wider debate (Williams and Cochrane 2010). There are a diverse range of agendas on which universities collaborate with local organizations. This includes *health* sector; *education* – for example, working with local schools on widening participation initiatives; *cultural* sector – with local museums, theatres, local cultural amenities or sporting organisation; and *third sector* – including community engagement activities and student volunteering (Goddard *et al*. 2010). There is another area where universities' contribution is recognized, but not so explicitly documented. Universities are important in terms of "provision of public space", providing 'space' for key dialogue among stakeholders (Lester 2005), which Lawton Smith calls as a "normative governance role" (Lawton Smith 2007).

The "city-university relationship" (Williams *et al*. 2008) or "the roles of universities in knowledge based urban development" (Charles 2006) has attracted growing policy attention as the concept of 'city-regions' (Turok 2009; Etherington and Jones 2009) gained popularity in both policy and theoretical discourses (see Perry 2011). In a report by the Work Foundation, *Embedding Universities in Knowledge Cities*, the "city–university relationship" was seen as pivotal to the economy by helping places "adapt to changes in the wider economy, increase the proportion of knowledge intensive jobs and workers, and deliver beneficial outcomes for communities"(Williams *et al*. 2008: 4). However, it was also recognized that implementation was not so straightforward, and difficulties occurred finding balance between the expectations and agendas of various stakeholders, For local authorities, uncertainty about "how to engage best with universities and make the most of their knowledge assets and community activities" was recognized as a key challenge (Williams *et al*. 2008: 49).

The financial crisis that hit the global economy in the autumn of 2008 strongly affected the UK economy, negatively influencing the roles of universities in their regions and city-regions. In 2009 and 2010, under the Economic Challenge Investment Fund (ECIF) funded by HEFCE, universities in the city-regions started working with new regional partners such as Job Centre Plus and Business Link to support businesses and individuals during the economic downturn. Under the economic crisis, economic as well as social engagement activities have made universities, in principle, a more integrated part of the institutional fabric of the city-region (see Kitson *et al*. 2009). These are particularly seen pertinent at the city-regional level and have become even more relevant in the current economic climate.

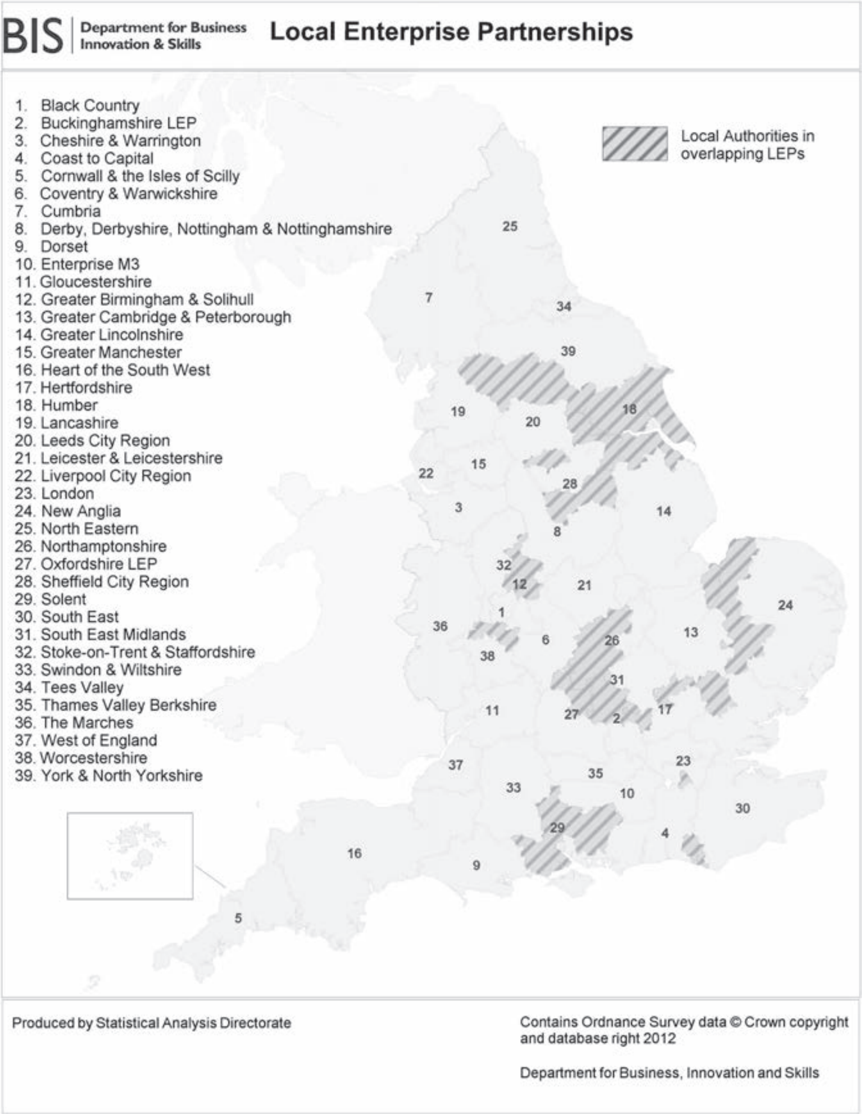
The evolution and transition of the regional governance, public funding and higher education in the UK

Recent research scrutinized the UK government's approach to economic competitiveness and social cohesion by examining the concept of 'city-regions' as sets of policy strategies as well as an analytical framework (Etherington and Jones 2009; Harding 2007). The UK HM Treasury *et al*. (2006 p.8) presented the notion of 'city region' as "the area over which key economic markets, such as labour markets as measured by travel to work areas, housing markets and retail markets, operate". According to Jonas and Ward, "city-regions are places where new cooperative forms of governance *might* have emerged to reinforce the strategic development role of city regions (e.g. new metropolitan authorities and public–private partnerships)" (Jonas and Ward 2007: 171). The growing recognition of the city-region as policy unit had co-existed with the economic governance model primarily at the regional level.

The landscape was again rapidly changing in the UK, as the Coalition government announced in October 2010, in the White Paper *Local Growth: realizing every places potential*, the abolition of the nine RDAs in England, to be replaced by Local Enterprise Partnerships (LEPs) at a city-region level. LEPs are partnerships between local authorities and businesses and are expected to play a key role in promoting local economic development. Half the LEP board members were to be drawn from industry/local commerce and led by a local business person, which reflects the perceived importance of private sector investment and expertise. As of July 2011, there are 38 approved LEPs for England (see Map 16.1), while there are several local authorities in overlapping LEPs. Two rounds of the Regional Growth Fund (RGF) were announced by the government for which LEPs could bid. The impact in terms of growth in employment has been identified through the RGF projects (DBIS 2011 website).[1] Other recent development includes the creation of 21 Enterprise Zones (EZ), with specific provisions for local business growth in the designated areas.

LEPs do not have even the limited economic resources that RDAs used to have, and one might argue that LEPs will not have sufficient powers to create the private sector jobs growth needed for the city-regions to recover from recession. Concerns are expressed about the over-competition between LEPs as well as sustainable economic growth in less-favoured regions with scarce public support for local economic development. Other institutions that used to operate at the regional level such as Government Regional Offices were also abolished under the Coalition government. This will have implications for the administration of EU regional policy, funding and relations with the European Union (Bentley *et al*. 2010). Thus the emergent 'system' has suffered a multi-dimensional and multi-scalar 'shock'.

The overall development represents a significant scalar shift in local economic development with an emerging vacuum at the regional level, and the "re-centralisation of many economic development functions" (Bentley *et al*. 2010) as well as the potential emergence of new urban governance institutions and structures. The removal of the regional tier of economic development policy, delivered by the RDAs, means many of the functions, including inward investment, SME support and development, sector and cluster policy will be "passed back to" national level (Bentley *et al.* 2010). The technology, innovation and research responsibility by the RDAs is being transferred to Technology Strategy Board (TSB), which is a UK body attached to the Central government, seen as "central to innovation strategy" in the UK under the new Coalition government. The UK government also announced the creation of "£200 million national network of



Map 16. 1 Local Enterprise Partnerships

Source: Department for Business Innovation and Skills, http://www.bis.gov.uk/policies/economic-development/leps/statistics, accessed 20 November 2011.

elite Technology and Innovation Centres (TICs)" working with universities and businesses.[2] With the "asymmetrical" devolution structure and with recent re-centralisation processes of economic development governance in England, collaboration between TSB, higher education funding councils and research councils is embryonic. It is unclear that these new mechanisms can constitute incentives for the 'new governance institutions' for innovation at the city-region level, with new dynamics of technology and innovation and an interface of actors at international national, regional, and local levels.

In terms of relationships between LEPs and the higher education sector, it is still too early to make judgments. In England, where LEPs are replacing RDAs, colleges and universities are to be involved in the LEP partnerships as well as other stakeholders through LEP board representation. The Government is encouraging, without funding, HEIs and businesses to work more closely together to support economic growth, and in particular, LEPs and HEIs are encouraged to work together in the areas of "effective investment in skills, research, knowledge exchange and innovation" and in responding to local skills needs in the communities (DBIS 2011 website).[3] In England, most of the regional collaborative funding from RDAs is coming to an end. At least it is clear that the abolition of the RDAs in England has undermined the relationships between the regions and their universities. Without the main regional institutional framework,which supported the collaboration of different types of universities within a region, institutional collaboration, especially at the regional level, is scarcely resourced and becoming more difficult.

On-going spatial evolutions from RDAs to LEPs and universities as transitory urban governance institutions

It is of interest to this chapter now, to look at some of the emerging mechanisms at the city-regional level and see what roles universities are taking as part of the new urban institutional governance. It is fair to say that the transition of economic development governance from the RDA to LEP is a process of multi-scalar interactions and adaptation, where relationships are path-dependent and evolutionary, as two examples of city-regions and higher education sector may illustrate below.

Figure 16.1 shows the percentage of small businesses showing employment growth comparing West of England LEP and Greater Manchester LEP and the comparator non LEP local authorities in England. Both LEPs show greater employment growth through small businesses, which may indicate the two city-regions are active in terms of enterprise and innovation activities.

The qualitative institutional processes illustrated below exemplify the nature of multi-scalar adaptation of institutions in each of the city-regions and the resilient nature of the city-regions.

Bristol city region in the South West region

Bristol city region is relatively new in terms of its political identity. The area, variously named such as West of England sub-region, Greater Bristol, Bristol

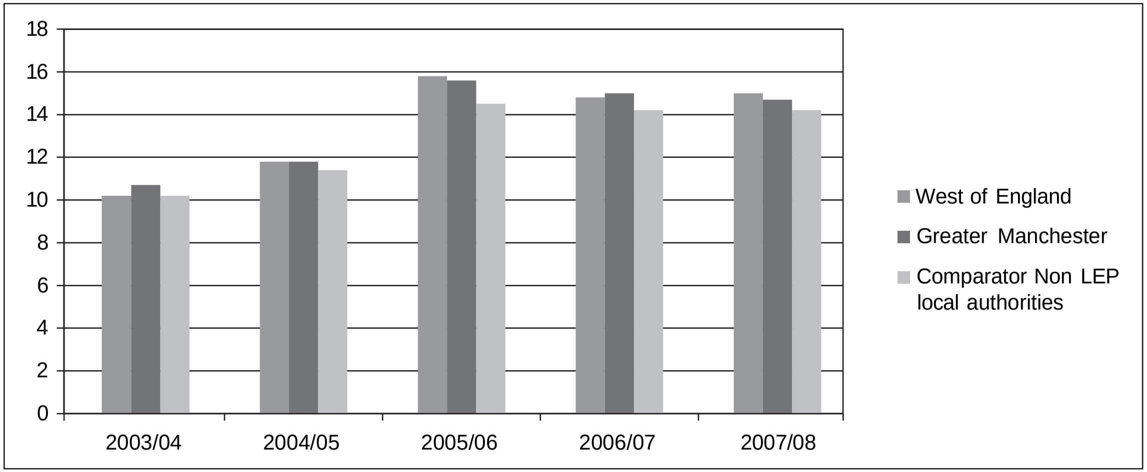


Figure 16.1 Percentage of small businesses showing employment growth comparing West of England LEP and Greater Manchester LEP

Source: Collated from data, Department for Business Innovation and Skills, http://www.bis.gov.uk/policies/economic-development/leps/statistics, accessed 20 November 2011.

city-region, or Bath Bristol city-region, encompassing the four unitary authorities – Bath & North East Somerset Council, Bristol City Council, North Somerset Council and South Gloucestershire Council, has population of around one million. The *West of England Partnership* was formed demonstrating leadership around the future vision for "the city and wider region" (Work Foundation 2006).

In 2006, Bristol and the surrounding region was chosen as one of the six Science Cities in England because of its "world-class academic research, strong scientific SME-base, and its potential to drive economic development through science and innovation" (Science City Bristol, website). In 2006, following the nomination as Science City, the Vice-Chancellor of the University of Bristol, Professor Eric Thomas, took the chairmanship of a newly formed Science City Group. The Group, formed under the RDA, the South West Regional Development Agency (SWRDA), contained representatives from each of the key partner organizations: four universities in Bristol and Bath (Bristol, Bath, University of West of England and Bath Spa), including both old and new universities, the West of England Partnership, the four unitary authorities, and other organizations such as the Bristol Zoo, At-Bristol, the Bristol Cultural development Partnership and Business West. Through Business West, a separate interface was arranged with representatives from business so that they can feed into the process. This new multiple partnership including universities, business sector, local authorities and other partnership bodies, focuses on "connectivity", "investment" and "public engagement" (Science City Bristol website).[4] This top level leadership seems to have created a momentum for the universities to come together to an unprecedented level under the brand of Science City Bristol, which paved the way for future collaboration at city-region level. In September 2010, Science City Bristol "graduated out of the SWRDA" and incorporated as "a (not-for-profit) company limited by guarantee" – Science City Bristol (SCB) Ltd, now owned and funded by Universities of Bath, Bristol and West of England.

In February 2009, Greater Bristol decided to bid for 'city region' status under the Labour government but was not successful, while Manchester and Leeds were awarded the pilot city region status. Under the new Coalition government, West of England LEP was approved in early 2011 and also got one of the Enterprise Zones for local economic growth.

The institutional collaboration of the four universities in the city-region is a relatively recent phenomenon driven by the Science City Bristol initiative, and a recent growing policy attention over the last couple of years under the New Labour government to the higher education sector's leadership role at city-regional level (Goddard *et al*. 2010). This coincides with the eminent innovation agenda at the city-region level, exemplified by the long-awaited opening of the Bristol Bath Science Park – *Spark* – at Emerson's Green, in the area between Bristol and Bath, which has been planned for over 20 years, as Bristol city-region was one of the few areas in the UK with big universities which didn't have Science Park up until this point. Spark is a partnership between the Universities of Bath, Bristol and the West of England, the South West RDA and Quantum Property Partnership, and opened in the summer of 2011. The National Composite Centre (NCC)[5] is located on Spark, and has attracted £25 million investment supported by European and UK Governmental funding and the private sector, working with University of Bristol's Advanced Composites Centre for Innovation and Science (ACCIS) and a number of key business partners including Airbus and Rolls Royce. Furthermore, Bristol's NCC is one of seven new Technology and Innovation Centres (TICs) for high-value manufacturing, the government's new flagship innovation initiative – with more than £200 million investment in total in the UK over four years. Bristol city-region, despite being a new political entity, is going through the current scalar shift successfully, as a new space for innovation agenda, with new resource inputs – combining private and public – European, national and (former) regional and city-region levels – and institutional partnership with the universities as core members in place.

Manchester city region in the North West region

Another example of the city-region and collaborative relationship with higher education sector is that of Greater Manchester in the North West. Greater Manchester as a sub-regional political entity has a long history, created in 1974 as a result of the Local Government Act 1972. In 1986, Association of Greater Manchester Authorities (AGMA) was established. Greater Manchester, with ten local authorities surrounding the city of Manchester, developed the Manchester Multi-Area Agreement (MAA) in 2008. It proposed a range of actions and targets across a range of issues that are perceived to be best tackled on a sub-regional basis – such as transport, business support, skills and employment. Greater Manchester was awarded Statutory City Region Pilot status in 2009 allowing for their constituent district councils to pool resources and become statutory "Combined Authorities" with powers comparable to the Greater London Authority. Several county-wide services have been coordinated through the AGMA. AGMA created Commission for New Economy in 2009, which is an intelligence body for the economic growth of Greater Manchester city region. An independent economic analysis of Greater Manchester city region was provided by the Manchester Independent Economic Review (MIER) (2009). Two key challenges were identified through the review: first, to increase the productivity and the competitiveness and efficiency of the labour markets; and second, to ensure that all parts of Greater Manchester and its people benefit from, and contribute to, growth through tackling low skill levels, worklessness and public service dependency. Based on the review, the AGMA approved the *Greater Manchester Strategy* setting the strategic direction of the city-region until 2020 (AGMA 2009).

Universities have played an important role in the development of the city region and the wider region in the context of knowledge based economy. The University of Manchester was created in October 2004 as a result of a merger of two institutions: The Victoria University of Manchester and UMIST. The institutional merger, to create 'a world-class university' outside the golden triangle of Oxford–Cambridge–London area, the biggest in the history of the UK higher education, was supported by £65m of extra public funding secured from government and regional bodies (HEFCE, the Office of Science and Technology and the North West Regional Development Agency (NWDA)).

Manchester Knowledge Capital (M:KC) was established in 2003 as a strategic partnership of Greater Manchester universities, local authorities, regional government, businesses, NHS and key local agencies. A large part of M:KC's impact has been bringing partners together, facilitating the development of ideas and providing capacity for profile-raising and funding bids for Greater Manchester, as well as developing innovation agenda for Manchester city region (AGMA 2008). Like Bristol, Manchester was chosen as one of the Science Cities in 2006, and M:KC played a key role in this by contributing to the development of partnerships for innovation agendas across the city region and attracted investment from outside. However, M:KC was closed in March 2011 with the end of funding, and its function has been integrated under the new Manchester Innovation Group and the new LEP. Another university partnership, Manchester Beacon for Public Engagement, was created in 2008 at the city-region level, involving University of Manchester, Manchester Metropolitan University, Salford University, M:KC and Museum of Science and Industry. It was part of the national initiative funded by higher education funding councils, research councils, and other funding bodies, which ends in January 2012. Through these university partnership institutions, Manchester city-region has created a cultural and social space where universities play critical public roles not only for innovation agendas, but also with wider social and cultural agendas. It is interesting to note that the two key collaborative initiatives between universities in Greater Manchester as urban governance institutions both have come to an end; and it is unclear how the collaborative mechanisms that have been established will survive under the new city-region governance mechanism.

In terms of the new political boundary of the city-region, the Coalition government approved AGMA's proposal for a business-led LEP in October 2010. On 1 April 2011, the Greater Manchester Combined Authority (GMCA) was established. This means the ten authorities in Greater Manchester are the first in the country to develop a statutory Combined Authority which will coordinate key economic development, regeneration and transport functions. On the same day, Greater Manchester LEP was established as the city region's business-led partnership while Manchester Airport was named as one of the Enterprise Zones. Given the historically established political boundaries of Greater Manchester, the city-region is in transition – the abolition of the NWDA and the formation of the new LEP – without much evident pain, whilst other areas in the North West region have struggled. However, the Greater Manchester city-region as a space of institutions for an innovation agenda is suffering the transitory processes of scalar shift as well as their public funding cut.

The brief illustration above shows the two city-regions' transition and evolution as spaces of political partnerships, local economic development, and the development of urban governance institutions including universities. Bristol city region has had historically fuzzy and contested territorial identity as a political territory whilst Greater Manchester has had a much stronger political boundary as a combined local authority, but still with contested identity. Through recent national initiatives such as Science Cities, both city-regions evolved into the new “knowledge space” and partnerships were created and strengthened with a perception of new opportunities driven by the prevailing science, technology and innovation agenda, and also driven by wider social and public engagement agenda, with universities acting as key active partners. Given the current economic development scalar shift from the RDAs to LEPs, it is still early to tell whether much of the new structure will take over the old RDA mechanisms. The new ‘private sector led’ LEPs – West of England LEP and Greater Manchester LEP and their remit in relation to the existing partnerships and various bodies of local authorities is still unclear. These on-going processes illustrate the construction of new territorial identities and negotiation of interests to build new urban governance institutions, with an emergence of new business actors combined with new territorial as well as institutional alignments – these new partnerships are to set new innovation agenda at the city-region level. However, the actual process is highly complex given the uncertainties of national politics, with unclear divisions of labour between new LEPs and national government bodies concerned with the innovation, skills and competitiveness agenda. Whether or not higher education institutions will take a leading role in this process needs to be empirically observed.

Concluding remarks: innovation agenda, universities and a city-region as a socio-economic space

Short illustrations of the evolution of the two city-regions in England highlighted the nature of multi-scalar adaptation of institutions in each of the city-regions. The empirical institutional processes depicted above illuminate several dimensions of a possible conception of a city-region in analytical terms. First, city-regions provide ‘political territory’ where a number of private and public partners affiliated by the territorial boundary are working together for perceived economic benefits and political agenda setting, including the strategic formation of the innovation agenda. Second, within city-regions, a new ‘economic territory’ emerges with new organizational boundaries and new forms of organizational management including technology networks, and technological and social enterprise activities. Third, the recent emergence in England of the city-region as a ‘social and cultural territory’ opens up the public space for engagement, for example, with universities and partner organizations promoting cultural awareness of science and technology and also social cohesion agenda. Finally, the city-region space is evolving into a set of institutional frameworks for urban governance tackling a number of different projects with different logics – namely, social issues as well as competitiveness and innovation agendas through cross-border partnerships. The creation of a new knowledge space at a city-regional level is a highly complex process of multi-scalar negotiation of political and economic interests and institutional uncertainties.

The innovation agenda at the city-region level has a challenge of reconciling a wide range of ‘areas’ of policies at multi-spatial levels. The openness of the city-region as ‘socio-economic space’ is contested with a number of institutional and structural constraints. The policy scope of institution building is conditioned by historical path dependencies, current political power relationships between national and sub-national governance institutions, the lack of strategic coordination and the cuts in resource allocation. It is argued that broader approaches to institution building are required to meet a wide range of innovation challenges, and to overcome constraints in selective and narrow dimensions of the innovation agenda (see Shapira *et al*. 2009). How broader social dimensions of the innovation agenda are conceptualized and negotiated within the city-region, and how the urban governance institutions are constituted through vertical negotiation between multiple levels of governance with horizontal coordination across different logics remains to be empirically investigated further.

The transformation taking place in the city-regions as a "new state space" in terms of "functions, identities, policy mechanisms and spatial forms" (Lakshmanan and Chatterjee 2009) have to be recognized. This can be seen as the transitional evolution of "urban governance institutions". The formation, evolution and transition of "urban governance institutions" can be seen as the process of creating new 'ownership' of partnerships at the city-region level. The process has also been conditioned by rapid scalar policy shifts (Swyndegouw 1992; Brenner 2002), and policy interventions taking place between national, (formerly) regional and city-region levels. The qualitative observation presented in this chapter shows that in each of 'territorial conception' of city-regions – either as a political, economic or socio-cultural project – universities played significant roles. Top level leadership and partnerships across universities provided a momentum for institutions to work together within the city-region under the shared innovation agenda combined with each university's different strengths and missions. Universities had worked together in terms of bridging the technology and innovation spaces to social spaces through a number of engagement and outreach activities, for instance, through engaging with surrounding communities including socially disadvantaged areas**.** However, under the current shifting spatial governance in England, abolition of the institutional and financial supports at regional level, along with the changing funding regimes of the higher education sector, the state of engagement of universities in their city-regions as urban governance institutions is in flux, possibly in decline. This exemplifies the inherent waveform nature of 'institutional spatial-economic frameworks' for innovation and regional development processes conditioned by specific "time-space dependency" (Thrift and Olds 1996) characteristics of market economies.

Notes

1 See http://webarchive.nationalarchives.gov.uk/+/http://www.bis.gov.uk/policies/economic-development/regional-growth-fund/regional-growth-fund-round-1-analysis, accessed 15 February 2012.
2 See http://www.innovateuk.org/deliveringinnovation/technology-and-innovation-centres.ashx, accessed 11 February 2011.
3 http://www.bis.gov.uk/policies/economic-development/leps/lep-toolbox/helping-smes/higher-education, accessed 24 November 2011.
4 Science City Bristol http://www.sciencecitybristol.com/?page_id=805, accessed 15 February 2011.
5 http://www.nationalcompositescentre.co.uk/about, accessed 26 November 2011.

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