1 Introduction to the *Handbook of Regional Innovation and Growth*

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INTRODUCTION

This book marks the maturation of a field of study that is only some twenty years old. Regional innovation systems is taught in university undergraduate and graduate studies courses in numerous social sciences, notably economic geography, regional planning, business economics, innovation systems analysis, development studies, political science, sociology of science, science technology and society, and environmental studies. Moreover, it is increasingly widely applied in regional economic governance practice by development, innovation and enterprise support agencies. It is related to, but has a distinctive lineage from, teaching, research and practice in national, sectoral and technological systems of innovation, as David Wolfe makes clear in Chapter 3. Its origins lie in three related strands of research that pre-date the regional innovation systems discourse (Cooke, 2008).

These are, first, the systems view of planning, dating from the late 1960s as a comprehensive perspective on the integrated analysis and planning of city and regional systems. The importance of this perspective resides in its broad application and integrative perspective, way beyond urban and regional economic processes, in biology and engineering for example. However, with respect to spatial studies its value lay particularly in its insistence on analysis of, for example, land use and transportation interconnections and innovation in these fields, and its interweaving of understanding spatial economic processes with better-informed aspirations to improve them by means of policy and management. These conjoining aspects are central to each of the systems of innovation fields noted above. They are captured by the early terms 'technological paradigm' and 'technological regime' in, for example, Dosi (1982). Here the first refers to the predominating technological profile on the macro-scale, such as 'the Computer Era' or 'the Information Age', which is pervasive in modern working and domestic life and tends accordingly to influence the nature, direction and pace of change (for example, Pavitt, 1984; Carlsson and Stankiewicz, 1991). 'Technological regime' expresses the norms, institutions, organizations and rules that tend to sustain the dominant technological paradigm by means of standards, institutional mindsets, dominant technological discourses, government regulations and organizational preferences. For a swift taste of this relationship, think of the ways in which the fossil fuels 'paradigm' resists the challenging discourse of a potential renewable fuels 'paradigm' by its influence on the predominating fossil fuels regime of subsidies (and their frequent absence for the challenger paradigm), regulations (low renewables requirements), technologies (sunk costs of past and expense of new infrastructures) and economic discourse (for example only 'scale', hence cheapness, matters).

Second, regional innovation systems thinking was influenced by empirical research findings, initially from Italy, that showed economies of scale inside the large or multinational corporation were not the only pathway to economic competitiveness (Bagnasco, 1977; Becattini, 1978; Brusco, 1982). These authors pointed, in different ways, to the success of small and medium-sized enterprises (SMEs) working collaboratively and competitively with success in both mass and specialized markets ('flexible specialization', after Piore and Sabel, 1984). Mass markets included, for example, mass-consumption food production and clothing, the latter marketed through German and American department stores; specialized markets included specialist types of engineering such as agricultural irrigation systems, food packaging machinery, spectacle frames, hiking and skiing boots, luxury footwear, luxury fashion clothing and super-cars (also super-bikes).

This was interesting because the systems of production – diffused, often in the countryside – as Bagnasco and Brusco observed it, concentrated in 'industrial districts' as Becattini saw it, were characterized by often rapid, collectively inspired and managed innovation in products and processes, later also in services, including organizational innovation (for example specialized engineering or production software, telematics and systems). Regions were important to this phenomenon in a multitude of ways. Industrial districts, as one variant of 'Third Italy', were found mainly in a macro-regional belt across north-central Italy, from Marche to Veneto and nearby regions. Some regions like Emilia-Romagna and Tuscany were Communist-governed or 'red'; others, like Veneto, were conservative ('white', Christian Democrat). There were different regional nuances, even between the 'red' modes of economic governance: decentralized in Emilia-Romagna, centralized in Tuscany. Enterprise support services were available, either through the regions or the regionally important business associations. In the 'white' regions chambers of commerce were among the most important support organizations. Thus 'system variety' added interest to the networked concept of SME production. Later, such regionalized SME networks or 'milieux' were discovered in Germany, Switzerland, Sweden, France, Spain and Portugal (notably by the GREMI group; Aydalot, 1986) and then in developing countries (Schmitz, 1995). Accordingly, an influential and related research agenda had opened up.

Finally, the emergent discourse of regional innovation systems, rooted strongly in regional science, applied regional economics and economic geography, as shown in the apparently seminal article (Cooke, 1992) found shared conceptual interests with the national systems of innovation literature. This was principally through connections between the Science Policy Research Unit at Sussex University, notably its director, Chris Freeman, and a graduate course in Regional Economic Development at Cardiff University where, in 1988 he guest-lectured on 'Networks of Innovators', subsequently published as Freeman (1991). The innovation systems perspective, developed from Friedrich List to Joseph Schumpeter, the emphasis on overturning a hegemonic academic and policy discourse favouring the 'linear model' of innovation, and the advocacy of a collective learning approach among interacting users and producers after Lundvall (1985), resonated positively with the lengthily gestating regional innovation systems concept. Systems, networks and interactive learning were the common threads linking the three complementary schools of thought that came to inform the regional innovation systems model of regional economic evolution. Both the systems approach and

Schumpeter's economics were evolutionary, and 'learning', along with 'networking' and 'variety', were cornerstones of the evolutionary view.[1]

KEY THEMES IN THIS HANDBOOK: INNOVATION, PRODUCTIVITY AND GROWTH

No mention has yet been made of the 'growth' aspect in this *Handbook*'s title. In reality it was the title proposed to the lead editor when approached by the publisher with the idea for the project in 2008. Reflecting upon it, all the editors found it valuable to keep 'growth' in the title. The main reason was that it not only adds a valid dimension to the general approach to the chapters assembled in this collection but, importantly, it also gives an answer to the question: what, exactly, is innovation for (for example Moulaert and Sekia, 2003)? The purpose of innovation is growth, measured in terms of productivity, efficiency and effectiveness. The fundamental belief in Porter (1990), for example, is that 'co-location' by firms increase efficiency (for example reducing supply chain costs; accessing talent), start-up activity, innovation and productivity while more generic conditions for growth, such as good infrastructure and education, are insufficient (for empirical support, see Delgado et al., 2010; Spencer et al., 2010). Growth is not only an economic but also a social process. It is itself subject to critique from activists and others who seek certain 'limits to growth'. Reasons for this range from the moral to the environmental, and the two in combination are not unusual. From an evolutionary perspective, growth is a successful indicator of the health of an organism, whether biological or socio-economic. It seems that capitalism, which from a Schumpeterian perspective is fuelled by innovation, must grow in order to survive. Growth is implicit in the notion of markets, the inefficiencies in which stimulate innovative efforts to profit from seeking better alignments between value and price, whether of commodities, companies or currencies. For more citizens to have access to the quality of life of the typical middle-class household of the advanced economies is not a morally indefensible position, given the massive inequalities that exist even in many such countries, let alone between them and the developing world. Such a benign outcome may not be achievable, but that does not make it undesirable. Indeed, it is what democratically elected governments continue to pursue around the world.

Hence, innovation is not simply the pursuit of the new, or an abstraction to satisfy the psychology of novelty. Improving on some technology or process is what most economic activity has been concerned with across geography and its history. Of interest to the project of this book is the extent to which innovation is conceived of in this way, implicitly or explicitly. It would be misleading to say that every contribution addresses this interdependence explicitly. Most focus upon innovation and implicitly assume more or less the above argument (for a widely cited economic geography of endogenous growth theory, see Martin and Sunley, 1998). However some address the innovation growth nexus more overtly, including through the lens of innovation and productivity (Capello's Chapter 8 in this volume), and for the moment it is useful to identify some salient points in her argument. This is important for two reasons: first, it is seldom done in innovation studies in general, let alone regional innovation studies; and second, it reminds us of the two-way implications of the relationship. Thus innovation depends on growth because it carries certain key implications regarding investment, capabilities and organization. Most growth is asserted to come from intra-industry trade among advanced economies, not even from interindustry trade between them and less developed economies (Krugman, 1991). If true, it is because, in effect, advanced economies can afford to trade innovations made affordable by past growth, which is replenished by returns from present investment in future innovation.

Capello's key points about the relationship between productivity and innovation are the following. There are three perspectives on the relationships between regional innovation and productivity, depending what kind of knowledge determinants prevail. Taking a functional approach to understanding knowledge, innovation and productivity relations, the key idea is that science-based innovation in 'scientific regions' short-cuts the invention-to-innovation circuit. Schumpeterian radical innovation may ensue, with associated profits from the increased translational productivity from invention to innovation. Geographical proximity is accordingly crucial to this kind of productivity gain. However, research into innovation shows that it often occurs without science and is thus not confined to 'scientific regions' (Asheim and Gertler, 2005). In this case, it is necessary to take a more structural perspective on the innovation–productivity nexus. Accordingly, the regional system and its entrepreneurship talent, knowledge and industrial assets replace science as the determinant of a virtuous innovation–productivity cycle. Productivity gains are reaped from the rapid recombination of knowledge (innovation) and its commercial exploitation (entrepreneurship), which are regional innovation system processes. Innovation is incremental and productivity gains from the pervasive and rapid knowledge–innovation recombinations that are proximate and systemic. But neither all innovation nor all associated productivity gains are confined to or derived from the region, as an enormous amount of research literature shows (see Cooke, 2009; Ponds et al., 2010; Breschi's Chapter 10 in this *Handbook*). Indeed, not only may innovation involve relational proximity over great distances but its productivity gains involve collective learning processes. Hypothetically, these result in global network hierarchies in which typically factor (for example labour) value is extracted from the 'learning region' and productivity increases are lodged at the top of the hierarchy (innovative region). This is the working out of the law of combined and uneven development, the law of increasing returns to (knowledge) scale, and that of 'cumulative causation'. The question remains, to what extent and at what magnitude may learning gains be repatriated, as seems to happen at least to some extent among returning Taiwanese and Indian migrants from Silicon Valley (Saxenian, 2000)?

Thus treating regional innovation as a means to the end of increasing growth by enhancing productivity opens up an important research agenda. This has been broached somewhat by research that compares productivity gains from innovation *in situ* but little yet seems to have been done in terms of interregional productivity magnitudes deriving from knowledge flows of the kind exemplified by science-intensive innovation activities such as biotechnology. Edquist et al. (2001) conducted research into product and process innovation, focusing on their comparative contribution to productivity and employment. Broadly, they concluded that productivity increased with both types of innovation, although the former contributed more to capital than labour productivity, while this was reversed for process innovation. The reason for these results is clear: by definition a product innovation creates employment while contributing to increased efficiency (greater quality or value at lower cost), whereas process innovation almost always involves labour-shedding. Considered from a regional viewpoint the region where product innovation predominates should always display high job growth (except in recessions) and capital (technological) productivity. The process-innovating region will lose jobs but gain in labour productivity. The nature and quality of regional production then determine regional growth. Schumpeterian regions should, in theory, constantly reap high profits from radical innovations (see the discussion below on the problem of 'what is radical' in innovation studies) and the region should also reap gains from the constant demand for high-value labour. Labour-intensive production will tend to produce the opposite result, except for bursts of labour productivity occasioned by investments in new process technology.

A different question is addressed in comparative productivity research conducted by Van Ark (2005). His spatial productivity question concerned differentials in productivity and productivity growth between the US and the European Union (EU) in the 2000s. His results were interesting and instructive, and add a dimension of understanding to the centrality of innovation to regional increasing returns in productivity and growth. They identified three key influences on the superior productivity profile of the US over the EU in manufacturing and services. First, most innovative technology – especially pervasive, even radical innovations related to information and communication technology (ICT) – originate in the US, where users have an early opportunity to know about and understand their possible contributions to business enhancement. Second, budgets for investment in improved technology are higher in the US; hence early adopters are more numerous. This was particularly so in services, where EU productivity is poor in sectors like banking, which in some large countries remains mainly paper-based. Finally, knowledge spillovers were identified as an asset to early adopters. Thus a new system of, say, e-commerce introduced to a firm or organization might be disruptive, but collective 'learning-by-doing' means that solutions to problems swiftly circulate the office. Logically, therefore, higher growth from productivity gains associated with innovation should accrue to regions with many innovators and early, communicative adopters – a combination of product innovation in one part of the regional system and process innovation amongst the user community. Stasis or comparative productivity decline would be hypothesized for the non-innovating, non-adopting, non-communicating region.

Felsenstein's Chapter 9 in this *Handbook* addresses the issue of human capital and labour mobility in ways directly relevant to this discussion. He, too, draws attention to three perspectives for illuminating understanding of the relationship between innovation and labour as a factor of production. Though the fit is not perfect, there is some resonance with Capello's taxonomy. The first perspective is that of new economic geography (NEG; after Krugman, 1991) which initially accounted for regional innovation in terms of labour pooling behaviour, namely firms and workers seek out regional market-size and pecuniary externality effects, agglomerating where they find a region where industry has a lead over everywhere else (see also Vatne's Chapter 4 on regional agglomeration in this *Handbook*). This is not hugely dissimilar to the sector-function view on regional productivity. In modelling terms, this approach produces naive results, which Felsenstein calls 'catastrophic' agglomeration (and regional desertification) that have to be corrected technically but which still produce misleadingly overconcentrated spatial results. An alternative that does not fall into the trap of overemphasizing a single type of knowledge determinant of regional growth (for example, science region) is new growth theory (NGT) with which Krugman (1991) is also closely associated, along with Romer (1990) on endogenous technological change. Here, by analysing regional externalities interactively with human capital mobility, the approach estimates the way that human and physical capital, labour mobility and innovation impact on regional productivity and growth. In terms of our earlier discussion on this, theory supports the deduction that the higher the average level of human capital, the more rapid the diffusion of knowledge, therefore the higher the level of regional productivity (including earnings). So NGT allows different kinds of regional knowledge and innovation into the innovation–productivity analysis, in common with Capello's structural approach. However, while human and physical capital are found to impact upon regional productivity, the model results are confounded by a 'regional innovation' effect. Thus a third approach receives some degree of support from this inconsistency, namely evolutionary economic geography (EEG). This, like Capello's cognitive approach, sees institutions, organizations and cultural practices as critical in generating regional growth. Thus cultural and institutional proximity are as important as spatial proximity and the region represents an active innovation agent.

LINEAR, INTERACTIVE AND NEOLINEAR INNOVATION MODELS

The preceding section formed a bridge from innovation via productivity to growth as an explanation of the reasoning behind the use of the 'regional innovation and growth' coupling in the title and main thematic of this *Handbook*. This introduction next proposes to draw up a list of a further six key issues in innovation studies that arise from subjects tackled in the chapters that are of wider relevance, although of central importance to regional innovation systems analysis. As in the preceding section, not all chapters will be invoked in constructing analyses and arguments about these as yet unresolved, indeed in quite large part unraised, topics for debate. Each chapter is introduced according to the seven-section structure of the book. Chapters are alluded to where they can help illuminate the specific issues raised, alongside the broader published innovation studies literature. They are intended to stimulate interest, debate and further research (Box 1.1).

BOX 1.1 SOME CONCEPTUAL ISSUES IN REGIONAL INNOVATION STUDIES

- Beyond the interactive innovation model?
- Radical innovation: how radical is radical?
- The roles of innovator and entrepreneur.
- Path-dependence and new path creation.
- Technological or innovation paradigm and regime?
- System self-organization or system leadership?

The first of these concerns the core concept in evolutionary innovation systems theory and suggests that a re-examination of the received wisdom of the interactive, user–producer critique of the traditional linear model of innovation is now overdue (Lundvall, 1985, 1992). This is for the following reasons. First, in recent research the user–producer interactive innovation model no longer seems to capture the variety of forms that innovation processes may take in time or space. To clarify, when the model was introduced in the 1980s it was because of a perceived necessity to move away from a hierarchical administrative model of the mode of innovation that had appeared with the rise of the modern, especially American, large and increasingly multinational corporation (Hymer, 1976). Conceptually, innovation contained three distinct phases, consisting of invention, innovation and diffusion. In the context of the large corporation this frequently translated into invention being done in the corporate research and development (R&D) laboratory, innovation being done by production engineers, and diffusion being the responsibility of the sales and marketing departments. Each phase was a discrete step. Much responsibility rested on the shoulders of the production engineers, responsible for prototyping, trialling and testing an invention, the scientific origins of which they may only have had a hazy understanding. Some inventions proved unworkable, some R&D projects could seem endless. In this model, the corporate in-house R&D scientist and team were a privileged and expensive elite.

Firms like General Electric, AT&T and RCA were exemplary carriers of this tradition, evolving spatial divisions of labour that separated places where R&D was conducted from places where the other functions occurred. Of course, the needs of everyday practice eroded such rigid conceptual boundaries. Thus university scientists might be given sub-projects where in-house R&D capabilities were lacking; or a scientist or doctor might bring an invention to the corporation for analysis of its potential. Much pharmaceutical invention followed the latter course even though scientific teams were organized like armies of molecule-hunters focused on specific diseases. In those 'linear' times hospital doctors frequently found or made time to conduct patient-based research of an informal kind in the hospital or clinic. In Le Fanu (1999) such 'chance discovery' by scientists and doctors outside corporate pharmaceuticals R&D laboratories accounted for penicillin, cortisone, streptomycin, heart pacemakers and numerous other radical – 'paradigm shifting' as Le Fanu refers to them – treatments for disease. If anything, from the 1940s to the 1990s when productivity requirements brought an end to informal medical research, and biotechnology further 'scientized' it, big pharmaceuticals corporations, despite retaining major R&D laboratories, could be said to be akin to prototype engineering and marketing departments in manufacturing firms. With the aforementioned 'scientization' they are primarily marketing and financing agents for university invention and biotechnological innovation, often by small and medium-sized enterprises (SMEs). Hence, it is arguable that the linear model was never an accurate representation of innovation in 'Big Pharma' and was based on more of an electronics or engineering paradigm.

In engineering, too, the impact of Japanese 'lean production' industrial processes effectively ended the last vestiges of the linear model wherever it might have existed, because here was the apotheosis not of in-house design and production but of the evolution of radically decentralized production by means of outsourcing to increasingly elaborate and globalized supply chains. The manner in which customers and suppliers, now normally independent corporate entities, would negotiate innovation and other product and process qualities had now moved further away from the linear conception presumed of intra-corporate ordering. While subcontracting had been present from the earliest days of the emergence and evolution of capitalism, it had often developed a 'stress' or 'sweating the suppliers' culture. This practice extended, in some industries and economies, even into the 2000s. Not untypically it involved highly capricious requirements being made by customers of suppliers, such as ordering parts, short-term, then changing the order many times before the delivery deadline (Jones, 1984). Accordingly, as in the case of the West Midlands (UK) automotive industry, where it reached its apotheosis, it presaged the oblivion of once important suppliers like Lucas Automotive, on the one hand, and assemblers like Rover, on the other.[2] Elsewhere, notably in the Nordic countries and Germany, with their coordinated rather than 'stressing' or 'cut-throat' forms of supply-chain cost minimization, this was less prevalent. Nevertheless, even in German engineering, notably automotives, despite more benign customer–supplier traditions, organizational innovation occasioned by the rise of Asian luxury car production placed seemingly unsustainable new burdens on suppliers. Hitherto, these had been meticulous executors of blueprints handed down from the customer design engineering department: now, they were themselves required to innovate in fulfilling client requirements. The threat of outsourcing to innovative suppliers outside the region or transplanting supply to newly liberated, low-wage Eastern Europe acted as an incentive.

A common way of innovating organizationally to meet Asian competition was to relax corporate hierarchy slightly, moving towards matrix management, which allowed for greater cross-departmental teamwork, and giving innovation a project-based character. 'Simultaneous engineering' (also known as 'concurrent engineering') brought representatives from marketing departments into project teams with engineers, designers and external suppliers to develop innovations. It is matrix management, and giving innovation a project-based character, that captured the core of user–producer interactive innovation. Thus, the modern marketing manager had become expert in framing issues relating to user needs. Meanwhile, the supplier or producer was increasingly external to the intermediate user corporation. From an innovation perspective, the following question was posed: 'How can the producer know the needs of potential users, when markets separate users from producers?' (Lundvall, 1992, 50). Lundvall's answer is somewhat Nordic: 'The relative importance of product innovations indicates that most markets are organized markets' (Lundvall, 1992, 51). This involves information exchange, cooperation, hierarchy, mutual trust, with durable and selective relationships. This is an important observation of the social embeddedness of markets, against the neoclassical view that they are atomistic and utilitarian, which is what was being critiqued. But while the point is made that we should expect to find user-driven, or customer-driven innovation as it is now commonly referred to, in this, it might at times be more producer-driven (for example see below, also Chapter 43 on design-driven innovation in this *Handbook*). As will by now have become clear, the ensuing complexity was in general beginning to be tackled by 'collaborative manufacturing' (Sabel et al., 1991).

Into this lacuna has stepped a discourse of 'neolinear' innovation models that are in key ways anathema to the notion of durable, loyal and selective principal–agent relations between producers and users presented above. Times have changed and the EU requires competitive tendering, although such rules are not so difficult for firms and organizations to innovate around and there is much regional variation in observing the letter of the law (for example on food procurement; Morgan et al., 2006). But much more far-reaching than the imposition of supranational and national transaction rules since the 1980s has been the wholesale removal of them, particularly during the neoliberal epoch that commenced then. In Engelen and Faulconbridge (2009), reference is frequently made to the geography and variable quality of financial regulation between national regulatory regimes. They note the fact that California and Florida were engines of subprime mortgage demand, but miss the fact that it was geographically variable deregulation that both stimulated 'securitization' of everything, from fish catches to student loan pools, and that it was initially only legal in a handful of US states, mostly in the sunbelt as such. Producer-driven innovation had come to dominate financial services.

Securitization began on Wall Street when Lewis Ranieri, a utility bond manager at Salomon Brothers, innovated the first collateralized mortgage bond (CMB) that fathered the collateralized debt obligations (CDO), which brought the global financial system to its knees. Much lobbying of Washington by Ranieri and others legitimated this risky trade, which along with the Clinton administration's repeal of the Glass–Steagal Act incentivized normal banks to become investment banks, gambling with their investor capital. We might refer to this as 'supply-driven' financial innovation because the normal mortgage market was starved of capital for new loans, while deregulation enabled securitization to provide mortgage firms with instant returns from banks buying the loans and transforming them into tradeable bonds. The user–producer interaction in this kind of innovation gives effectively zero innovation capability to the user. Even over time, the user does not become increasingly familiar with the inner workings of the innovation or, indeed, the codified let alone the tacit knowledge behind it. Ultimately, even the innovators did not understand the basic modelling flaw, which was that the data utilized to estimate CDO probabilities of defaulting were inevitably historically based. Therefore, anything worse than the historical trend could not be predicted or, in a cognitive sense, understood or intuited except by a few heretical 'outsiders' (Patterson, 2010; Lewis, 2010). Without labouring the point, it can be seen that other areas of deregulation such as energy and telecommunications also gave rise to supply-driven innovation opportunities but also casualties in earlier times.

If the user–producer innovation interaction is non-existent in financial innovation, it is only slightly less so in respect of another 'neolinear' variety known as design-driven innovation (Verganti, 2006; see also Chapter 43 on design-driven innovation in this *Handbook*). Verganti holds that design-driven innovation is akin to 'technology-push' innovation as conceived by Dosi (1982) as being capable of provoking regime and/or paradigm change in dominant technologies and innovation trajectories. Verganti's (2006) field of interest is the Lombardy regional innovation system, particularly its overlapping and interacting design-intensive furniture and kitchenware clusters, where the equivalent to a technological paradigm is a socio-cultural paradigm. Instead of technology, its discourse is meaning, and by changing meanings designers, like technologists, are capable of changing paradigms and regimes through innovations that entrepreneurs commercialize. This innovator–entrepreneur division is quite pronounced here, with 'circles' of external as well as internal designer-innovators iterating rounds of 'meaning analysis' to set an exclusive tone for new ranges of design-intensive products to be 'proposed' to consumer markets (Pisano and Verganti, 2008). In neither supply-driven nor designer-driven innovation models is there significant change in the key source of impulse, the producer, over time.

A third 'neolinear' innovation model is referred to as user-driven innovation. First articulated as such by Von Hippel (1988), his research showed that often technologically radical innovations such as the semiconductor, apparently 'producer-driven' in its design by AT&T's Bell Laboratories (as they were in the 1960s when the innovation occurred) and their leading micro-electronics scientist William Shockley, were largely defined in the extremely detailed specifications of their ultimate user, the US Department of Defense. Other innovations of the time were shown to be considerably more user-driven than believed at the time, notably gas chromatography, thermoplastics and magnetic resonance equipment. However, many of Von Hippel's examples include manufacturer rather than user-driven innovation, suggesting mainly that the kinds of highly technologically advanced innovations he is concerned with are less determined by 'producer power' than the two preceding models.

As Verganti (2006) sees it, user-driven innovation, whose main input is market research, the data for which are often highly technical (for example eye-tracking equipment) and statistically rigorous consumption analyses, predominates nowadays in mass consumer product markets because competition is so fierce that even marginal nuances concerning packaging, advertisement or product placement design can be advantageous. Contrasting this with what he conceives as 'paradigm-shifting' design-driven innovation which, after Dosi (1982), regarding radical 'technology-push' innovation also inclines to the radical, he sees 'market pull' or user-driven innovation as always incremental. This, however, betrays Verganti's product innovation bias. Contrariwise, if organizational innovation in service markets is considered, the radical nature of the introduction of supermarkets, fast food outlets (including drive-through), budget airlines, mobile telephony and Internet finance, to name a few, would suggest that not all mass market innovation is user-driven, and that such markets can sustain radical innovation. In Von Hippel's (2005) more recent work on the democratization of innovation, he suggests that a notable share of contemporary innovation has become user-driven, citing many leisure industries in support, such as mountain bikes, hiking and mountaineering gear, snowboards, sailboards, microlite aircraft and microbreweries as cases in point. To some extent regional and organic food can be subsumed here. However, the hobbyist tone that many of these entail suggest this to be a noteworthy but limited niche of primarily incremental innovation. Moreover, the commercialization of such products usually reveals that entrepreneurs remain at the heart of the imitation process, expropriating the innovators or recombiners of knowledge, much as Schumpeter predicted.

Finally, attention must be drawn to a variant of user-driven innovation: demand-driven innovation, where increasingly what were perceived as interchangeable terms now denote different scales and kinds of innovation. This is now clarified to mean collectively specified demand for major public investments that may not be forthcoming through markets due to market failure. States, national or regional, must coordinate demand and supply as users defining demand to producers. Hence at times user drivers supersede producer drivers and vice versa because many technologies and institutions must combine systemically through 'strategic niche management' to achieve success. This is exemplified where regions seek transition towards sustainability. The complexity of this tends to mean that though specific eco-innovations are incremental, in combination their effect is 'paradigm-shifting' under a sustainable technology regime or even production–consumption 'landscape'. The latter is a long-term expectation in 'co-evolutionary transition' theory, capable of being glimpsed in 'transition regions' which, nevertheless, must coexist with the broader, global, hydrocarbon path-dependence and its prevailing regulatory regime.

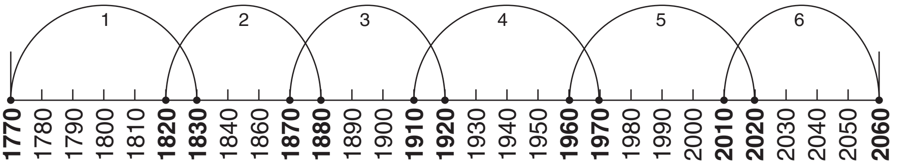
It is important to understand the role of discourse articulation in stimulating change from established development paths. Just as neoliberal discourse formed the basis for a thoroughgoing critique of the regulated character of financial markets, so in such sustainability hot spots as Denmark, critical discourses were articulated to undermine prevailing norms (see also 'Green innovation', Chapter 32 in this *Handbook*). The first of these was an anti-nuclear energy discourse; the second was its reverse, a pro-renewable energy discourse. Protest movements acting out the discourse brought reversal of government policy, suspension of nuclear energy policy and redirection of Denmark's nuclear research towards renewable energy research. In such demand-driven innovation settings, subsidies are a necessary element of 'strategic niche management' and can be found being made to consumption rather than only to production. The Danish case involved what *ex post* is revealed as a successful consumer subsidy policy regime that more than paid for itself in tax returns from wind turbine production. From the early 1970s, government subsidies were made available to users of first-generation wind turbines. This sustained the industry, initially based largely upon domestic demand, and enabled the north and mid-Jutland-based cluster's design to evolve considerably from its path-dependent roots in agricultural and marine engineering where the plough and the ship's propeller were the inspiration.

RADICAL INNOVATION: HOW RADICAL IS RADICAL?

In neo-Schumpeterian innovation theory, innovation can be radical or incremental. Why only these two alternatives? The answer can be found in the intellectual origins provided by Schumpeter's theory of business cycles (see Andersen's Chapter 2 in this *Handbook*). These are waveform fluctuations that can be traced statistically through the evolution of capitalism. Also known as 'long waves', they have been applied in regional science to explain the rise of 'new industrial spaces' such as Silicon Valley (Hall and Markusen, 1985), spatial processes underlying globalization (Dicken, 1986; Knox and Agnew, 1994), regional development (Marshall, 1987) and regional innovation (Martin and Simmie, 2008) among many others. Figure 1.1 presents a stylized representation of these waves since the onset of the Industrial Revolution and into an uncertain future where, nevertheless, the not unreasonable emphasis on nanobiotechnology and neuroscience arises from economic geographer and evolutionary biologist Zack Lynch's BrainWaves weblog.[3] The key point in respect of the neo-Schumpeterian perspective on innovation is that long waves are the linchpin of its scientific theory, analysis and to some extent predictive power. Innovation is the engine of capitalism, long waves set its course for epochal periods, and creative destruction represents the punctuation of its evolution caused by radical innovation.

Accordingly, each of the six epochs in Figure 1.1, with the possible exception of the last one, represent widely accepted as key evolutionary moments of the capitalist era.

Six Long Waves of Techno-Economic Development (1770–2060)



Long Wave	**Mechanization**	**Railroadization**	**Electrification**	**Motorization**	**Informatization**	**Neuro-nanobio**
Time Period	1770–1830	1820–80	1870–1920	1910–70	1960–2020	2010–60
New Inputs	Water Power	Steam Power	Electric Power	Oil	Micro-processor	Biochip, Brain Imaging
Driving Industry	Textiles	Railways	Electricity	Automotive	Micro-computers	Nano-biotechnology
New Industry	Canals, Cotton Mills	Steamship, Telegraph	Motors, Power tools	Aerospace	Software	Neuro-theranostics

Source: Based on Z. Lynch, http://www.neurosociety.com.

Figure 1.1 The waveform evolution of capitalism (1770–2060)

As such, they had sometimes brutal (hand-loom weavers rapidly obsolesced by factory production), sometimes gentler, more long-lasting transitional impacts upon societies in which they occurred (such as the evolution of motorization). To the extent that society's norms had become embedded in the dominant preceding technological regime it could be its regulatory, socio-economic governance instruments that enforced constraints to hold back the negatively perceived impacts of such radical change. In the UK, the Factory Acts moderated the depredations wrought on factory workers; the 'Red Flag Act' set motorized speed limits of 4 mph in the country and 2 mph in towns, with a man walking ahead warning locals by flapping a red flag; while steam still has to give way to sail at sea. Hence the concept of technological 'regime' became an important accompaniment to the concept of 'technological paradigm' associated with the radical innovation and its pervasive influence in itself. As noted, this regime–paradigm distinction weaves through the main elements of the regional innovation systems framework. There, the paradigm is the firm-based 'exploitation' or 'commercialization' subsystem, while the regime is the socio-economic governance subsystem that sustains it.

However, as is well known, for the neo-Schumpeterian school radical innovation is accompanied by incremental innovation, which occurs during the paradigmatic epochs as marginal improvements are made under broadly technologically equilibrium conditions. This is when path-dependence resumes, albeit renewed and redirected, following the punctuated evolution caused by creative destruction. As Martin shows in Chapter 15 of this *Handbook*, elements of this may set in early, such as the QWERTY keyboard still used in iPhones, or late, as in the case of increasingly efficient automotive engines in the face of 'peak oil', global warming and renewable energy vehicles. Late path-dependence is a frequent response to perceived paradigm shift as discussed by Dosi (1982) and Freeman et al. (1982) in respect of advances in clipper ship technology in the face of steam, or piston engine aircraft in the face of jet engines (Geels, 2006). But, in any case, it is a key tenet of neo-Schumpeterian innovation studies that incremental innovation is regular, common and more of a central feature of innovation than radical innovation. In Lundvall (1992) it is clear that this is a necessary consequence of the rise of user–producer innovation relationships. Geographical and cultural proximity are assets in the tacit knowledge exchange this implies: 'distance will play an important role. Being close to advanced users will form a comparative advantage for the producers and vice versa . . . they base their comparative advantage upon geographical and cultural proximity' (Lundvall, 1992, 57–8).

The contrasts between this and 'radical innovation' are stark. Norms, codes and standards become inadequate, producers lack communicability and users become confused. Geographical proximity thus becomes even more important because face-to-face contact, trust and even friendship are the only solvents of cognitive radical innovation blockages. Accordingly, radical innovation is disturbing and unsettling until the new paradigm has demonstrated its value, and hitherto resistant multinationals, for example, start to make acquisitions of new paradigm start-ups.

Hence, there is long-wave-inducing innovation interspersed with epochal passages of incremental innovation or 'normal science', an idea taken from Thomas Kuhn's (1962) pioneering research on the 'structure of scientific revolutions'. Clearly, such a restrictive binary division between these opposites is inadequate, except as a guide to certain interesting cultural and geographical 'infrastructures' of innovation as implied by the user–producer, interactive critique of the prevailing command model of linear innovation then prevalent. Thus not long afterwards Christensen (1997) introduced a more cost-based, middle-range distinction between 'disruptive' and 'sustaining' innovation; the first occurring with the 'democratization' of innovations, creating mass markets by cost reduction that disrupts the market for hitherto dominant technologies. 'Sustaining' innovation is the opposite, where to sustain a presence firms innovate upwards, making more exclusive, expensive products. However, these are fundamentally marketing rather than innovation strategies, since in both cases the 'innovation' to be re-packaged already exists. Nor does this possible solution pretend to have the theoretical depth to trace the socio-technical and economic-geographic implications of creative destruction displayed by the neo-Schumpeterian approach.

Verganti's work on design-driven innovation discussed above also introduces a different, less epochal or long-wave take on radical innovation, which is nevertheless neo-Schumpeterian in its theorization. Design is defined as dealing with the meanings people give to products, and the messages and product languages that can be devised to convey meaning– 'de-sign', 'signing it' and giving it 'sign-ificance': 'design is making sense of things'. It also has paradigmatic representation in distinct design languages. Thus innovation of meanings is incremental if framed within existing aesthetic norms, but radical when significant reinterpretation of meanings is achieved. Radical innovations in meaning are not immediate and imply profound changes in socio-cultural regimes. Product ranges may be transformed from simple tools to 'transition objects' intended to appeal, for example, to child-like affections dormant in adults. The innovation model of a firm such as this means it pushes innovative design onto the market, as 'technology-push' does, with radical effect. The discourse is one of making proposals to the potential consumer or user of the innovation. This is not 'technology-push' but 'design-push' and conceivably 'regime-push'. Design is not inclusive but negotiated by members of knowledgeable 'circles', some with hierarchical structures (Pisano and Verganti, 2008). However, this is clearly not 'epochal' but more 'episodic' radical innovation. It is economic but it is also symbolic, invoking 'creative destruction' in the relatively short-term aesthetic sphere.

Accordingly, from within the same broad theoretical perspective we have, first, an 'epochal', long-wave technological radicalism that has pervasive and transitional effects on communities and markets of many if not all kinds. Contrariwise, in more specialist markets we have 'episodic' radical innovations that are transformative of taste and affection towards objects. These may spawn radical innovation in related fields, even contributing to a broader 'design-intensive' product ethic, while drawing process and content novelty from 'epochal' innovation such as widespread computerization in society. It displays interactive qualities between the design 'paradigm' and the 'regime' of ideas, norms and standards that envelops it cognitively. In these respects, and drawing attention to the possibility of other varieties of radicalism in innovation, this marks an important enrichment of the neo-Schumpeterian perspective on regional innovation.

THE ROLES OF INNOVATOR AND ENTREPRENEUR

This is a lesser order of issue for the perspective informing this *Handbook* than the preceding ones concerning relations between innovation and growth; linear, interactive and neo-linear innovation models; and 'epochal' versus 'episodic innovation radicalism. It has, nevertheless, long been a grey area in innovation studies where they can be treated as the same thing or even act as substitutes. Thus Garud and Karnøe (2001), in a widely cited review of the literature on path-dependence (see Chapters 14 by Boschma and Frenken, and 15 by Martin, in this *Handbook*) discuss innovation only in terms of entrepreneurship, not innovators. It can, of course seem pedantic to dwell on this, but in the absence of any discussion as to why entrepreneurship is being privileged the reader is justified in querying the usage. For a moment's thought reveals that it is arguable that most entrepreneurs are not innovators or indeed innovative. Those that are can often be seen employing specialist professionals to manage innovation. This is pronounced in fashion design as we have just seen, and can be observed in the haute couture industry studied by Wenting (2008), where signature designers are hired routinely as in-house or freelance consultants. But this separation is not confined to fashion for nowadays innovation in, for instance, the automotive and knowledge-intensive services industries is subject to comparable outsourcing. In automotives, this ranges from the combustion engine consultancy A.V. List in the Steiermark region of Austria, where research, experimentation and examination of engine technology are conducted for leading global brands, to the production and prototype design habitually done by consulting engineers in other parts of the automotive industry (Schamp et al., 2004; Strambach, 2008).

This is unexceptional and yet another marker of the rise of user producer innovation across the economy, as lean production has eroded the hitherto 'M' form of departmentalized corporate hierarchy. This reached its apotheosis in the era of ambitious claims about the virtues of economic and spatial planning. In Chapter 2 by Andersen in this *Handbook*, neglect of innovation in the literature is put down to the interest of 'post-Schumpeterian' regional economists in growth modelling, where innovation was forgotten because its dynamics were also less amenable to formalization. They were more interested in static interdependence between different parts of the industrial system and its translation into policies of regional development planning. According to Andersen, Schumpeter was of the opinion that an innovation could neither be implemented nor financed by its inventor. This is because the inventor of the innovation (or innovator, a term Schumpeter is not recorded as using much, if at all) requires the skills of the entrepreneur to implement the innovation, including borrowing the necessary capital and establishing a new firm to invest it. The entrepreneur may also recombine other innovations in the new firm, but the innovations are by someone else (that is, the Schumpeterian 'inventor'). So, as the word implies, the entrepreneur is the active intermediary (middleman) among the active knowledge source (inventor or innovator), active financial source (bank) and the active market (attracting customers).

This makes sense, even in early capitalism, because engineering skills to invent or innovate were specialized even then, as Uglow (2003) shows for the Boulton and Watt relationship in marketing steam engines, most of which were sold to Cornish tin mines, largely at the behest of the entrepreneur Boulton rather than the engineer Watt. Nowadays, in innovative industry such as digital services or genomics, venture capitalists play a role comparable to that of the Schumpeterian entrepreneur. Typically, they provide finance, are likely to be involved in establishment of a start-up or spin-off firm and will oblige the inventor or innovator to accept that the firm should have both coaching and professional management, something academic entrepreneurs sometimes refuse, thus killing the deal (Hellmann, 2000). In reality, the innovator may be an entrepreneur, but such hybrids are unquestionably a tiny minority. Most entrepreneurship is, again in reality, moderately routine: even venture capitalists, like consultants, have their methodology worked out and it probably does not change much in its essentials. What may distinguish them is their relatively sophisticated knowledge of specific technologies, necessary to help determine investment risk. As today, the Schumpeterian entrepreneur could actually also be a serial entrepreneur, although this was disallowed in his analysis for technical reasons. Finally, this analysis is based on Schumpeter I; in Schumpeter II oligopolistic corporations were increasingly also innovators, meaning that in-house 'entrepreneurship' and use of retained profits, outlawed in Schumpeter I, could be used in innovation investments.

PATH-DEPENDENCE AND NEW PATH CREATION

This is also something of a dependent variable in relation to the bigger picture of 'punctuated evolution' and 'creative destruction'. It arises from the perspective that equilibrium prevails in economic development, but that it is epochally 'punctuated' by radical innovation and relatedness of innovation associated with the 'carrier wave'. The idea of 'path-dependence' (David, 1985) is intended to capture this claimed characteristic of innovation, namely that its resonances may persist right through the long intervals and possibly beyond. This is rather akin to the echoes of the 'Big Bang' that signified the birth of the universe that may still be observed amongst the universe's background noise by astrophysicists. But does it serve the same purpose of confirming one theory and inclining to disprove a competing theory (for example the 'steady-state' origin of the universe)? What is served by showing persistence in a subject-field that is largely devoted to understanding how socio-economic and technical novelty and innovation occur? In one respect, it is a little like listening for the echoes of Big Bang in seeking retrospectively to understand why things are as they are. In David's (1985) study, the focus was the QWERTY keyboard, still utilized in today's digital micro-devices because, although better arrangements have been innovated none has been adopted, largely for institutional, practical reasons at the behest of users. This is helpful, as it underlines the fact that 'institutions matter' in technology analysis and that it is indeed a human artifact rather than a disembodied and societally neutral device or procedure.

Much the same can be said for the subject matter of this *Handbook*, regional innovation and growth. The urban and regional socio-technical paradigm changes, sometimes quite dramatically, as in recessions or lengthier periods of industrial decline. The spatial regime that accompanies it can, according to inherited theory, only change with difficulty and slowly, if at all, because it is institutionally path-dependent. This means that the education system, the standard social norms and expectations, the skills base, even the means to be entrepreneurial or innovative for most firms and people are path-dependent, and the region in question is 'locked in' to an obsolescent socio-technical regime. This is rather a strong explanation that can find good empirical support in some regions, notably older heavy industry regions formed in the early Industrial Age. Yet, as Boschma and Frenken's Chapter 14 in this *Handbook* shows, much evidence is emerging that the more accomplished regional economies are those with relatedness to established industrial structures. In other words, new path creation is possible and actually occurs.

The acid test is, perhaps, coal mining regions. In the UK, France and, to a lesser extent, Germany such regions seem to illustrate the path-dependent, locked-in profile quite well. However, in the Netherlands, where much of the early work on relatedness was conducted, its former coal mining region of Limburg prospers. Why is this? One important reason is that the former state-owned concern Dutch State Mining (DSM) was privatized and chose to diversify, first into chemicals, and more recently into 'biologics' or inputs into biotechnology and pharmaceuticals (for example vitamins). This 'Nokia-type' strategy of internal corporate transformation has also served the region, as well as DSM's shareholders, well. Innovative links with regional, and later global, universities have assisted these efforts. This is an example of what Martin (Chapter 15) refers to as industry-focused evolution from path-dependence, but in a context of radical renewal (not necessarily radical innovation). Indeed it is more akin to Verganti's version of radical innovation in that there is episodic, large firm-led technological paradigm shift, which happens also to be interactive with a relatively modernizing socio-cultural regime in the Limburg region. One hypothesis about the unexpected event has two sub-elements: first, weak relatedness and, second, an inappropriate socio-cultural (including political) regime. The UK is easily the country that most evolved regional unrelatedness in ushering into old industrial regions branch plants in many kinds of light industry as its regional policy. Germany, by contrast, has not entirely unsuccessfully benefited from path-dependent relatedness among coal, pharmaceuticals, steel and engineering in its policy, and France is somewhere in between.

Thus relatedness offers niche understanding of ways out of negative path-dependence as a policy that encourages entrepreneurship from innovation around established industry branches. The aim is to diversify from an 'industrial monoculture', but not too distantly in terms of industry profiles. This happens more as a norm of regional innovation in the Nordic countries, as three brief sketches show. First, as Chapter 32 on 'Green innovation' in this *Handbook* shows, Jutland, Denmark's expertise in wind turbines, followed by power station design and other eco-innovations, stems from path creation from marine and agricultural engineering. Vastragotland's (Gothenburg region) loss of ship construction was mitigated by the build-up of automotive engineering and the development of technical expertise and innovation in specialized ship component subsystems sold to the Asian shipbuilders who displaced them but still need such expertise. Finland's pulp and paper equipment industry sought less reliance in Finland and in the case of ValMet (Vaasa region) diversified into luxury sports car assembly (Porsche Boxter). When the parent repatriated assembly to south-west Germany in the 2007–09 recession, a contract was won to assemble US firm Fisker's electric sports car. These are sufficiently related business moves to enable rapid adjustment, notably in relation to the engineering skills base of the industry in question. Accordingly, while regional innovation must pay attention to analysis of, especially, negative path-dependence, its prime focus will remain better understanding regional innovation by judicious new path creation.

TECHNOLOGICAL OR INNOVATION PARADIGM AND REGIME?

With its origins in economic geography and applied regional economics, the language of regional innovation systems research is not significantly influenced by that of the national innovation systems approach, part of the origins of which reside in the analysis of science and technology and its relationships to society (but see Asheim and Gertler, 2005; Asheim, 2007 for a more 'national' view of regional innovation). Many early definitions of that field of study betray those origins, giving what Lundvall (1992) refers to as the 'narrow' definition of innovation:

> we may make a distinction between a system of innovation in the narrow sense and a system of innovation in the broad sense. The narrow definition would include organisations and institutions involved in searching and exploring – such as R&D departments, technological institutes and universities. The broad definition . . . includes all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring. (Lundvall, 1992, 12)

The narrow definition is influenced by the American perspective of the time, as conveyed by Nelson (1993) and Rosenberg (1994), in which innovation was seen as largely technological. As we have seen, the roles of R&D departments (for example Bell Labs) had been instrumental in evolving the technological lead of US firms and the economy more generally. The phenomenon of computerization and its later 'democratization' in the form of personal computers owed much to military and other government contracts paid to large laboratories from which new technology firms spun out. This, captured in the rise of territorial technology complexes like Silicon Valley, needed to be understood. Economic geographers and regional scientists were in the vanguard in this task (for example Hall and Markusen, 1985; Scott, 1988) but were typically rather technology-struck and descriptive rather than analytical.

Accordingly, the technology emphasis to innovation studies in the narrow sense hung over the field for a long time. Even when more nuanced analyses of systems of innovation emerged in which the enveloping regime of regulations, standards and rules gave social content to the narrow view, thus broadening it out somewhat, the discourse was of technological paradigms and regimes, sometimes techno-economic in the latter case (Dosi, 1982; Freeman et al., 1982). Contrariwise, the broad definition of innovation that Lundvall alludes to in the quotation above was really far too broad, although he nuanced it somewhat by saying that at different epochs different subsystems of the whole economic structure and institutional set-up would be the focus for study of innovation. Thus workshop systems would be the focus in study of the earliest epoch of the Industrial Age; the electrification epoch would put newly emergent R&D labs under the microscope; while the Information Age would highlight universities and academic entrepreneurship. Yet, as is evident, the perspective on technology remains resolutely to the forefront as the broad view of innovation is whittled down to manageability for research purposes. Even then, accounts of national innovation systems such as those in Nelson (1993) could be fairly sprawling and with low analytically based comparability across national cases as a partial consequence. To try to achieve some further kind of manageability, researchers specialized more in technological or sectoral innovation systems analysis (Carlsson and Stankiewicz, 1991; Breschi's Chapter 10 in this *Handbook*) but technology again dominated and the measurements deployed in sectoral comparisons were often not measures of innovation but of invention (patents, R&D expenditures).

Importantly, therefore, regional innovation systems research involved neither only the narrow technology focus nor the complexities of trying to research exemplar subsystems of epochal technology regimes in relation to leading technological paradigms. Crucially, it depended heavily on theory, on the one hand; and tailored empirical research on firm and organizational innovation, on the other. This is not to say that the regional perspective produced results or insights superior to the others, mainly because the focus was different, but rather to say that its methodology was more grounded and its data for testing propositions was focused entirely on processes and institutions responsible for innovation. This is accounted for clearly in chapters in this volume such as Tödtling and Trippl's Chapter 33 (see also Tödtling and Trippl, 2005) and Heidenreich and Koschatzky's (Chapter 39). In the former, the authors emphasize the taxonomic approach to analysis of difference, which enabled research-based testing to eventuate in typologies that were both valuable for comparative analysis and for the design of regional innovation policies. Furthermore, because of the regional science and regional policy origins of the perspective, innovation systems research examined more deindustrializing and rural regional settings than ever occurred in the technology-focused work of national, technological or sectoral systems research. Thus an innovation focus has paid dividends from its comparative and primary empirical emphases, as it has from its encompassing of the study of innovative aspects of regional governance. Heidenreich and Koschatzky note the importance of this in highlighting variability in regional governance powers as key elements in understanding the structure of regional economies, especially in Europe. As they show, there can be swift recovery from economic setbacks where there are political commitments to regional innovation and resources to implement them, and the opposite where these are absent, citing contrasts between Spanish autonomous regions and much weaker governance set-ups in support of their argument. This is extended *a fortiori* to federal governance, where despite the traumas of transition, notable successes have been registered around regional innovation strategies in Thuringia, Saxony and Brandenburg in former East Germany, indicating the advantages of 'regional experimentalism' of the kind that regional innovation analysis is well-attuned to (Sabel, 1995).

It has been noted in the section of this 'Introduction' on neolinear innovation models that there is still much to be gained from adapting foundational concepts such as technological paradigms and socio-technical regimes to less narrow and also less epochal subjects than long waves. Verganti's (2006) adaptation of technological to socio-cultural regime is innovative in the manner that it shows how the broader 'regime' concept, first introduced in international relations studies (Ruggie, 1975) can be usefully deployed more episodically and regionally than hitherto. Similarly 'design paradigm' speeds up the application of what began life, after Kuhn (1962), as a concept denoting less than long-wave longevity. Accordingly, preference should generally be shown for utilizing the terms 'innovation paradigm' and 'innovation regime' where they are found analytically useful. 'Regional innovation paradigm' is not strictly synonymous with 'regional exploitation sub-system' (one of the two subsystems in a regional innovation system, as demonstrated in Tödtling and Trippl's Chapter 33 and Heidenreich and Koschatzky's Chapter 39 in this *Handbook*.) This is because paradigm denotes 'dominance' (prevailing) whereas an 'exploitation subsystem' denotes variety (for example clusters, oligopolies, supply-chain elements coexisting regionally). But as long as usage is clear, reference to, for example, Lombardy's 'design-driven regional innovation paradigm', to paraphrase Verganti (2006), seems unexceptionable. Equally, 'regional socio-cultural regime' adds value and takes innovation away from its hitherto prevailing technological bias. Research on precisely this phenomenon has been conducted in the EU 6th Framework Programme in the Corporate Culture and Regional Embeddedness (CURE) project (http://www.cure-project.eu/; Heidebrink and Soul, 2007). The research reveals significant regional socio-cultural regime distinctiveness interacting in path-dependent and path-creating ways with corporate innovation practices in production, organization and marketing.

SYSTEM SELF-ORGANIZATION OR SYSTEM LEADERSHIP?

Finally, we arrive at a culminating issue that is of wide-ranging importance to regional innovation systems studies, not least because it addresses a conceptual and real issue about systems. This concerns the extent to which 'practice systems', of which regional innovation systems are an exemplar, are intended to achieve optimal efficiency and effectiveness through tending towards autopoiesis or self-organization, or through a hierarchical form of directed organization involving system leadership (Wenger, 2000). Clearly, the latter concept has received much attention in business school literature in the shadow of airport biographies of the likes of 'Neutron Jack' Welch, former chief executive officer (CEO) of General Electric, who is presented as almost single-handedly turning around the fortunes of that company through aggressive cost accounting, including an infamous annual cull of the company's bottom-performing 10 per cent with massive workforce reduction during his period of stewardship. Such beliefs spawned a plethora of consultancy reports and business school articles and books on 'leadership', drawing on heroes as varied as football coach Vince Lombardi, Sun Yat Sen and Antarctic explorer Sir Ernest Shackleton. The business writings of Machiavelli were even pored over for the guidance of modern managers.

In the Welch era, GE's pollution of the Hudson River made the company a target of the US environmental movement, but post-Welch the firm's two key marketing campaigns, 'Ecomagination' and 'Healthymagination', repositioned GE as a champion of green technology and healthcare initiatives. Even so, the company's once huge financial services division, GE Capital, a Welch-inspired innovation supplying 55 per cent of GE revenue, reported \$500 billion in debt occasioned by the credit crunch and bad loans. Recourse was required to the US Treasury's Troubled Asset Relief Programme (TARP) for a \$3.5 billion loan in 2008. Separately, GE was forced to retreat from the media business, selling its controlling stake in NBC Universal to Comcast. An accounting scandal and dividend cut dented its reputation for financial reliability, and in Britain it was accused of medical censorship after it took a radiologist to court for claiming that there were potentially fatal side-effects to one of its healthcare products. It could be argued that this and other hard-driving corporations, notably Royal Bank of Scotland and Lehman Bros, were not especially advantaged by charismatic leadership in difficult times.

What about softer forms of leadership in more 'loosely coupled systems' typically found in regional innovation systems? Sydow et al. (forthcoming) study this comparatively. They conceive it as involving motivating, involving, empowering, supporting, sense-making, mobilizing, controlling, manipulating, legitimizing and representing. They suggest that it is not so different from internal management in the large corporation; but in one respect more than the others, regional innovation system management, possibly more than clusters, can have parallel and rotating leadership of action lines in pursuit of strategic aims. Stakeholder governance of regional innovation systems means that they are appropriate vehicles for such focal and temporary management of specific actions, and it is a method for keeping commitment from the relatively high-powered individuals who are likely to find themselves invited to serve on innovation system governance networks. This is not self-management; it is leadership by a collective organization responsible for managing, for example industry clusters and it may pass swiftly or rotate among incumbents who are not employed and may not even be reimbursed expenses. Innovation system management is unlike cluster management in being this step nearer to autopoiesis since it is unusual to find a cluster without a cluster-management team in the form of a network (for example the Cambridge Network Ltd) or a common services council (for example Massachusetts Biotechnology Council). Variable governance of multi-client subsystems maintains the loose coupling and related flexibility, variety and reflexivity of regional innovation systems.

The key problem of overpersonalized leadership as revealed in the Sydow et al. (forthcoming) study is that when the charismatic leader steps aside there may not be an equivalent available to replicate any successes of the past; worse, the system may crumble

– precisely the result in the Arizona optronics case that is one of Sydow et al.'s exemplars. Thus while collective leadership might not be autopoiesis of the self-organizing kind that systems thinking tends to favour, it is far less risky than the 'cult of the personality' that is its diametric opposite. This is analysed in relation to Lombardy's design-driven regional innovation paradigm by Pisano and Verganti (2008), where a hierarchical, exclusive circle of experts is deemed the appropriate collaboration model. Given the obvious weaknesses of personality cult 'leadership' – especially for non-corporate, stakeholder, loosely coupled systems – the uncertainties of commitment that can be imagined from a flat-hierarchy, network-managed, loosely coupled arrangement, perhaps Wallin's (2006) model of 'orchestration' is an elegant compromise, embodying the notion of 'conducting' as an expertise distinct from that of being the highly expert leader of the orchestrated woodwind or violin section. The role of 'orchestration' is developed at greater length in Chapters 23 and 42, in this *Handbook*.

NOTES

1. Articulating this took longer. It occurred first in the Introduction to Braczyk et al. (1998), the original manuscript for which was written in 1995, lost by the publisher during an ownership change, then rediscovered 18 months later. It could easily have come second to a rival project with which at least two of the editors of the present volume (Asheim and Cooke) were associated. For also in 1995 a regional innovation systems seminar was held in Oslo, chapters for a book were prepared, and co-editor Keith Smith from the Science, Technology and Economic Policy (STEP) research group in Oslo impressed on authors an evolutionary systems approach to regional innovation. But the project was never completed.
2. Interestingly, this 'stressing' effect was not unknown in 'lean production' as practised by Japanese companies. Thus Cooke and Morgan (1998) reported evidence of, for example, Panasonic requiring annual incremental innovation of parts from its in-house *keiretsu* suppliers (typically a 3 per cent cost reduction and increased quality) to the point where this could not be achieved. The supplier then vacated the market, the customer turning to obliging suppliers elsewhere. Acculturation to this mode of cost control meant suppliers constantly searching for and selecting new customers, often for largely unfamiliar products, something which is now far more widely practised as a survival strategy in European engineering (Knie and Hård, 2010).
3. The term 'neuro-theranostics' refers to treatments that are both therapies and diagnostic treatments in neuro-medicine.

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