Chapter 6
Transition Regions: Green Innovation and Economic Development

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1 Introduction

This chapter has three main aims. The first of these is to discuss and critique the main spatial and non-spatial theories that address methods by which societies may transition from a hydrocarbon to a post-hydrocarbon technological regime. It is argued that the first approach, which combines urban regime theory of politics with ecological modernisation theory, is ultimately contradictory and rooted in an inadequate "sustainability" discourse. The second approach is more interesting, not least because it adopts an evolutionary rather than a conflict perspective, it visualises the problem as "climate change" rather than "sustainability" and it conceptualises change beyond the level of mere technological regimes of a Schumpeterian kind. It allows the strategist to progress from the potential of building a "green" market *niche* that includes the urban governance stimulus but is not limited by it. Then it facilitates thinking about how such niches may coalesce to form an intervening "green" technological *paradigm* Schumpeter-style. Finally, it opens out a co-evolutionary process by which all social, political and economic sub-systems become synchronised long term into a post-hydrocarbon socio-technical *landscape* of a kind that would mitigate anthropogenic global warming. Its weakness is a lack of spatial sensibility regarding how this process would work, an underdeveloped notion of the role of governance in niche, regime and landscape co-evolution, and an inadequate appreciation of how innovation operates in facilitating these processes. To overcome this we propose the theoretical and practical concept of *Transition Regions*.

Second, this chapter seeks to demonstrate how a more theoretically informed framework based in regional innovation systems thinking, allied to evolutionary

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economic geography and development analysis, produces a superior transition model. This is particularly in reference to its basic idea of economic development caused by interactions between elements in regional economies displaying *related variety*. Finally, it is shown how his concept has the following powerful theoretical implications. First, applying the notion of related variety has led to new insights in the externalities literature. Second, it has provided additional insights to the question whether or not extra-regional linkages matter for regional growth. Third, relatedness is now also investigated in network analysis. Fourth, the notion of relatedness enriches the literature on labour mobility, which is often regarded as one of the key mechanisms through which knowledge diffuses. Fifth, relatedness may also show its relevance through entrepreneurship dynamics. Experienced entrepreneurs (those that have acquired knowledge in related industries), as opposed to spinoff companies, may play a crucial role in the regional diversification process. Each aspect of this advocacy of the use of an evolutionary conceptual framework is examined below in discussion of the form and content of theoretically and actually existing *Transition Regions*.

2 Theoretical Perspectives

Fundamentally, there is a strictly limited literature on economic geography or regional innovation from a "green" perspective (Bridge 2007). However, three sub-fields that engage with sustainability issues tangential to green innovation exist. Two of these begin from a clearly aspatial embarkation point, while the other takes its position from an urban viewpoint and seeks to *spatialise* the first of these aspatial approaches, namely "ecological modernisation" theory. The second aspatial approach is known as "co-evolutionary transition theory" which has some strengths, among which is an evolutionary perspective and an overt compatibility with neo-Schumpeterian innovation systems thinking, but many weaknesses that are moderated by fuller engagement with regional and national innovation systems theory. The three approaches involve, respectively, urban regime theory, ecological modernisation theory and a co-evolutionary socio-technical transition framework. Because economic geographers attempt a synthesis between the first two, we shall here conflate them as and discuss two broad themes: the "urban ecological modernisation regime" and co-evolutionary transitions approaches. The former is a complex and ultimately contradictory synthesis of regulationist school (see Footnote 1) political economy, which has an established application in the urban geography literature, itself influenced by neo-elitist urban governance research, which takes the form urban regime theory (e.g. Broomhill 2001). The second is initially a more self-contained perspective, which nevertheless takes its inspiration from evolutionary social theorising to which its adherents give the designation "system innovation". The tradition is therefore related to but distinct from neo-Schumpeterian innovation systems thinking. The former concerns the co-evolution of social, political, economic and scientific systems on a grand and lengthy scale while the latter is more narrowly focused around national, regional or technological

modes of transforming laboratory knowledge into commercial product, process or organisational novelty in use—on the market. While the former claims (Geels 2006) to be compatible with NIS/TIS perspectives, this is not entirely accepted by critics such as Hekkert et al. (2007) and Hillman et al. (2008) who take a more embedded national (NIS) and technological (TIS) innovation systems approach in their research.

2.1 *Urban Regime and Ecological Modernisation Theory*

Governance and regulation are pronounced in both elements of this perspective. Regarding the former, as the study of urban politics evolved towards a popular focus upon urban *governance* in the 1990s (Stoker 1999), it engaged with older regime theory, particularly urban regime theory (Stone 1989, 1993; Stoker and Mossberger 1994). A research group addressing UK urban sustainability governance deploys regulationist[1] class analysis and urban regime theory (Gibbs et al. 2002; While et al. 2004). They conclude that a presumed contradiction between a pro-growth and a pro-green urban governance agenda may be illusory. Their focus is on the implications of environmental challenges for the composition and strategies of urban regimes. Their position and findings are as follows. Arguing against a fundamentalist perspective that saw economic globalisation facing urban governance with mounting pressure on protected open space, regulatory dumping, increased levels of consumption, negative environmental externalities and increased material flows into and through the built environment, often at the expense of poorer residents and communities, they have sought to uncover evidence that environmentalism is not simply a matter of the demands placed on local state regulation by national government, business or pressures from upper and middle-class residents. Moreover, they suggest the apparent contradiction between

[1] Regulation theory analyses capitalist economic development in terms of a relationship between two key sub-systems. The first is the "regime of (capital) accumulation" and the second is the "mode of (capitalist) regulation". It is also a theory of transition, albeit Marxist in inspiration, which was utilised particularly penetratively in analysing the 1980s transition in the predominant way of organising factory production. This had been based on Fordist mass production means, involving repetitive work and a strict division of labour producing standardised goods for mass consumption markets under a Keynesian welfare state mode of state regulation. A transition period denoted neo-Fordism with intense automation was a prelude to post-Fordism, which was a transition to a more flexibly specialised, even customised mode of production, with outsourcing to supply chains under a neoliberal or so-called "Schumpeterian workfare state" mode of regulation. It captured the way in which the Reagan–Thatcher "small state" ideologies synchronised with western capitalism's crisis of productivity and competitiveness arising from Asian rivals, notably the Japanese "lean production" model in an ideological context focused on ending the Cold War by the "creative destruction" of the Soviet bloc. Interestingly, lack of innovation was seen by many observers as a key factor in the demise of the Soviet model (Lipietz 1987; Halliday 1990; Cooke 1990; Amin 1994; Jessop 1995; Peck 2000).

a pro-growth and a pro-green urban governance agenda may be illusory. Their focus is on the implications of environmental challenges for the composition and strategies of urban regimes. A sustainability perspective can provide a range of theoretical and empirical insights into urban entrepreneurialism, the changing context for urban politics and, to some extent, the social contradictions of urban environmental regulation under a regime of "ecological modernisation".

Ecological modernisation is a by now rather dated perspective, well critiqued by Desfor and Keil (2007). A key proponent of the conjoining of economic geography and ecological modernisation is Gibbs (2006). His commendable starting point is to assist economic geography to be more "real world" problem-focused and policy relevant. He holds that ". . . . . .ecological modernization, at least in its stronger formulations, can offer a substantive political challenge to neoliberal ideologies" (Gibbs 2006, p. 195). The relevant stiffening is applied by reference to Gibbs' group's adherence to regulation theory, as noted above. This seems questionable given that the basic idea is that a "technological fix" can be found to the ecological degradation inflicted by modern capitalism. This is at the heart of ecological modernisation and along with it goes an optimistic outlook on the achievability of that aim (e.g. Mol 1999). But its optimism has been belied by neoliberal consumption politics and financial services "innovations" such as consolidated debt obligations (CDOs). These, as is by now becoming clearer by the day, influenced the accumulation of enormous sub-prime mortgage and car loan debt that caused the freezing of global inter-bank lending and associated bankruptcies in 2007–2008.

A final issue, notably a flawed element in one of the few spatial articles to advance a system of innovation perspective on a "green paradigm" for economic geography (Hayter and Le Heron 2002), is that the massive and overarching problems associated with climate change and "peak oil" demand, as has been suggested, rather more than the "technological paradigm" perspective associated with that literature. That is, the present ecological crisis requires that the hydrocarbon "paradigm" or "regime" that has underpinned industrial capitalism from the outset, itself, needs transcending in a transition to post-hydrocarbon "landscape" (see below; Kemp 2002; Smith et al. 2005). Accordingly, the ecological modernisation perspective tends nowadays regularly and justifiably to be critiqued for its "reformism", failure to step outside the dominant western, neoliberal consumptionist paradigm and essential philosophy of "cleaning up after capitalism" as a means to approaching broad sustainability goals (Desfor and Keil 2007).

These contradictions make it difficult to square the regulationist critique of capitalism's evolving regimes of accumulation and modes of regulation, with its implicitly revolutionary objective of overthrowing the whole mode of production, with an attempt to utilise a far more reformist urban "ecological modernisation regime" to achieve it. That is not to dismiss either the role of cities as "policy lighthouses" contributing to the envisioning of a future "green paradigm" on a wider scale or the efforts of economic geographers to formulate a synthetic theory to illuminate progressive practices. The next stage of theoretical development of value to the achievement of such an objective, a spatialised co-evolutionary transitions model, ignores regulationism while seeking to transcend the conceptual

limitations of ecological modernisation. This approach removes the key contradiction in urban ecological modernisation in developing an approach to theorising transition to a post-hydrocarbon paradigm that rejects also the view that a sustainability perspective is also complementary. This is because "sustainability", in the sense of husbanding resources for future generations, has no explicitly or implicitly inherent critique of the fossil fuel origins of climate change. Rather "sustainability" advocates "economising on their use so they are available for succeeding generations to, in effect, continue degrading the earth's atmosphere". Hence, to the extent it can provide, as it claims, a range of theoretical and empirical insights into urban entrepreneurship, the changing context for urban politics and, to some extent, the social contradictions of urban environmental regulation under a regime of "ecological modernisation" (While et al. 2004) its real contribution is mainly descriptive. Thus many of the empirical findings of this work are interesting but have relatively little theoretical purchase even on an urban regime approach, largely because the use of the regulationist-regime metaphor still over-narrows the research perspective to a classic and irremediable social conflict causality.

Nevertheless sensitivity to city and county governance is an advance contributed by the urban regime approach comparing favourably to the overtly aspatial ecological modernisation model and the co-evolutionary transitions approach to be discussed. It will be argued, as noted, that the latter lacks any serious *governance* analysis with no municipal, regional or national/federal or, as appropriate, supranational perspective in its theory of change. It is demonstrated in the subsequent empirical sections below that the most recent "green innovation" and "green governance" approaches, especially when combined, offer superior insight into how transitions occur. Hence, a "co-evolutionary innovation systems transition" model transcends the naïve way in which current transition models rely on a notion of "markets". These are, rather uncritically, expected to bring forth green technologies through "strategic niche management" presumably by, in the main, firms. Just as the "ecological modernisation" model betrayed a rather touching optimism about that, the transitions approach offers little clear guide, except an undefined process of "experimentation" as to how that happens. Nevertheless two redeeming features of the co-evolutionary transitions model are that it has demonstrably evolutionary tendencies and that it makes claims to be compatible with a system of innovation approach. Usefully, in the context of the necessary macro-level conceptualisation of a post-hydrocarbon landscape, it also transcends current "innovation systems" thinking by reaching beyond "technological paradigms". Hence, preferable for this approach to a narrow urban regimes perspective is an approach in which, for example, innovative "clean technology" interests or social movements or networks including those of a "counter-cultural" nature may be observed to have impacted upon, for example, raising "green consciousness" such as green politics, "green growth", organic farming and catering, green urbanism, climate change and/or "peak oil" analysis (Wolch 2007; Guthman 2004; Manning 2004; Kunstler 2005; Strahan 2007; Kahn 2007). This as we have seen is because such a perspective moves beyond the obvious limitations of established "sustainable development" and "ecological modernisation" perspectives. It prioritises

anthropogenic climate change through atmospheric emissions and post-fossil fuel issues in the context of the planetary need to mitigate emissions through transition to a post-hydrocarbon economy and society. This improves upon a structural weakness of the more traditional *sustainability* discourse where, as noted, it is possible to construct an argument for sustainable utilisation of, for example, hydrocarbons so they are available for future generations to use, whereas this is not possible from a climate change perspective. This is clearly because their exploitation is seen as the cause of the potential destruction of the earth's atmosphere. This chimes with the predominance of a theoretical and practical *climate change* discourse, increasingly animating social scientific and political interests, while nevertheless not totally rejecting but rather encompassing many traditional sustainable development concerns.

2.2 Co-evolutionary Transition Theory

This approach, focused upon "system innovation" as distinct from "innovation systems", moves us forward by injecting rigour into the manner in which "development" has to be reinvented (e.g. eventual removal of greenhouse gas emissions from production and consumption; see Tukker et al. 2008). As noted, much of the newer social scientific discourse on environmental issues is governed by a climate change perspective and one that moreover questions the adequacy of long-term technological change concepts and analytical instruments as never before (see Geels 2004, 2006; Smith 2006). At issue here is the question of which social scientific theoretical perspective is best at capturing the long-term implications of a global response to climate change? Smith and Geels as well as Tukker and colleagues (see also Weber and Hemmelskamp 2005) hint at the need for a broader conception of the implications of policy intended to mitigate increases in global warming. That is, the established discourse of technological regimes (Dosi 1982; Freeman and Perez 1988) that explains economic change in terms of disequilibria forced by the evolving replacement of one technological regime by another, in a Schumpeterian (1975) process of "creative destruction", seems to work well in relation to "long waves" of development (Manning 2004). However, the technological *regime* literature from innovation studies has not received the level of scrutiny and critique seen, for example, in the international relations regime perspective. One clear cavil already noted is that all Schumpeterian regimes depended upon hydrocarbon energy. Stabilisation and subsequent reduction of hydrocarbon emissions requires innovative, clean technologies across the board.

The *co-evolutionary* perspective tentatively tackles the meta-system implications of policies to reduce utilisation of hydrocarbons. This introduces novelty in the selected field of governance of climate change issues by associating them with the co-evolutionary idea of "strategic niche management". It presents a dynamic multi-level perspective on *system innovation*, here "system" involving the co-evolution

of social, economic, political, scientific and technological sub-systems beyond that of the specific technological regime (Smith et al. 2005). Co-evolutionary thinking of this kind identifies three conceptual levels: niches; regimes; and landscapes (Rip and Kemp 1998). These contribute to a technological regime change that may be envisaged as "sustainable" and conceivably evolving into a new socio-technical, production–consumption "landscape" denoted here as "post-hydrocarbon". Our focus on the niche level is also because this is where innovations, which may influence regimes and ultimately co-evolutionary socio-technical "landscapes", begin. However, and from a critical perspective, the "niche" approach focuses only on how innovations are adopted in markets, a process involving uncertainty, experimentation, market probing and learning. It pays little or no attention to governance, as we have seen (Voss et al. 2006). In existing research, known cases of, for example, introduction of widespread renewable energy (Taylor 2008) or combined food, energy and recycling-related climate change strategies are utilised to explain how "niche" innovation is mediated by governance, including local, entailing early uptake in some settings (Jensen and Tollin 2004). Second, the transitions approach appears little interested in the extent to which ground up and top-down processes influence the possible emergence of regional or national technological regimes. Hence the novelty of innovation systems research in this context is that it investigates the roles of governance (government plus NGOs) and markets (enterprises and technological innovation) as drivers of "strategic niche management", whereas, as Voss et al. (2006) noted, hitherto these have been disconnected conceptually and empirically. Clearly, apart from the absence of a governance dimension, problems with this leading approach to understanding transition are its conceptual thinness, linear logic, equilibrium-mindedness and lack of spatiality. A fuller, interactive, partial or non-equilibrium transition governance model is accordingly required for reasons argued below.

Since the transitions perspective currently has no economic geography, evolutionary or otherwise, it cannot move forward satisfactorily until it does. As it has no concept space but it does embrace the concept of "innovation system", it is faced with a contradiction since much of the latter research focuses on spatial levels such as "national" and "regional" including notions of innovation leaders and laggards. Even the less overtly spatial "technological" and "sectoral" branches nevertheless focus on whether the, mainly, national level is eroding in the face of globalisation. A spatially informed co-evolutionary transitions model would insist on recognition that new "green" niches, regimes and ultimately the socio-technical landscape arise from an inherently asymmetric process of regional economic development. Accordingly, co-evolutionary transition authors fail to recognise why certain concatenations of institutional, entrepreneurial and innovative interactions occur where they do and for what reasons. This is far more than simply reading off the environmental implications of "economic geography" as Bridge (2007) notes, but this in turn means that for comprehensibility the notion of "environment" must be narrowed down from the multi-faceted and wide-ranging meaning implied in Bridge's critique of eco-environmental geography to suit the perspective denoted in the discussion so far. This does not propose to offer an overview of the spectrum

of environmental interests and objects that constitute geography; rather, it is interested in the ways in which consciousness and action, whether in relation to consumption of innovation meant to mitigate hydrocarbon emissions or its production, have a distinct economic geography and from the innovation perspective a pioneering practice in some regions and an absence of recognition of its importance in others. More will be said about this in the empirical subsections that follow. But for now, the three following concepts may be previewed. The first is *path dependence*, one of evolutionary economic geography's master concepts and one in which conceptual progress has been made by economic geographers seeking to escape the "endogeneity problem"[2] inherent in the earlier innovation economics literature (Martin and Sunley 2006). For many decades, regional economic theory and policy coincided as resource-based or resource-exploiting regional economies evolved with relatively narrow regional specialisations. Whether in the nineteenth century industrial "basins" such as Germany's *Ruhrgebiet*, Britain's northeast England, central Scotland or south Wales, Spain's *Basque Country*, or *Pennsylvania* in the USA or the *industrial districts* for textiles, ceramics and footwear that Marshall (1918) and later Becattini (1979) wrote about in *laissez-faire* Britain or, later, contemporary Italy, it was seen as benign that the market produced relatively narrow regional industrial specialisation. To counter that, when competitiveness defects brought industrial decline, an opposite discourse of regional economic development through industry diversification into often unrelated new sectors took over. Nowadays, a new discourse of regional evolution through the exploitation of *related variety* has been emphasised and, where observed, found to be associated with reasonable regional economic success

[2] The *endogeneity problem* is common to social sciences and economics, particularly in econometrics where it, for the moment, casts doubt on much econometric analysis that utilises secondary data not designed to tackle precisely the focus of the research problem being tackled. For example, in innovation studies, it is too tedious to begin listing the innumerable published papers that profess to "explain" the distribution of, for example, "regional innovation systems" by conducting sophisticated technical analyses of regionalised research and development (R&D) or patent data, which a moment's thought will bring realisation that they are not measures of innovation in any significant way. Innovation is defined by the neo-Schumpeterian school as, in simple terms, "the commercialisation of new knowledge (or sometimes 'new combinations of knowledge')" (see, e.g. Edquist 1997). Thus, such indicators not only mis-measure their object of interest but they also reveal that places with concentrations of such research and patenting activity are indeed the "innovation" capitals. However, a moment's further reflection reveals that in most countries, most R&D is conducted in the capital city because a governments pay for a large share of it and historic path dependence analysis shows many such research institutes were set up by governments in the capital city for reasons to do with easy access to important research intelligence. Private businesses often followed suit for similar reasons of knowledge access or access to skilled labour pools. Hence *endogeneity* is built into the statistical patterns being "explained" even if only "the geography of research" were the object of interest. Accordingly, nothing of significant interest is explained at all, but especially nothing regarding innovation, by such metrics. The endogeneity problem in more historical economic accounts such as that of David (1985) is that they seem to offer little opportunity for new combinations or novelties by which evolution may occur. In other words that kind of path dependence has a "locked-in" endogeneity pathway. As will be shown, "green innovation" presents a particularly clear opposite to this viewpoint.

(Boschma and Wenting 2007; Klepper 2002; Cantwell and Iammarino 2003; Buenstorf and Klepper 2005). Finally, consistent with the other key concepts is *proximity*, which has greater reach than simply its geographical dimension, which can involve cognitive and relational dimensions as shown in Carrincazeaux et al.'s contribution to this *Handbook* (see also Boschma 2005) and which facilitates rapid knowledge transfer through *lateral* absorptive capacity among entrepreneurs and managers in related industries, assisted by *knowledge spillover* external economies of scope where *cognitive dissonance* among sub-sectoral actors is relatively low. In these respects we envisage the rise of regional economic "platforms" of related industry activity, which is particularly clearly exemplified in the observed cases of "green innovation". "Green innovation" is defined as:

> . . .diverse new and commercial products, technologies and processes which, through improvements in the clean energy supply chain from energy source through to point of consumption and recycling, result in reduction in greenhouse gases. (Cooke 2008)

In what follows, we report some hopefully interesting and somewhat curious facts that arise when the "tipping point" of awareness or consciousness reaches the "green turn". As noted, the perspective from which this turn is observed is informed by evolutionary economic geography concepts that prove especially appropriate given the geographically uneven incidence of observably accomplished production and consumption practices. These are involved in what can be demonstrated to be convergent technologies often arising in diverse regulatory, institutional and organisational contexts. Hence the key concepts of related variety, path dependence and proximity are both clarified and exemplify the complexities involved in ways that facilitate policy-oriented reflection.

3 Further Conceptual Contributions of a *Related Variety* Perspective

The insights available from evolutionary economic geography in relation to regional economic growth were outlined in the introduction to this paper; here they are further elaborated. First, applying the notion of related variety has led to new insights in the externalities literature. Empirical studies tend to show it is not so much regional specialisation or regional diversification (Jacobs 1969) regarding externalities that induce knowledge spillovers and enhance regional growth, but a regional economy that encompasses related activities in terms of competences (i.e. regions well endowed with related variety). Second, it has provided additional insights to the question whether or not extra-regional linkages matter for regional growth. Adopting a relatedness framework, empirical studies on trade patterns tend to show that it is not inflows of knowledge per se that matters for regional growth, but inflows of knowledge that are related (not similar) to the existing knowledge base of regions. Related flows concern new knowledge that can be understood and exploited and, thus, be transformed in regional growth.

Third, relatedness is now also investigated in network analysis. For instance, studies show that collaborative research projects tend to create more new knowledge when they consist of agents that bring in complementary competences. Fourth, the notion of relatedness enriches the literature on labour mobility, which is often regarded as one of the key mechanisms through which knowledge diffuses. Recent studies show that neither inflows nor outflows of labour are properly assessed if not also considering how these knowledge flows match the already existing knowledge base of firms and regions. Fifth, relatedness may also show its relevance through entrepreneurship dynamics. Experienced entrepreneurs (those that have acquired knowledge in related industries), as opposed to spinoff companies, may play a crucial role in the regional diversification process. More generally speaking, longitudinal studies show that long-term development of regions depends on their ability to diversify into new sectors while building on their current knowledge base. The following section aims to exemplify these and the neighbouring insights from evolutionary economic geography in recently researched "green regional development" case studies. They focus on California, Jutland and Wales, but ongoing research demonstrates that processes of "cluster mutation" occur in Israel, Cambridge (UK) and elsewhere in Scandinavia. This is due to entrepreneurial translation of path dependent but convergent knowledge derived in proximity (geographic and relational) to emergent market niches. It is the innovative application of their and their related network partnership knowledge that enhances and evolves the emergent "green cluster".

4 Transition Regions: Emergence of Green Regional Economic Development Platforms

The idea of a *Transition* Region, which is wholly new and for which no publication yet exists that explores its validity, requires some identification at least in conceptual terms. We shall see below how it is characterised by displaying certain key emergent or existing properties. It will be a sub-national administrative area, with some power to support industry, especially in regard to regional innovation. It will have a *platform* of related variety sectors and sub-sectors. It will likely possess clusters expressing this relatedness in the variety of industry and these will provide much if not all of the possibilities for convergence and divergence of innovative opportunities. Finally, though this is demanding of much further and deeper study, it will have demanding users, consumers or customers both individual and institutional that stimulate the formation of green market niches as proposed in co-evolutionary transition theory. The concept of industries coexisting in a regional "platform" as a basis for mobilising regional evolution connects directly to the related variety argument of the previous section. Neither over-diversified nor over-specialised, and with opportunities present for revealed relatedness in "new combinations" of innovation at interfaces between industries, the accomplished

regional economy works with agility and flexibility to meet increasingly user-driven demand. That is not to say that innovation does not continue to be an interactive process between user and producer, rather it recognises that innovation studies in the past, perhaps echoing aspects of the practice of innovative businesses, have been overly "productivist", that is, during the years of excess firms competed on the basis of disruptive innovation (Christensen 1997). Thus the greatest novelty was the prize that competitors in ICT, from personal computers (PCs) to software, DVD and *BluRay*, *iPod*, *iPhone* and *BlackBerry* have sought in their quest to dominate markets. That many of the "bells and whistles" installed by the higher priesthood of software and systems engineers were scarcely used by most consumers and not understood by many was of little consequence. Following the credit crunch and widespread condemnation of the excess it bred in financial and technological innovativeness, the green turn signifies a new privileging of listening to consumer demand for more usable, less over-engineered and more sustainable goods and services.

So innovation remains interactive, but the asymmetry between demand and supply is re-balanced. This means that regional policies will have to change their colours accordingly. In the decades when "supply-side economics" ruled the roost, the role of policy became that of subsidising instruments to aid producers. Enterprise zones were an early exemplar, followed by other kinds of tax-free trade zones, subsidised technology parks, incubators and the like. Often these deregulatory measures did little to promote robust regional development; often they simply offered low-rent havens to out-of-town retail warehouses or lay empty.

4.1 Green Epiphanies

John Doerr is America's leading venture capitalist (VC). He is head of Silicon Valley's top investor, *Kleiner*, *Perkins*, *Caufield and Byers*. In a lecture to a Californian "green technology" forum *TED.com* in 2007 he reported how at supper one evening his 15-year-old daughter berated him and the rest of the VC industry for their contribution to the destruction of the planet, and, by the way, what was he going to do to put things right? This seems, judging from the lecture, downloadable at *TED.com*, to have caused Doerr to experience the kind of epiphany more normally associated with religious conversion. He immediately starts networking among his community of high-tech investors and entrepreneurs. He gets some of the smartest brains he knows to lobby the California legislature on tougher emission controls. He takes his network to Brazil to see its successful bioethanol industry. He even goes to Wal-Mart, arch-discounter of consumption goods, to observe the implementation of its new green strategy. He discovers how petrol can be made from algae, subsequently leading the charge, in harness with Al Gore's green investment fund, *Generation Investment Management*, to back numerous such Californian biofuel start-ups. Yet as each scene of this narrative closes, he assesses the likely outcome of all these niche activities, declaring "I don't believe it's going

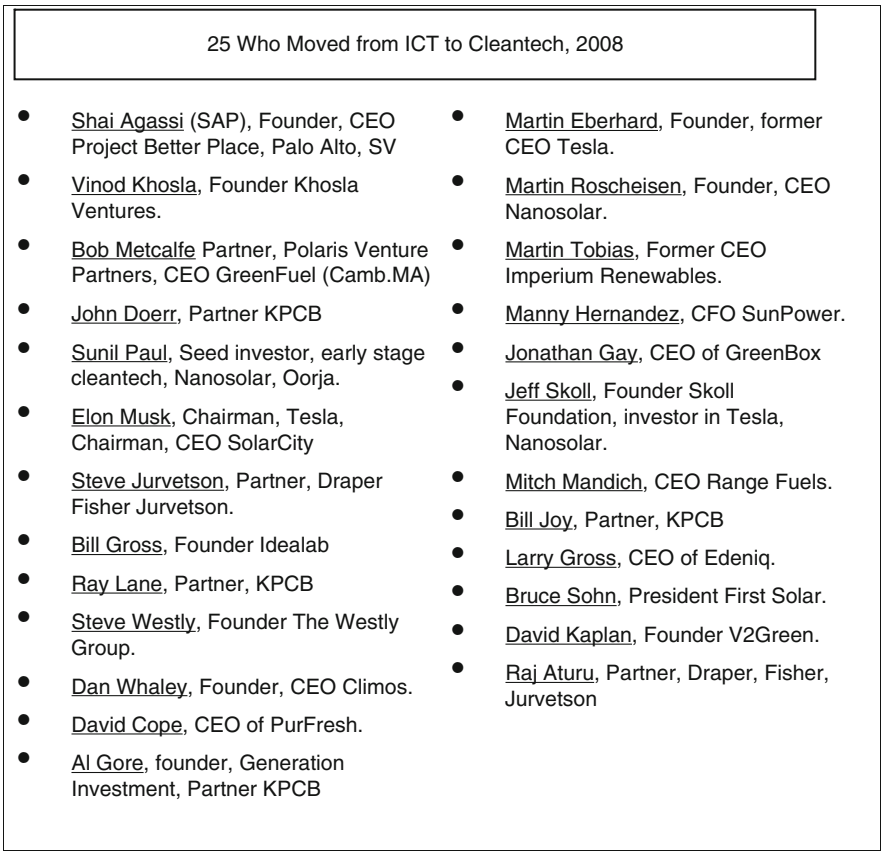

Fig. 6.1 Recent moves by California ICT Entrepreneurs into Clean Technologies. *Source*: earth2tech

to be enough" . . ..to save the planet, that is. Eventually, he breaks down on-screen at the thought that he has been complicit in irretrievably poisoning the earth's atmosphere, leaving the prospect of his daughter's generation having to survive in a world that only has that one source of oxygen. I have shown this performance to numerous audiences including hard-bitten environmentalists, and the consensus is that "he may be a venture capitalist, but he's a hell of a good actor". To which I now respond to the effect that whether he's acting having spotted a great market opportunity, or genuine in investing in a new "green moral economy", does it really matter? Doerr has visibly changed his practice and evidently interacted with many of his peer group, including persuasive Al Gore, to do the same, as Fig. 6.1 shows.

What is theoretically interesting and important about the data in Fig. 6.1 are the following: First, clean technologies of the kind these investors and entrepreneurs are keen to become involved in are convergent. Convergence here means that innovations in numerous apparently not too closely related industries may open

pathways to entrepreneurship in industries displaying what we may call "revealed related variety". We will see later how this operated in Wales, where revealed relatedness among organic food producers, biofuel producers and theme park tourism, not normally considered close business bedfellows, produced a successful developmental outcome. It is important to note that these entrepreneurs were initiating start-ups not being hired as "big names" in pre-existing firms. Second this relatedness works because of two important, subsidiary concepts. These are, first, "absorptive capacity" and, second, "knowledge spillovers". In regional economic development terms, absorptive capacity is lateral, whereas in industrial economics it is vertical. Lateral "absorptive capacity" means that entrepreneurs in adjoining and/or "revealed relatedness" industries can understand each others' business models and focus and apply tacit knowledge or even "routines" from the one business type or model to their own. In this way innovations might cross-fertilise and migrate from one industry to a related or revealed related one. The means by which such cross-fertilisations occur rely upon "knowledge spillovers"—external economies that spill over accidentally from firms located in geographical proximity that have the absorptive capacity to translate such tacit knowledge into explicit, codified, usable and repeatable knowledge in a new business context. Where a regional economy is over-diversified, as that of Wales became by the turn of the millennium, there are few knowledge spillovers and little absorptive capacity except of the generic kind that was promoting, for example, the virtues of outsourcing to "supply chains" in a context of "lean production". Such generic knowledge is by no means useless but nor does it offer specific opportunities for novelty since it is available to all competitor firms. Equally, where it is over-specialised, everyone is so familiar with the fundamentals that knowledge spillovers are ubiquitous but absorptive capacity absorbs less and less novelty accordingly. Michael Porter's example of the alloy golf club head cluster in Carlsbad, California, is an example of such an over-specialised, by now not especially innovative sub-sector dominated by *Callaway*, the firm that once conceived innovative opportunity from aerospace materials and skills to revolutionise the last bastion of wood in the drivers of that Royal and Ancient game (Porter 1998).

4.2 From Clusters to a Green Regional Innovation System

In the user-driven green economy subsidies are increasingly to be found being made to consumption rather than only to production. Probably the most celebrated case of the success of consumer subsidy as a successful policy regime is to be found in the history of Denmark's world-leading wind-turbine industry. From the beginning in the early 1970s, government subsidies were made available not to the producers but the 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 to out-compete its main rivals in California. The user subsidy stimulated

experimentation, knowledge spillovers and niche market evolution in regionally "path-dependent" trajectories in both Jutland and California. But Ronald Reagan jettisoned his predecessor Governor Brown's subsidies while in Denmark they continued until a right-wing coalition entered government in 2000. By which time the Danish design had evolved considerably from its roots in agricultural and marine engineering where the plough and the ship's propeller were the inspiration. Meanwhile the Californian design atrophied around its inspiration, propeller driven aircraft. Already something of an anachronism, the two-blade, pointed upwind turbine design proved inferior to the three-blade, point it downwind Danish solution and for once Californian ingenuity was defeated. *Vestas*, Denmark's national champion, has 40 % of the world wind-turbine market and has been joined in its Aarhus–Aalborg cluster by the likes of Germany's *Siemens*, acquiring the other main Danish companies, S*uzlon* from India and *Gamesa* from Spain. Including home market production of turbines in Germany and Spain, these European producers, along with Denmark have 70 % of world turbine production capacity with employment of 133,000 and global demand far from saturated.

To continue with small-country, moderately peripheral Jutland a little longer, it is instructive to find that interspersed within the wind-turbine cluster is another with a comparable 1970s "alternative energy technology" genealogy. This is its solar thermal cluster consisting of some twenty firms of varying sizes and types, ranging from manufacturers of solar-powered water pumps for use in developing countries to consultants designing massive solar power stations and those that simply supply heating systems for communities, factories, offices and individual homes. One of these is *EnergiPlan*, whose founder Per Alex was one of a number interviewed by this author about the green energy "platform" in North Jutland. *EnergiPlan* designed as one of the first local solar power stations at Skorping, near Aalborg, a communal housing scheme of some thirty houses. It is a simple mirror collectors, pipes and covered swimming pool arrangement that supplies communal free heat and power for 9 months of the year. Thereafter the commune, which operates communal dining and laundry facilities, resorts to the local biomass District Heating station in the village, which commune members can access at a discount. Per Alex described how in 30 years these combinations of distinctive alternative energy technologies have helped evolve one of the first "green regional innovation systems" in the world.

The demanding customers for District Heating in Denmark are the municipalities, most of whom run local energy supply companies, and some 60 % of Denmark's citizens rely upon it. Municipalities seek a balanced supply and order customised mixes of biomass, biogas, wind, solar and marine energy depending on location and the type of solution required. Enormous export markets for District Heating have opened up in mature and emerging markets faced with climate change and "peak oil" constraints. Within North Jutland is a community of some 100–150 specialist renewable energy firms, many of which are innovative. He cited the case of *Logstor* a District Heating company in North Jutland that had innovated a pre-insulated dual pipe system that minimised heat loss by fitting the cold water input pipe inside the hot water pipe.

- 'Innovative Region: Flexible District Heating' Platform
- Biogas, Biomass, Solar Thermal, Wind - 'plug-ins'
- 'Social Network' >100 'system' & 'solution' firms
- Aalborg U, Municipalities, DTI, VåkstForum Fund (40 mn.DK bid).
- 'Aggregators' or 'system integrators' include:
- Arcon Solar (Velux VHK), Xergi, Logstor (Pipework), Baracon (Biogas), Grundfos
- Humvel, NIRAS, EnergiPlan (consultants)

Fig. 6.2 North Jutland's Green Regional Innovation System. *Source*: Centre for Advanced Studies

Together, the District Heating firms, municipalities, university laboratories and technology transfer agencies created an association entitled *Innovative Region: Flexible District Heating* with characteristics described in Fig. 6.2. It is important to note that there was no cluster or other industrial promotion policy behind this "green innovation" emergence.

This echoes the 2007 regionalisation of Denmark's administration into five, one of which is North Jutland. It warrants the regional innovation system designation precisely because it consists of a commercialisation sub-system and a knowledge generation sub-system. The former consists of networks of firms in supply chains focused around the District Heating engineering platform while belonging to distinctive renewable energy business segments. These are, nevertheless, capable of being system-integrated by lead "aggregator" firms such as solar thermal specialist *Arcon*, biogas contractor *Xergi*, green engineering firm *Grundfos* or consultants *NIRAS* into consortia for plant assembly. Supporting this sub-system is a knowledge and enterprise support sub-system consisting of public laboratories, regional development agency, municipalities and technical agencies such as the Danish Technological Institute. In 2008 the business office of Aalborg had taken responsibility for leading a €5 million platform bid to the Danish Growth Fund—*Väkstfonden* for "user-driven design and innovation" support (Ministry of Foreign Affairs of Denmark 2008).

Finally, it should be recalled that the regional platform described above has evolved from the earlier development of a number of clusters such as those focused on wind turbines, solar thermal and photovoltaics, pipework and green engineering. With the cross-fertilisation of innovative ideas such "Jacobian" clusters (after Jane Jacobs' stress on variety in economic innovation and growth; Jacobs 1969) offer, the rise of a green regional innovation system based on the convergent and related variety platform described can be expected, as in California. Both have strong aspects of "collective entrepreneurship" in the form of the venture capital and entrepreneur networks "mutating" from ICT to *GreenTech* in the former while in the latter there is a greater emphasis on communal associativeness among firms and

support organisations with a pronounced degree of "informal investment" by successful entrepreneurs in interesting start-up businesses.

The tenacity of entrepreneurial practice in North Jutland's "green" RIS is testified to by the activity of *Grundfos*, one of the "aggregators" mentioned above. The company is among the world's largest manufacturers of pumps, employing some 15,000 to produce 16 million pumps a year. In 1992 *Grundfos* embarked on an innovation initiative to improve the performance and energy efficiency of circulation pumps used in household heating and cooling systems. *Alpha Pro* is the result, an "intelligent pump" with sensors to assess current heating requirements; the performance of the pump is adapted according to the actual heat demand. By 1998, determined to commercialise this technological innovation, *Grundfos* embarked upon a political lobbying process to seek a ban on the least efficient circulation pumps on the market. Lobbying was conducted through *Europump*, the European Association of Pump Manufacturers in order to reach a wider regulatory audience. Through *Europump*, *Grundfos* raised their issue at the highest EU levels and simultaneously lobbied Danish politicians to raise it in their EU dealings. The EU Directorate General for Energy took interest and commissioned studies under the EU Specific Actions for Vigorous Energy Efficiency (*SAVE II Programme*). This resulted in a pump energy efficiency classification scheme based upon energy consumption in use, formulated as an energy efficiency index (EEI). When the classification scheme was launched in early 2005, *Grundfos*, as we have seen, had a product ready for market launch.

4.3 A Green Turn in Wales?

The preceding account demonstrates three key features of probably the world's two leading green regional platforms, with Jutland, if anything, the premier of the two due to its systemic aggregative capabilities at related variety business interfaces. First, California, with its benign green innovation support regime and climate, is less concerned with communal heating and more with substitutes for oil. In Sacramento, home to former Governor Schwarzenegger's California Fuel Cell Partnership, a network among numerous infrastructure suppliers and the major vehicle producers has burgeoned since 2005. Here exacting users like the State of California fuels its fleet of hydrogen fuel cell (HFC) vehicles at this Sacramento station or at nearby partnership member University of California, Davis. This is part of the governor's hydrogen highway initiative. It is indicative of the renewable automotive fuel emphasis that underpins much of the federal and regional subsidy regimes for renewables in the USA. However informed judgement suggests HFCs will not be the preferred alternative to hydrocarbons in this market. Second, although many US municipalities run fleets of cars and buses fuelled by hydrogen, indicating the role of city and county administrations as lead markets for niche renewable products and services, "plug-in" electric hybrid vehicles of the kind Shai Agassi (Fig. 6.1) builds through his *Better Place* company in Israel are a better bet. Silicon Valley start-up *Tesla* is also a leader in the electric car market (Fig. 6.1).

But, third, announcements in 2008 by *GM* regarding a hybrid *Volt* car, hitherto an HFC prototype, and *Ford* that its new low emission and higher mileage *EcoBoost* engine is to be built at Bridgend were in the balance, given the Bug Three's request for a $25 billion bailout from the US government t stave off bankruptcy.

In Wales, there has long been a close relationship with HFC technology since the technology, the predominant motive force in rocket engineering, was invented by Swansea scientist William Grove in 1857. Accordingly, Wales is identified as one of Europe's top 16 HFC regions in research by Nygaard (2008). Among achievements warranting that status are the prototype *Tribrid Bus* developed at the University Glamorgan, the *H2Wales* network based at Baglan Energy Park, Port Talbot, and the car-design work of *Connaught Engineering* and the *Naro* car company. But HFC is not the most prominent technology design in the Welsh renewable energy equipment spectrum. That accolade probably belongs currently with the production of energy from biomass. Here is a sphere in which Welsh research is at the global forefront, mainly through its grassland research institute IBERS (formerly the Institute of Grassland and Environmental Research—IGER) since 2008 part of the University of Wales, Aberystwyth. In 2004 I.E. opened a biofuel research and commercialisation division due to its evolving expertise in understanding improving the calorific content of feedstock plants by experimenting with ryegrass, short-rotation willow and *miscanthus* (Asian elephant grass). This connects to our earlier point regarding "revealed related variety" because this research institute manages to combine innovation at interfaces among organic food, biofuels and tourism promoting indigenous entrepreneurship in three industries on which Wales has been path dependent for centuries.

IGER conducts much industrial contract research and advisory activity. This interweaves with the three noted sectors in the following ways. First, IGER advised the tourist theme park business *Oakwood Leisure* in Pembrokeshire on a green tourism plan for a new leisure complex named *Bluestone* for the uniquely coloured stone quarried nearby of which many Neolithic monuments like Stonehenge are composed. The €130 million leisure park consists of 340 sustainably sourced wooden chalets and a Celtic village of 80 adjoining buildings part-located in the Pembrokeshire Coast National Park. Additional facilities include a Snowdome, Waterworld park, indoor tropical garden and sports centre. It houses 2,000 residents and receives 5,000 day visitors. *Bluestone* directly employs 600 catering and hospitality staff and indirectly supports 100 jobs with its suppliers. By offering a "green tourism" solution *Oakwood* finally achieved planning permission to go ahead with such a development, which included building on two fields that were inside the National Park boundary. The project was grant aided by the national park authority through its Sustainable Development Fund and by DEFRA's carbon-neutral crops scheme. University of Wales, Bangor's Centre for Alternative Land Use (CALU), was also consulted. IGER advised *Bluestone* on its renewable energy strategy, which consists of 3 MW of biomass burning combined heat and power (CHP) units. Initially IGER favoured *miscanthus* but opted finally for short-rotation willow wood chips as the main fuel source. These are grown by 50 farmers in a localised supply chain managed by an energy company called *Pembrokeshire Bioenergy*.

Completing the green symbolism of this tourism project is the *Bluestone* culinary strategy, which is to supply tourist food from a localised food network of mainly but not exclusively organic farms. Among its suppliers are successful food "aggregator" firms such as *Castell Howell Foods* based at nearby Cross Hands Food Park, a major west Wales centre for food processing and packaging. One of *Castell Howell's* affiliates is a meat supply firm called *Celtic Pride Ltd*. This firm specialises in premium Welsh-grown meat supply and is a joint venture between *Castell Howell Foods* and *Wynnstay Group plc*, Wales' largest quoted agricultural supplies company. A regional network of 85 farmers supplies Welsh beef to *Celtic Pride*. The IGER connection is important for its advice on an innovative, consistent feed quality system called *Celtic Pride Feed*. In cooperation with *Wynnstay* this resulted in an oil-based cattle feed, important since protein balance must be correct for the last 60 days before slaughter. Thus high vitamin E is known to give best colour and texture to meat and increases the shelf life. Matured for 21 days before consignment, the product is born, reared, finished, slaughtered and processed in Wales, warranting the European Union PGI (Protected Geographical Indication) brand, achieved by the joint venture in 2003.

Wales now has 15 biomass power stations, including two in the pipeline and three co-firing arrangements with large coal burning power stations. Among these is Europe's first commercial scale biomass power station in Port Talbot, where construction work started in July 2006. The £33 million station was scheduled to be fully operational by June 2008. Producing 13.8 MW of renewable energy the station will generate 104 GWh per year, sufficient to meet the needs of around 31,000 homes. The Cardiff-based renewable energy company *Eco2* designed and managed construction of the power station, for a project originally proposed by the *Western Log* group, which secured planning permission in 2004. The plant is fuelled with 16,000 tonnes per year of clean wood which has come from sustainable, managed forests and saw mills. With trees drawing carbon dioxide from the atmosphere as they grow, the carbon dioxide produced in combustion results in no net increase of the gas. By generating electricity in this way, some 47,000 tonnes of equivalent fossil fuel carbon dioxide emissions are avoided. This will help reduce the negative effects of global warming.

Eco2 is probably Wales' number one eco-innovator business and a global leader in tidal energy systems. Most of Cardiff-based *Eco2*'s contracts are with UK and increasingly European clients. Interviews conducted with David Williams, CEO of *Eco2*, reveal the company to have a business model said to be common in eco-business, whereby the firm calls on a group of ten or so investors to fund projects and take a return subject only to capital gains rather than corporation tax. This is realised when the project is sold or a project client makes final payment. This enables *Eco2* to be a tax-efficient, knowledge-based research, development and innovation vehicle. Among its clients is the *Sleaford Renewable Energy Plant* which received the go ahead for a straw-fired power station in late 2008. *Eco2*'s first such plant, generating 38 MW was built at Ely, Cambridgeshire for *Energy Power Resources Ltd*. The new one is the UK's largest straw-fired biomass burner and first in *Eco2*'s new £1 bn programme to develop up to ten biomass facilities

across Europe. It will create 80 jobs, bringing £6 m a year to local farmers in fuel supply contracts and £20 m for local construction firms. It will power the equivalent of 65,000 homes, one quarter of all houses in Lincolnshire. Having begun in the wind farm business, of which the firm owns a number with two awaiting planning permission, wind energy has now scaled up beyond *Eco2*'s capacity, hence the move into biomass. The company's most recent development is in tidal energy as it partners fellow Cardiff firm *Tidal Energy Limited* to develop DeltaStream—an innovative technology designed to generate electrical power from tidal stream resources. A 1 MW tidal energy turbine is currently being trialled in Milford Haven, Pembrokeshire in partnership with *Carbon Connections Ltd.* along with Cardiff and Cranfield Universities.

5 Conclusions

In this paper, three key aims were set and the text demonstrates that to a large extent they have been successfully accomplished. First it was considered important to discuss some weaknesses in the main theoretical approaches to understanding transitions in production–consumption paradigms. One of the main criticisms of the predominant perspective in co-evolutionary theory of transitions is that it lacks any spatial content. We discovered by empirical analysis that spatiality is crucial to an understanding of how transitions occur and we coined the term *Transition Regions* to capture these specificities. This applies also to cities and city-regions and the urban regime approach to this issue offers some insights into how this may happen at the urban governance level, though in truth it is not helpful in relation to innovation or the production side more generally and it is unhelpful in attempting to align urban regime and ecological modernisation approaches, which have contradictory explanatory aims.

The second aim was to demonstrate how these problems are overcome by the adoption of an evolutionary economic geography approach that is rooted in regional innovation systems and related variety concepts, both closely allied to the neighbouring concepts of path dependence and proximity (geographical and relational). Where these phenomena converge sectorally and geographically we found the notion of regional *platforms* useful because the concept captures the multi-cluster manner in which "cluster mutation" among related variety industries actually occurs in such settings. Evolutionary mutation occurs as entrepreneurs take knowledge from their own and their firm's path-dependent evolution in one sector and finds ways in combination with network partners from related but distinctive industry clusters to form a new or emergent cluster built from these knowledge convergences. Such skills in the labour market are thus crucial to such regional innovation and economic development. Finally, to test the theory, it was exposed to some detailed case analysis in different settings in different parts of the world where, nevertheless, "green innovation" could be seen to be flourishing. Remarkably, in different ways the insights of theory were almost completely vindicated and

it may be concluded that this effort has made a major contribution not only to understanding of "transition regions" in themselves but also the theory of evolutionary economic geography and development more broadly.

References

Amin A (ed) (1994) Post-Fordism: a reader. Blackwell, Oxford
Becattini G (1979) Dal "settore" industriale al "distretto" industriale. Alcune considerazioni dull'inità di indagine dell'economia industriale. Riv Econ Polit Ind 5:7–21
Boschma R (2005) Proximity and innovation: a critical assessment. Reg Stud 39:61–74
Boschma R, Wenting R (2007) The spatial evolution of the British automobile industry, does location matter? Ind Corporate Change 16:213–238
Bridge G (2007) Environmental economic geography: a sympathetic critique. Geoforum 39:76–81
Broomhill R (2001) Neoliberal globalism and the local state: a regulation approach. J Aust Polit Econ 48:115–140
Buenstorf G, Klepper S (2005) Heritage and agglomeration: the Akron tyre cluster revisited. In: Papers on economics & evolution 2005–08. Max Planck Institute of Economics, Jena
Cantwell J, Iammarino S (2003) Multinational corporations & European regional systems of innovation. Routledge, London
Christensen C (1997) The innovator's dilemma. Harvard Business School Press, Boston
Cooke P (1990) Back to the future: modernity, postmodernity & locality. Unwin Hyman, London
Cooke P (2008) Cleanness and an analysis of the platform nature of life sciences: further reflections upon platform policies. Eur Plann Stud 16(3):1–19
David P (1985) Clio and the economics of QWERTY. Am Econ Rev 75:332–337
Desfor G, Keil R (2007) Nature & the city. University of Arizona Press, Tucson
Dosi G (1982) Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. Res Policy 11:147–162
Edquist C (ed) (1997) Systems of innovation. Frances Pinter, London
Freeman C, Perez C (1988) Structural crisis of adjustment, business cycles and investment behaviour. In: Dosi G et al (eds) Technical change & economic theory. Pinter, London
Geels F (2004) From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory. Res Policy 33:897–920
Geels F (2006) Co-evolutionary and multi-level dynamics in transitions: the transformation of aviation systems and the shift from propeller to turbojet (1930–1970). Technovation 26:999–1016
Gibbs D, Jonas A, While A (2002) Changing governance structures and the environment: economy-environment relations at the local and regional scales. J Environ Policy Plann 4:123–139
Gibbs D (2006) Prospects for an environmental economic geography: linking ecological modernization and regulationist approaches. Econ Geogr 82:193–215
Guthman J (2004) Agrarian dreams: the paradox of organic farming in California. University of California Press, Berkeley
Halliday F (1990) From Kabul to Managua: Soviet-American relations in the 1980s. Pantheon, London
Hayter R, Le Heron R (eds) (2002) Knowledge, industry & environment: institutions & innovation in territorial perspective. Ashgate, Aldershot
Hekkert M, Suurs R, Negro S, Kuhlmann S, Smits R (2007) Functions of innovation systems: a new approach for analysing technological change. Technol Forecast Soc Change 74:413–432
Hillman K, Suurs R, Hekkert M, Sandén B (2008) Cumulative causation in biofuels development: a critical comparison of the Netherlands and Sweden. Technol Anal Strateg Manage 20:593–612

Jacobs J (1969) The economy of cities. Vintage, New York
Jensen J, Tollin N (2004) Networks as tools for sustainable urban development. Presented at the 'Innovation, Sustainability & Policy' international conference, Munich, 23–25 May 2004
Jessop B (1995) The regulation approach, governance and post-Fordism: alternative perspectives on economic and political change? Econ Soc 24:307–333
Kahn M (2007) Green cities: urban growth & the environment. The Brookings Institution, Washington
Kemp R (2002) Environmental protection through technological regime shifts. In: Jamison A, Rohracher H (eds) Technology studies and sustainable development. Profil Verlag, Munich
Klepper S (2002) The capabilities of new firms and the evolution of the US automobile industry. Ind Corporate Change 11:645–666
Kunstler J (2005) The long emergency: surviving the converging catastrophes of the twenty-first century. Grove, New York
Lipietz A (1987) Mirages & miracles. Verso, London
Manning R (2004) Against the grain: how agriculture hijacked civilization. North Point Press, New York
Martin R, Sunley P (2006) Path dependence and regional economic evolution. J Econ Geogr 6:395–437
Marshall A (1918) Industry & trade. Macmillan, London
Ministry of Foreign Affairs of Denmark (2008) Invest in Denmark. Government of Denmark, Copenhagen
Mol A (1999) Ecological modernization and the ecological transition of Europe: between national variations and common denominators. J Environ Policy Plann 1:167–181
Nygaard A (2008) Regional innovation systems and emerging hydrogen fuel cell clusters. In: Presentation to conference: climate change & eco-innovation: regional perspectives, Aalborg University, 12 November 2008
Peck J (2000) Doing regulation. In: Clark G, Feldman M, Gertler M (eds) The Oxford handbook of economic geography. Oxford University Press, Oxford
Porter M (1998) On competition. Harvard Business School Press, Boston
Rip A, Kemp R (1998) Technological change. In: Rayner S, Malone E (eds) Human choice & climate change. Battelle, Columbus
Schumpeter J (1975) Capitalism, socialism & democracy. Harper, New York
Smith A (2006) Green niches in sustainable development: the case of organic food in the United Kingdom. Environ Plann C Government Policy 24:439–458
Smith A, Stirling A, Berkhout F (2005) The governance of sustainable socio-technical transitions. Res Policy 34:1491–1510
Stoker G (ed) (1999) The new management of British local governance. Macmillan, London
Stoker G, Mossberger K (1994) Urban regime theory in comparative perspective. Environ Plann C Gov Policy 12:195–212
Stone C (1989) Regime politics: governing Atlanta. University Press of Kansas, Lawrence
Stone C (1993) Urban regimes and the capacity to govern: a political economy approach. J Urban Affairs 15:1–28
Strahan D (2007) The last oil shock. John Murray, London
Taylor G (2008) Bioenergy for heat and electricity in the UK: a research atlas and roadmap. Energy Policy 36:4383–4389
Tukker A et al (2008) System innovation for sustainability. Edward Elgar, Cheltenham
Voss J, Bauknecht D, Kemp R (eds) (2006) Reflexive governance for sustainable development. Edward Elgar, Cheltenham
Weber M, Hemmelskamp J (eds) (2005) Towards environmental innovation systems. Springer, Berlin
While A, Jonas A, Gibbs J (2004) The environment and the entrepreneurial city: searching for the urban 'sustainability fix' in Manchester and Leeds. Int J Urban Reg Res 28:549–569
Wolch J (2007) Green urban worlds. Ann Assoc Am Geogr 97:373–384