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Path Dependence and Regional Economic Evolution

Ron Martin and Peter Sunley



Utrecht University
Urban & Regional research centre Utrecht

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Ron Martin* and Peter Sunley**

* Professor of Economic Geography, Department of Geography,
University of Cambridge, Cambridge CB2 3EN, UK
E-mail: rlm1@cam.ac.uk

** Professor of Human Geography, Department of Geography,
University of Southampton, Southampton, SO17 1BJ, UK
E-mail: P.J.Sunley@soton.ac.uk

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Abstract

In recent years, economic geographers have seized on the concepts of ‘path dependence’ and ‘lock-in’ as key ingredients in constructing an evolutionary approach to their subject. However, they have tended in to invoke these notions without a proper examination of the ongoing discussion and debate devoted to them within evolutionary economics and elsewhere. Our aim in this paper, therefore, is, first, to highlight some of the unresolved issues surround these concepts, and, second, to explore their usefulness for understanding the regional economic evolution. We argue that in many important aspects, path dependence and lock-in are place-dependent processes, and as such require geographical explanation. At the same time, there has been little discussion of regional path creation: the assumption has been that new technological-economic paths emerge at random or spontaneously across space, an assumption that we find too simplistic. This leads on to the key question as to why some regional economies become locked into development paths that lose dynamism, whilst other regional economies seem able to avoid this danger and in effect are able ‘reinvent’ themselves through successive new paths or phases of development. We conclude that whilst path dependence is an important feature of the economic landscape, the concept requires further elaboration if it is to function as a core concept in an evolutionary economic geography.

Time present and time past
Are both perhaps present in time future
And time future contained in time past
(From *Four Quartets*, by T.S. Eliot)

1. Introduction: Path Dependence and Economic Geography

In the past few years, an embryonic ‘evolutionary turn’ has begun to emerge in economic geography. One aspect of this is an increasing tendency for economic geographers to employ ‘evolutionary’ metaphors, concepts and terminology – such as ‘learning’, path dependence’, ‘selection’ and ‘novelty’ - in their writings. Yet, whilst often suggestive, this body of writing often entails little if any detailed discussion of the evolutionary terms and concepts employed. A second dimension of this ‘evolutionary turn’, however, is much more explicitly concerned to explore how and in what ways recent developments in evolutionary economics itself can be applied to economic-geographic studies, and indeed used to construct a new ‘evolutionary economic geography’ as a distinct body of theory and empirical research (for example, Cooke and Morgan, 1998; Boschma and Lambooy, 1999; Martin, 2000, 2006; Schamp, 2002; Bathelt and Glückler, 2003; Boschma and Frenken, 2003, 2005; Boschma, 2004). In their paper, Boschma and Frenken (2005), for example, adapt the question posed more than century ago by Thorstein Veblen (1898), namely ‘why is economics not an evolutionary science?’ to ask instead ‘why is economic geography not an evolutionary science?’ In response, they attempt to set out how an ‘evolutionary economic geography’ might provide a third or middle alternative to existing approaches in economic geography, both the new ‘cultural-institutional’ perspective that many economic geographers have championed, and the so-called ‘new economic geography’ that has grown rapidly over the past decade within economics. As they acknowledge, “there is still a long way to go before Evolutionary Economic Geography becomes an established field”, but they are nevertheless “convinced that evolutionary theory constitutes a truly new and promising paradigm in economic geography” (p. 20).

We too are enthusiastic about this possibility, but are also of the view that there are several major challenges to be confronted before it is achieved. Obviously, by its very ambitions, ‘evolutionary economic geography’ seeks to apply and adapt ideas and concepts from evolutionary economics. But therein

is the first issue: what sort of evolutionary economic concepts and theory should this new approach to economic geography draw upon for inspiration? This is not a straightforward question, for in fact there is not a single, generally agreed or coherent body of evolutionary economics, but rather several different forms and approaches, with different emphases and different conceptual foundations. The problem is that whilst an 'evolutionary perspective' has emerged as a self declared heterodox approach to economics, its very heterodoxy has meant the appearance of a number of alternative theoretical interpretations and perspectives (some in fact less heterodox and more mainstream than others). As one recent survey of the field puts it:

It has been one of the programmatic concerns of this heterodoxy to formulate evolutionary economics as an alternative approach to economics, leading to various attempts in the literature to define evolutionary economics. Not surprisingly, this has led to a range of different definitions of evolutionary economics. Evolutionary economists themselves have taken a defensive stance on this issue, pointing to the young nature of the field (Klaes, 2004, p. 359).

Similarly, Dopfer and Potts (2004a, p. 195) argue that "Evolutionary economics is a many-splendoured thing of great scientific promise. Yet such a massive hybridization of theory and method has left it rather analytically adrift." It is becoming a menagerie of concepts and approaches so that, "the central problem of evolutionary economics at present is the lack of a clear analytical framework for evaluating, integrating and developing theory" (ibid). In other words, in drawing on evolutionary economic concepts, geographers are seeking to utilise ideas that are often themselves still embryonic and the focus of ongoing debate and development, still without 'stabilised shared meaning' (as Klaes puts it). In short, the concepts of evolutionary economics are not unproblematic, and geographers need to exercise caution in applying and using them.

Second, to compound this difficulty, there is the issue of how evolutionary concepts should be applied in economic geography, and what they should be applied to. The application of any particular body of economic (or other) theory to economic-geographic phenomena and questions necessarily influences the very selection of those phenomena and questions and how they are defined: that is, the object of study as well as how it is studied. The same holds true for the construction of an evolutionary approach to economic geography. What should be the object of study of evolutionary economic

geography? What should be its core concepts? Further, and again as other approaches to economic geography testify, economic concepts and theories - which are almost invariably developed without regard to geographical conditions and considerations - rarely survive unchanged when used in economic geography, but typically take on new features and interpretations. We should expect the same to happen in the case of ideas and concepts taken from evolutionary economics. Of course, this might simply exacerbate the problem of 'hybridisation' and polymorphicity bemoaned by Dopfer and Potts. But, more positively, a geographical perspective might help throw light on the nature and processes of evolution in the economy. That is to say, the task is not just about applying evolutionary thinking and concepts to economic geography, difficult enough though that challenge is: it is also about exploring and explicating how geography - the role of place and space - influences the process of economic evolution itself, and thereby how economic geography can make a contribution to the development of evolutionary economic thinking and the concepts it employs. (In this context, one might argue this last possibility is consistent with the heterodox orientation of evolutionary economics, since this surely implies openness to ideas from outside economics itself).

In this paper we grapple with these twin sets of arguments by critically examining the notion of path dependence and its applicability to the issue of regional economic evolution. Some evolutionary economists have elevated path dependency to the status of a 'first principle' of evolutionary economics (see, for example, Hall, 1994); certainly since its original elaboration by Paul David (1985, 1988, 1993, 1994,) and Brian Arthur (1988, 1989, 1994), the concept has attracted considerable attention and discussion within evolutionary economics, and has also been eagerly taken up across a wide range of other social sciences (Hirsch and Gillespie, 2001), including anthropology, history, political science, sociology, management studies, and, the focus of concern here, economic geography.

Originally used by David and Arthur to analyse technological trajectories, and since extended by several other authors (for example, Magnusson and Ottosson, 1997; Garoutse and Ioannides, 2001; Garud and Karnøe, 2001; Castaldi and Dosi, 2004), the concept of path dependence is intended to capture the way in which small, historically contingent events can set off self-reinforcing mechanisms and processes that 'lock in' particular structures and pathways of development. Which structures and paths become

'locked in' depends on the particular sequence of events that unfold. To quote the oft-cited definition by David:

A path dependent economic sequence of economic changes is one in which important influences upon the eventual outcome can be exerted by temporarily remote events, including happenings dominated by chance elements rather than systematic forces.... In such circumstances, 'historical accidents' can neither be ignored nor reality quarantined for the purpose of economic analysis; the dynamic process itself takes on an essentially historical character (David, 1985, p. 332).

Many economic geographers have seized upon path dependence as one of the 'fundamental features' of the economic landscape. Thus Bathelt and Glückler argue that "a contextual, path-dependent and contingent perspective is quite different from the other theoretical programs which view economic geography in line with universal laws, linear developments and closed systems" (2003, p. 129). In particular, geographers have been especially attracted by the 'lock-in' aspects of path dependence, as a way of describing and explaining the 'quasi-fixity' of spatial structures of economic activity and patterns of regional development over time.

Our argument here is that, while there is indeed considerable scope for, and value in, applying the idea of path dependence to the study of the evolution of regional economies, there are also significant problems to be confronted in so doing. The basic problem, we contend, is that economic geographers have tended to apply the concept uncritically, whereas in fact the application of the notion to regional economies and their evolution is far from unproblematic. As Glasmeier (2000, pp. 269-270) has argued:

Like technological lock-in, path dependence is often invoked uncritically as an explanation for a particular industrial experience. Usually lying behind the notion of path dependence is a series of factors that together add up to a directional bias. Just exactly what provokes path dependency is rarely communicated, however; this often erroneously leads to unidimensional invocations of the term.

Our aim is to highlight these problems. At one level, they have to do with unresolved issues surrounding the path dependence paradigm itself. But at another level, when applied and used in a geographical context, additional issues arise that reinforce the need to move beyond the basic notion if it is to function as a core concept in an evolutionary economic geography.

2. The Notion of Path Dependence: Some Unresolved Issues

There is no doubt that the concept of path dependence provides a powerful perspective through which to highlight the importance of context, contingency and history in the economic process. As such, it would also seem to be a highly relevant explanatory framework for economic geographers to adopt. Indeed, both David and Arthur themselves have used geographical examples in developing the concept. David, for example, has used it to describe the role of Marshallian externalities in imparting path dependence to the trajectories of local technological ‘enclaves’ (David, Foray and Dalle, 1997); while Arthur has described how increasing-returns effects give rise to path dependence in the development of industrial and urban location patterns (Arthur, 1994a, 1994b).

Yet, almost from the instant that David and Arthur began writing about path dependence, interpretative debates have surrounded the notion (see, for example, Liebowitz and Margolis, 1995; Bassanini and Dosi, 2001; David, 2001a, 2001b; Garud and Karnoe, 2001a, 2001b; Hirsch and Gillespie, 2001; Castaldi and Dosi, 2004), and these have spread into other disciplines, especially political and institutional studies (see for example, Pierson, 2000; Crouch and Farrell, 2004; Schwarz, 2004; Greener, 2005). David has tended to adopt a somewhat defensive posture in response to these criticisms and debates, arguing that many of them have arisen through misuse and misunderstanding of the concept, even through outright misinformation (David, 2001a, 2001b), and that adherence to a strict, formalised definition (David’s is in terms of the asymptotic distributions of non-ergodic stochastic systems), would avoid these problems. Nevertheless, despite David’s reply to his critics and exhortations for formal definitions, several unresolved issues continue to surround the concept of path dependence (see Table 1).

One of the most basic questions concerns the very meaning and nature of path dependence, *whether there are different types and degrees of path dependence* (‘historicity’) in the socio-economy. In their critique of the concept, Liebowitz and Margolis (1990, 1995) tried to distinguish between three degrees of path dependence on the basis of the nature of the allocative efficiency involved - with the ‘most serious’ form (‘third degree’ path dependence) defined as the state in which full lock-in to an inefficient outcome occurs. Their classification has been rightly criticised by David, who argues that it is based on static, not dynamic criteria, and that their ‘first-degree’ and ‘second-degree’ forms do not in fact distinguish between path dependent and

path independent systems. David (2001b, p. 25) himself also distinguishes three varieties of history – weak, moderate, and strong - but seems to equate path dependence only with what he calls ‘strong history’, which is defined as existing when a dynamical system satisfies the conditions of path dependence of outcome. So his schema does not really seem to admit of differing degrees

Table 1: Some Unresolved Issues Associated With Path Dependence

| Problem/Limitation | Some Key Questions |
|---|---|
| Are there different types, degrees and causes of path dependence? | Under what circumstances does path dependence arise? Is it possible to separate causes from consequences? Are there strong and weak forms of path dependence or historicity in the economy? Do different elements of the economy exhibit differing degrees of path dependence? Is path dependence a pervasive feature of the economy? |
| Problems surrounding the meaning and nature of ‘lock in’ | Are there different degrees of path dependence (‘historicity’)? Is lock-in a necessary/inevitable feature of path dependence? Is lock-in necessarily associated with inefficient outcomes? Can lock-in have positive features and outcomes? Under what conditions does ‘positive lock-in’ become negative ‘lock-in’? Is it possible to avoid lock-in? |
| Lack of discussion of path creation | How do new paths emerge? How does novelty relate to path dependence? How are new paths selected? What is the relationship between path dependence and new path creation? Are new paths latent in old paths? |
| Does path dependence need a theory of human agency? | In what ways is path dependence intentionally created by actors, or an unintentionally emergent effect at system level? How do agents interact with, reproduce and transform the path dependence structures within which they are embedded? How do agents create new paths? |
| Are path dependence processes necessarily evolutionary? | What sort of evolution is implied by path dependence? Do all evolutionary processes imply path dependent, but not vice versa? What is the relative significance of incremental versus radical change? Is the notion of economic adaptation consistent with path dependence? |

of path dependence in the economic system. Subsequent discussions – such as Bassanini and Dosi (2001) and Castaldi and Dosi (2003) – have so far not fully resolved this issue. Yet it is clear that different components of an economic system do in fact change and evolve at quite different rates, some very slowly and others much more rapidly and radically: this would seem to indicate the existence of different degrees and types of path dependency. Even the now-famous case of the QWERTY typewriter keyboard used by David to illustrate the notion of path dependence actually exhibits this attribute:

Although the QWERTY keyboard configuration has remained constant, other aspects of typewriting, such as the shift to electric typewriters and then computers, have changed dramatically. General theory is necessary to explain why some aspects of typewriter technology seem to be strongly path dependent and others do not (Kiser, 1996, p. 263).

The same point applies, *a fortiori*, to the economic system as a whole.

The problem is compounded by the *tendency for path dependence to be equated with 'lock-in'*. The latter is said to arise when sequential patterns of activity and behaviour form a 'groove', a particular technological or economic trajectory, from which it subsequently becomes difficult and costly to deviate (Setterfield, 1997, p.36). The inference is often drawn – encouraged by David's own work on the QWERTY keyboard - that such locked-in paths necessarily imply market failure, since under a market system profit-driven entrepreneurs attracted by the potential surplus of alternative and more efficient opportunities would soon move the economic system into a different technological-industrial trajectory (Leibowitz and Margolis, 1995). The very term 'lock-in' does seem to carry a negative connotation. David, however, has taken emphatic exception to any such reading of the notion (David, 1997, 2001). In a recent restatement, he argues he uses the term 'lock-in'

as a vivid way to describe the entry of a system into a trapping [configuration] – a basin of attraction that surrounds a locally (or globally) stable equilibrium. When a dynamic economic system enters such a [configuration] it cannot escape except through the intervention of some external force or shock, that alters its configuration or transforms the underlying relationships among the agents. Path dependent systems – which have a multiplicity of possible equilibria among which event-contingent selection can occur – may thus become locked into attractors that are optimal, or that are just as good as any others in the feasible set, or that take paths leading to places everyone would wish to have been able to

avoid, once they have arrived there (David, 2001, p. 26).

However, despite insisting that there is nothing inherent in the concept of lock-in to suggest inefficient outcomes, the very language used ('trapped', 'escape') nevertheless gives the impression that lock-in is more likely to be sub-optimal. David then goes on to argue:

... if and when the structure of economic incentives and constraints bearing upon the process under study is altered by events that ... may reasonably be regarded as 'exogenous innovations' (in the state of knowledge, or in the regulatory institutional regime), the previous attractor(s) [locked-in configuration(s)] may be destroyed, freeing the system to endogenously begin to evolve some new configuration (2001, p.27).

This exposes what we consider to be a worrying inconsistency within the notion of path dependence. On the one hand, the essential argument of path dependence is that small contingent events can have large and long-term consequences. Path dependence is produced by processes *endogenous* to the system in question. Yet, on the other, it is argued that it takes an *exogenous* shock or intervention to enable the system to break free ('escape') from those consequences and to begin to endogenously evolve a new path dependent trajectory. In which case, this appears to admit of the possibility that large events as well as small events can also generate path dependent outcomes. If so, does the nature of the path dependence differ according to whether it originates in a small happenstance event or a major external shock? In economics the idea of hysteresis has often been invoked to describe how large shocks (such as major economic slumps, oil price hikes, stock market crashes, etc) can result in permanent (irreversible) shifts in economic structure and relationships (see, for example, Cross, 1993; Katzner, 1993), and thus set off new patterns of path dependent development.

In fact, the issue goes even deeper, since it impinges on the *relationship between path dependence and economic evolution*. David (2001) argues that path dependence is a property of a 'wide array of processes that can properly be described as evolutionary'. According to many authors, one of the key defining characteristics of economic evolution is 'endogenously generated change' (see Witt, 1992, 2003). Path dependence, however, would seem to subscribe to a particular view of evolution that is very close to biology's notion of 'punctuated equilibrium'. In the latter, evolution is a periodic or episodic process, whereby phases of relative stability are

‘punctuated’ by critical junctures wherein major shocks cause system-wrenching change that then establishes a new phase of relative stability or slow change. David’s description of path dependence has an obvious resonance with this model: ‘lock-in’ is defined as a stable ‘trapping’ equilibrium’, which can only be broken by exogenous shocks, thereby freeing the system to move towards another eventually locked-in path (trapping equilibrium). This seems to imply that path dependence only really captures very slow forms of economic evolution, since major and radical change must always originate from outside. On the other hand, even quite substantial shifts in economic structure and relationships can occur through the cumulative effect of ongoing incremental change, that is where lock-in to a ‘stable equilibrium configuration’ never occurs, yet where such cumulative change displays elements of path dependence. It also appears difficult within a path dependence perspective for ‘critical junctures’ – major ‘de-locking’ shocks – to emerge endogenously from the normal processes of change within a given path.

Indeed, of itself path dependence *tells us little about how new paths come into being*. In path dependence, the emergence of novelty is serendipitous. Although path dependence highlights how, *once selected*, a new form of economic development, structure or technology may generate its own self-reinforcing processes that ‘lock in’ that structure, development path or technology, about how history can influence the genesis of novelty, it is largely silent on the issues of *how and where* that novelty comes from, or *why* one form of novelty gets selected over another. According to Vromen (1995, pp. 212-213), path dependence and lock-in are phenomena that obtain under particular conditions, and are themselves the result of more ‘fundamental’ evolutionary mechanisms, such as selection and adaptive learning. In his view, it is the working of such evolutionary mechanisms rather than the results they produce under particular conditions that ought to be regarded as the ‘first principles’ of evolutionary economics. As a number of authors have begun to argue (for example, see the papers in Garud and Karnøe, 2001), there is a need for a ‘path as process’ approach, wherein the process of economic evolution must be understood as an ongoing, never-ending interplay of path dependence, path creation and path destruction that occurs as actors in different arenas reproduce, mindfully deviate from, and transform existing socio-economic-technological structures, practices and development paths. This suggests that processes of path destruction and new path creation are

always latent in the process of path dependence. It also recognises that these processes not only co-exist, but also co-evolve. And it highlights the fact that although path dependence focuses on a sequence of specific micro-level events, it does not have an explicated theory of agency.¹

All this is not to dismiss the notion of path dependence. But it is to signal that there is still as yet no fully articulated and generally accepted theory of path dependence. This fact appears not to have been properly acknowledged by geographers when applying the notion of path dependence to their work. Yet this ongoing controversy must surely be kept firmly in mind when exploring whether and in what ways the concept of path dependence offers a plausible theoretical framework with which to help explain the evolution of regional economies, especially when, as we now argue, the application of the concept to economic geography raises additional aspects and dimensions to the path dependence concept.

3. What is ‘Regional’ Path Dependence?

Even prior to their recent use of path dependence ideas, geographers had for some time recognised the elementary but important fact that the economic landscape inherits the legacy of its own past industrial and institutional development, and that this history can exert a major influence in conditioning its future development and evolution. In the radical Marxist theories of uneven regional development in the 1980s (such as those by Harvey, 1982, 1985; Massey, 1984; and Smith, 1984), the focus was very much on the tension between fixity and flux in the economic landscape, on how spatial and regional configurations of economic activity and relations tend to be self-reproducing over time but are periodically disrupted by shifts in the mode, organisation or profitability of production or by new major technological innovations. The image conveyed is not dissimilar to the ‘punctuated equilibrium’ model that underpins much path dependence thinking. Moreover, particularly as characterised in Massey’s work, the economic landscape at any point in time is portrayed as a sort of palimpsest, a composite entity in which remnants of the past co-exist with – and indeed shape the location of – elements of the new. Interestingly, Arthur’s depiction

¹ For one attempt to construct micro foundations for evolutionary economics, see Potts (2000)

of the path dependent nature of urban and industrial location resonates closely with these geographical accounts, when he describes

spatial order as process dependent. Almost geologically stratified, with new industry laid down, layer by layer, upon inherited, previous locational formations... [G]eographical endowments and transport possibilities are important... but the main driving forces here are agglomeration economies – benefits to being close to other firms or to concentrations of industry... [E]arly firms are put down by historical accident in one or two locations; others are attracted by their presence, and others in turn by *their* presence. The industry ends up clustered in the early-chosen places. But this spatial ordering is not unique; a different set of early events could have steered the locational pattern into a different outcome... We might call this view *historical dependence*. Here the locational system generates structure as it goes (Arthur, 1994c, p. 50).

It is precisely an interest in such local external economies (both traded and untraded) that has fuelled post-Marxist economic-geographical work on regional development, first with respect to so-called post-Fordist industrial districts of flexible specialisation and then more recently on regional innovation systems. Indeed, the role of localised learning and knowledge spillovers in the development of regional innovation systems, in particular, has been a major spur to the importation of path dependence ideas into economic geography over the past decade or so, although an associated emphasis on the local socio-cultural ‘embeddedness’ of economic activity - and hence on the emergence and development of local institutional forms - has also contributed to this trend. In this way, geographers have in effect used the two main strands of the path dependence literature, namely technological and institutional path dependence, the two main ‘carriers of history’ as David (1994) calls them, as building blocks of a new, ‘evolutionary approach’ to regional analysis. The upshot is a growing corpus of economic-geographic research concerned both with path dependence as an explanation of the growth of ‘high-tech’ regions, and with how regional economies can break free of old, ‘locked-in’ paths of development on the basis of new technological and industrial trajectories (see, for example, Grahber, 1993; Storper, 1995; Storper, 1997; Cooke and Morgan, 1998; Bode, 2001; Kenney and von Burg, 2001; Hassink, 2005a and 2005b; Gertler, 2005; Boschma, 2005; Bathelt and Boggs, 2003; Fuchs and Shapira, 2005). Such is the importance now ascribed to path dependence ideas and notions in economic geography, that Walker can claim that:

One of the most exciting ideas in contemporary economic geography is that industrial history is literally embodied in the present. That is, choices made in the past – technologies embodied in machinery and product design, firm assets gained as patents or specific competencies, or labour skills acquired through learning – influence subsequent choices of method, designs, and practices. This is usually called ‘path dependence’... It does not mean a rigid sequence determined by technology and the past, but a road map in which an established direction leads more easily one way than another – and wholesale reversals are difficult. This logic applies to industrial locations as well... (2000, p. 126).

Part of that excitement derives from the idea that many of the basic mechanisms that make for path dependence – various forms of external or network economies – have a quintessentially local dimension in their form and operation. In this way, path dependence can be seen not as a set of universal mechanisms that apply equally everywhere and anywhere, but as a process or effect that is locally contingent and locally emergent, and hence to a large extent ‘place dependent’ (see Cox, 1996). Indeed, this conception would seem to fit with how geographers have sought to think about the interaction of space and time. Thus, in terms that strongly echo the importance attached to ‘historical accident’ and ‘random events’ in the path dependence literature, in her account of place differentiation Doreen Massey emphasises the

element of ‘chaos’ which is intrinsic to the spatial. For although the location of each (or a set) of a number of phenomena may be directly caused..., the spatial positioning of one in relation to the other... may not be directly caused. Such relative locations are produced out of the independent operation of separate determinations... Thus the chaos of the spatial results from the happenstance of juxtapositions, the accidental separations, the often paradoxical nature of spatial arrangements that result from the operation of these causalities (Massey, 1992, p. 81).

However, she then goes on to argue that this chaos, these ‘happenstance juxtapositions’ and ‘accidental separations’, can have ‘emergent powers’, the nature and operation of which render economic activity and its historical development ‘spatially dependent’ in various ways:

Spatial form as ‘outcome’ (the happenstance juxtapositions and so forth) has emergent powers which can have effects on subsequent events. Spatial form can alter the future course of the very histories that have produced it... One way of thinking about all this is to say that *the spatial is integral to the production of history ... just as the temporal is to geography*. Another way is to insist on the

inseparability of time and space, on their joint constitution through the interrelations between phenomena ... (*ibid*, p. 84, emphasis added).

Whilst this argument is not couched in path dependence terms as such, it clearly is consistent with the idea that the process of path dependence is inextricably bound up with geography.

But our excitement should not be at the expense of exposition. A whole series of non-trivial questions attach to the notion of path dependence as a place-dependent or regional phenomenon (Table 2). First, when we talk of regional path dependence, what precisely are we referring to: a region's firms, its industries, or the regional economy as an aggregate? One of the unresolved issues in evolutionary economics concerns the level at which evolutionary mechanisms occur, the units of selection and transmission. The economy is organised in multiple levels, for example: at the micro-scale, individual agents; at the next level work groups and teams in business units; then business units; institutions and organisations; entire industries; communities of industries; national economies; and at the most macro-level, the global economy (Murmman, 2003). Regional and local economies constitute additional conceptual levels in this hierarchy, and can take on various spatial scales, depending on how they are defined. Whatever their definition, they consist of 'ensembles' or 'populations' of economic agents, workers, business units, organisations, industries, and institutions, and, importantly, the interactions (direct and indirect) between them. Thus a regional economic space is at once both an environment within which individual firms industries and institutions evolve, and an aggregate entity that itself evolves by virtue of the development of its constituent individual firms, industries and institutions. This complicates how we think about regional path dependence: does only it refer to the development paths of individual local firms, industries and institutions; or it can refer to the evolving trajectory of a region's industrial ensemble, or its 'technological profile', considered as a whole? ²

Second, and following on from this, it is clear that regional economies – however defined – vary enormously in industrial structure, business organisation, economic growth, and linkages with other regions, the nation

² In a not unrelated context, in exploring the dependence of adaptive macro-economic growth on the diversity of technology and demand at the industry level, Metcalfe, Foster and Ramlogan (2006) show how industry growth rates are constrained by higher-order processes of emergence that convert an ensemble of industry growth rates into an aggregate rate of growth.

Table 2: What is Meant by Regional Path Dependence?

| Key Questions | Issues |
|---|---|
| What is the object of study? | What precisely are we referring to: a region's firms, its industries, or the regional economy as an aggregate? What is the relationship between the micro-level and the regional aggregate level? Path dependence is multi-scalar process, operating at different levels. How do these interact within regional economic spaces? |
| Do the nature and strength of path dependence vary from region to region? | Regions differ markedly in economic structure, institutions, connections to other regions and beyond, etc, so the nature and degree of path dependence might be expected to vary from region to region. In what ways is path dependence a locally contingent process? |
| What are the sources of regional path dependence? | Some will be more or less specific to particular types of regional economy; but, different types or forms of path dependence are likely to co-exist and interact within a regional economy. In this sense, the notion of regional path dependence is a complex, multi-dimensional one that possibly defies any singular overarching theorisation. |
| Do all parts of a regional economy display path dependence? | Is a certain threshold of interaction and inter-relatedness within the region required before it displays aggregate path dependence? Can different systems and trajectories of path dependence co-exist within a region, and how do these interact – what is the nature of inter-path coupling? |
| How pervasive is path dependence in the economic landscape? | Is it a fundamental feature of regional development and evolution – ie inevitable and indeed necessary for regional growth to take place? Or is it more typical of economically specialised regions and localities, and less likely to emerge in areas with diverse economic-technical structures? |

and the wider global economy. Some are economically specialised, whilst others are economically diverse. Some are technological leaders – the loci of innovation – whilst others have economies that depend more on the application rather than the invention of new technologies. The sort of path dependence that emerges will thus also tend to vary from place to place. Several sources or forms of path dependence have been identified in the economic literature. In his early work, David (1985, 1987) referred to three main processes: technical inter-relatedness (the reinforcing effects of complementarity and compatibility between different components of a technology and its use); economies of scale (the benefits of associated with the use of a technology – such as a decline in user costs – as it gains in acceptance

relative to other systems); and the quasi-irreversibility of investments (in effect the inertia of sunk costs arising from the difficulties of switching technology-specific capital and human skills to alternative uses). These features are sometimes bundled together under the rubric of positive 'network externalities' (Ruttan, 2001). In his work, Arthur (1999, p. 112) identifies four types of increasing returns that he argues are the key sources of path dependence: large fixed, initial, set-up costs (which give the advantage of falling unit costs to increased output); dynamic learning effects (learning by doing, learning by interacting, and learning by using all tend to entail positive feedbacks); coordination effects (which confer advantages to 'going along' with other economic agents taking similar actions); and self-reinforcing expectations (where the increased prevalence of a product, process or practice enhances beliefs of further prevalence). Within a regional setting, it is possible to identify a similar range of sources of path dependence (see for example, Table 3). Some of these will be more or less specific to particular types of regional economy; but in most cases, different types or form of path dependence are likely to co-exist and interact within a regional economy, even within particular industries that make up that economy. In this sense, the notion of regional path dependence is a complex, multi-dimensional one that possibly defies any singular overarching theorisation.

Further, while path dependence may occur at many different scales, it cannot be assumed that path dependence at the micro-scale necessarily generates path dependence at higher levels and scales; or to put it another way, there need not be any isomorphism between the degree of irreversibility and path-dependence across different scales of observation (Dosi and Metcalfe, 1991). This applies in two ways. First while some aspects of a region's industrial, technological or institutional structure may well be path dependent this does not mean that other aspects will also show the same type or degree of change (witness the case of QWERTY and the typewriter, mentioned above). Second, while there is little doubt that path dependence is a typical feature of economic actors and firms this does not necessarily mean that the aggregation of such entities into collective entities such as regions, cities or clusters, will also produce path dependent behaviour. As Bassani and Dosi (2005) argue, systems may be composed of path-dependent entities but whether or not the system itself will be path dependent depends on the nature of the interactions and the related 'fitness landscape'. They add, "Consider an economy with an increasing number of identical sectors, without intersectoral input/output

Table 3: Possible Sources of Regional Path Dependence

| Source | Features |
|--|---|
| Natural resource based | Region's development path shaped by dependence on a particular raw material (eg coal, oil, forestry products, etc), and the technical possibilities this provides for related and derived industries. |
| Sunk costs of local assets and infrastructures | Durability ('quasi-irreversibility') of a region's capital equipment, especially in heavy industries and its physical infrastructures, such as urban built form, transport system and the like, which remain in use, and shape economic development possibilities, because fixed costs are already 'sunk' while variable costs are lower than total costs of replacement. |
| Local external economies of industrial specialisation | Local Industrial districts and clusters of specialised economic activity characterised by Marshallian-type dynamic externalities and untraded inter-dependencies – common pool of specialist skilled labour, dedicated suppliers and intermediaries, local knowledge spillovers, and local co-ordination effects in terms of business mechanisms, such as networks of co-operation, business practice conventions, etc., all of which create a high degree of local economic 'inter-relatedness'. |
| Regional technological lock-in | Development of a distinctive specialised regional technological regime or innovation system through processes of local collective learning, mimetic and isomorphic behaviour, dedicated technology and research organisations, inter-firm division of labour and other forms of technical inter-relatedness. |
| Economies of agglomeration | Generalised self-reinforcing development based on various agglomeration externalities, such diverse labour pool, large market, thick networks of input-output relations, suppliers, services and information. Wide scope for various specialist functions and activities. |
| Region-specific institutions, social forms and cultural traditions | Development of locally specific economic and regulatory institutions, social capital, social infrastructures and traditions, all which embed economic activity into local trajectory. |
| Inter-regional linkages and inter-dependencies | Development paths in a region may be shaped by those in other regions, though intra-industry and inter-industry linkages and dependencies; reliance on financial institutions elsewhere; and influence exerted by economic and regulatory policies pursued in other regions and at national level (or even beyond). Regional development paths co-evolve in complex ways. |

linkages or intersectoral knowledge spillovers. Even if each sector displays path-dependent dynamics, due to the law of large numbers the limit of that economy exhibits ergodic patterns [that is, path independent outcomes]" (p. 21-22). They explain that "Aggregate versus local path dependence seems therefore to depend on the structure of interaction. When local interactions are strong (i.e. every unit depends on each other with intensity above a certain threshold) path dependence at a local level induces path dependence at an [aggregate] level. Still, no conclusive results have ever been provided to define a 'minimum' interaction threshold below which no path-dependent aggregate outcome is observable." (p. 22). This clearly raises the crucial question of whether structures of interaction and local linkages are sufficiently strong within regional economies to give rise to collective path dependence. Many accounts appear simply to assume strong localised increasing returns and strong collective learning, rather than demonstrating their effects.

Such an assumption may be on safer ground when applied to specialised industrial districts and clusters where local linkages have been unequivocally identified. Most discussions of path dependence in evolutionary economics deal with a single technology or industry. The same is true in almost all economic-geographic applications of the concept, where attention is focused on highly specialised clusters, or on a particular or leading local sector of activity. However, most local and regional economies, however these are demarcated spatially, are not narrowly based on just one or two sectors. In the case of large economically diversified regions (such as the South East of England) we clearly should not automatically assume that local linkages are above this interaction threshold. As Simmie (2002) and others have demonstrated, local linkages in such a region may be far less important than their urbanisation externalities and international networks, and hence of less significance than the linkages to local suppliers and customers witnessed in other types of city-region. Further, if the Jacobsian argument that economic diversity stimulates innovation is correct, diversified regional economies might be expected to exhibit a high degree of adaptive development, and hence a low propensity to path dependence.

On the other hand, as argued above, several different path-dependent forms of development may co-exist in a diversified regional economy. Even some high-tech clusters are in fact quite diversified, consisting of a number of 'sub-clusters' each of which may be evolving along its own specific path-dependent trajectory of development (Bathelt, 2001). Regions may thus

contain multiple instances (and trajectories) of path dependence (Rigby and Essletzbichler, 1997; Essletzbichler and Winther, 1999). How do different sectoral and technological paths within a region interact? Some interactions (via knowledge spillovers, trade, and the like) may be positive and mutually reinforcing; others may be negative in nature, so that, for example, different but related sectors effectively lock each other in to sub-optimal trajectories. More detailed examinations of the relations or couplings between technological and sectoral trajectories within regional economies would undoubtedly be helpful. There may well be path-dependent processes occurring within a regional economy through learning, spin-offs, clustering and so on but in themselves these do not imply that the regional economy as a collective system is path dependent. The applicability of path dependence does not simply depend on whether we can identify a meaningful regional economic system, it also depends crucially on the strength of interactions and linkages within that system.

This then raises the question of just how geographically pervasive is path dependence? Or to put it another way, do different places, different local and regional economies, exhibit different degrees of path dependence, different degrees of 'historicity' (and hence lock-in)? To claim that path dependence is everywhere equally relevant and equally strong would be to promulgate a reductionist methodological injunction. Empirical observation suggests that path dependent development is not pervasive, or at least not equally significant everywhere. For example, path dependent development seems to be more evident, and stronger, in localities with highly specialised economic structures than in those with more diversified economies. As we have just argued, this is what we would expect, since local network externalities of various kinds are much more likely to emerge the more similar and functionally inter-related are local firms. Or is it that path dependence is always latent, but does not always emerge unless local context and circumstances are especially conducive? As Cox argues, the role of place, of local context, is again possibly of key importance:

Place- and path-dependence are transparently related. Particular places are characterised by particular types of path dependence and agents are not just locked into a particular development path but also into that particular place where their (path dependent) powers can be exercised. This follows from the sorts of externalities and social infrastructures characteristic of particular areas and their (specialised) physical infrastructures (Cox, 1996, p. 164).

The same argument might also be extended to the ‘random events’ and ‘historical accidents’ that are held to initiate particular paths and trajectories of techno-economic development. While the ‘selection’ of a location by a new industry or technology (to use Arthur’s phraseology) may well be wholly serendipitous or happenstance, it is difficult to argue that this is necessarily always or even typically the case, for it would suggest that the genesis of new techno-economic paths and trajectories occurs randomly across space. Again, empirical observation provides evidence to the contrary. Without becoming entrapped in a redundant regressive search for the ‘ultimate cause’, numerous examples can be found in which it is possible to discover local-context specific factors that influenced the discovery or birth of a new product, process, industry or organisation, and hence why it occurred in that place and not another. Indeed, as economic history shows, there are some areas and regions that have repeatedly been the site of path-forming innovations or new industrial sectors (such as Massachusetts over the past two centuries or more – see Best, 2001; Glaeser, 2005). On the other hand, there are other areas that have never spawned any major new technology or industrial sector. Yet again, there are examples of areas and regions that were once the crucibles of fervent innovative activity, but which – for some reason or another – later lose that leadership and become innovative backwaters. The fact that purely random chance may not be the only ‘birth mechanism’ that influences the location of a new technology or industry is actually recognised by Arthur (1994) who admits that “regions that offer great economic benefits will have a greater probability of being selected early on... [a]nd this will make them more likely to become the region that dominates the industry” (p. 105). In other words, Arthur acknowledges that “regions that are economically attractive enjoy ‘selectional advantage’, with correspondingly higher probabilities of gaining dominance” (p. 105). We might go further and suggest that local economic structures and previous industrial histories may play a significant role in determining where new technological and industrial developments occur. Some regional economic structures and histories may be conducive to the birth of new technologies and industries, while others may be antithetical. So once again, where techno-economic paths originate may itself be a place-dependent process.

All this is not meant to fetishise place or spatial proximity, nor to suggest that all path dependence processes are locally emergent phenomena. In a geographical context, in fact, scale issues come very much to the fore.

Local firms, organisations, and institutions are linked into a highly complex series of networks of relations with other businesses, markets, regulatory frameworks and institutions, in other places and regions, and at a whole variety of spatial scales, right up to the national level, and even beyond to the global. It is in this sense that regions are as much 'relational' entities as they are systems of 'structured coherence' (to use Harvey's, 1985, term). Economic agents and developments in one region can thus shape developments in another, so that the lock-in of a particular path in one region may result in the locking-in of a particular path elsewhere. Evolutionary economists increasingly emphasise how path dependence involves co-evolution of different 'arenas' - the economic, technological, institutional and socio-cultural. And some geographers have shown how local path dependence also occurs through such mutually reinforcing co-evolution of local economic, technological and socio-institutional 'arenas' (see, for example, the study of Silicon Valley's creation and growth by Kenney and von Burg, 2001). But path dependent development in a region may also involve the co-evolution, or mutually-reinforcing interaction, of local and non-local arenas. Thus the various intra- and inter-industry interdependencies that develop between regions mean that different regional economies will tend to co-evolve. Note that this can result in the 'locking-out' as well as 'locking-in' of particular techno-industrial paths across different regions. Further, a given pattern of uneven regional development will co-evolve with national-level (system-wide) 'arenas' (such as the financial system, and the national macro-economic policy and regulatory regime). How these different spatial scales of co-evolution and path dependence interact is an almost wholly unexplored topic.

The notion of regional path dependence is thus a complex one. For one thing, all of the unresolved issues surrounding the concept of path dependence itself carry over to its application to regional studies. For another, additional issues arise from applying the notion to geographical contexts. This is in part because regional path dependence is both a phenomenon and an approach, and both a cause and an effect. Path dependence shapes the economic development of regions, indeed creates regional configurations of economic activity. At the same time, regions shape the processes of path dependence. What is also evident is that, geographically, path dependence as outcome, and as process, occurs at a whole variety of spatial scales, with processes and outcomes at one scale influencing those at another. Dopfer and Potts (2004a, 2004b) have argued that evolutionary economics requires an appropriate

ontology, specifically one that stresses the modularity, openness and hierarchic depth of the economic system. The concept of regional path dependence similarly is in need of ontological foundations.

4. Regional Path Creation

As indicated above, a fundamental issue relates to the origins and explanation of paths. How do technological, industrial and regional paths come into being? Most path dependent models explain the initiation of paths in terms of (small) events that are in some ways exogenous to, or orthogonal to, the key system properties. Typically, these events are described as being ‘chance’, ‘serendipitous’ or simply as ‘historical accidents’. This would seem to suggest that there are innumerable different possibilities and that the preceding sequence of events (past history) plays no role in determining what new ‘historical accident’ occurs or whether or not it initiates a new techno-economic path. Beyond this, there is much ambiguity and confusion over what these ‘historical accidents’ and ‘chance events’ imply, and the widespread use of quotation marks certainly does not increase their clarity. One interpretation is that these descriptions refer literally to purely or mostly random events. For example, in Arthur’s model of path dependence based on ‘chance’, the location of an industry is determined by an initial ‘historical accident’, typically the random decision of one firm to set up in a particular region. Krugman (1991) has also argued that the significance of increasing returns in the economic landscape points to the role of historical accidents. Some evolutionary economic geographers have envisaged a similar (and uncritical) account of industry emergence and path formation in the economic landscape. Thus according to Boschma and Frenken (2004, pp. 20-21),

the evolutionary approach argues that the selection pressure of existing spatial structures is rather weak when new industries emerge. Under certain circumstances there are good reasons to assume that place specific features do not determine the location of new sectors. The environment is considered to be of minor importance at the initial stage of development of a sector when there exists a gap between the requirements of the new industry (in terms of knowledge, skills, etc.) and its surrounding environment. Windows of locational opportunity are open in emerging industries.

This view aligns with Storper’s (1999) argument that new technologies begin as generic assets and then only subsequently evolve into specific assets.

Initially, new technologically-based sectors have few established specific inputs so that they ‘invent’ their own input chains and the associated knowledge, which is why, he claims, their initial location is basically serendipitous: this explains why, he argues, the semiconductor industry grew up in Silicon Valley and not alongside its parent industry – radio and television equipment – on the East coast. Similarly, this thesis continues, dedicated and specialised institutional supports do not precede the emergence of an industry but tend to co-evolve and develop with the industry’s growth (Boschma and Frenken, 2004; Lambooy and Boshma, 2001; Boschma 2004). On the basis of these views, therefore, it is argued that “new technological trajectories often tend to emergence spontaneously and unexpectedly in space” (Boschma, 2004; Krugman 1991). Thus, as we argued above, the straightforward application of path dependence ideas would suggest that new paths emerge randomly across the economic landscape.

This account is entirely consistent with the way in which path dependence has been used in historical institutionalism. In these institutional stories, small initial events or accidents are usually distinguished from the subsequent causes that maintain and reinforce a particular institutional trajectory. Indeed, Schwartz (2004) argues that path dependent models *have* to separate initial small causes from system reproduction causes, as the trajectory would otherwise be predictable in advance. However, it is also possible to advance a different interpretation of initial events and the ‘birth’ of path dependent trajectories, and one that allows local context (and hence local prior path dependent development) a role in determining where (and when) new techno-economic paths emerge. Rather than being merely happenstance or wholly contingent, the events and occurrences that start off a new path of development may include a large element of strategic purpose and deliberate action (Puffert, 2001). Indeed as Puffert has argued, path dependence is not necessarily an alternative to purposeful strategic action, but may actually make actors even more eager and motivated to attempt to make their technologies and techniques the basis of a new path, or to make their region or locality the home of a new industry. The success of their efforts may well be partly affected by circumstances beyond their control or knowledge, and in this sense these events have an ‘accidental’ dimension, but they often depend on or spring from purposive agency. As Garud and Karnoe (2001) have argued, any theory of path creation should attach a prominent role to the importance of strategic agency and the deliberate, ‘mindful deviation’ of entrepreneurs from

established paths. Entrepreneurs mobilise resources, ideas and people in the collective creation of new technological fields. Entrepreneurship is not a random act of genius, and it is not a negation of the past, nor its simple extrapolation:

It is a reconstitution and transformation of the past in such a way that continuity and change are both preserved in the act of path creation. That is, entrepreneurs are always attempting to disembed from structures that they are embedded in while reusing some of the rules and resources” (Garud and Karnøe, 2001, p. 26).

Such mindful deviation may itself take various forms. It may be an incremental process, as Garud and Karnøe suggest, whereby agents consistently cultivate and nurture experimentation in the search for new technologies, products, processes and the like. In other instances, certain critical junctures and large-scale events or shocks may provoke individual agents or policy-makers to devise new strategies or develop new ‘windows of opportunity’ (David, 2005, Sydow et al, 2005). Thus, an exclusive focus on small arbitrary, contingent and wholly ‘non-contextualised’ events may distract attention from the effects of such purposive action or the impact of large scale events during critical junctures. For example, Feldman (2005) argues that a large scale crisis in public employment in the case of Washington DC due to Federal downsizing between 1970 and 2000 released a large supply of skilled labour that provided the critical resource underlying the region’s subsequent industrial resurgence.

Once we start to ask how purposeful action can have long-term effects then analysis leads away from the inexplicable degree of chance towards the explicable concatenation of causal and preconditioning factors in particular times and places. For example, Pinch and Henry (1999) demonstrate that the growth of the UK motor sport cluster can not be adequately explained in terms of Krugman’s ‘historical accident’ model. As we argued above, path dependence not only produces places, but place dependence is also responsible for path dependence. Local institutions and human resources that have developed as a result of one industry’s development in a region often appear to act as critical causes of, and inputs to, the creation of other industries. For example, Zook (2005) argues that the San Francisco Bay region’s pre-existing venture capital industry proved crucial to the development of the internet industry in that location, and that the other initial locations of internet production which lacked an experienced risk capital

system underwent relative decline.³ As another example, Bresnahan et al's (2005) large-scale, comparative study of the emergence of high technology clusters emphasises the importance of pre-existing comparative advantages in shaping new increasing returns effects. We should not ignore what these authors term 'old economy' inputs, such as the supply of technical and managerial skills, connections to market niches, and the role of key firms, as they remain crucial in determining whether and where 'new economy' based increasing returns actually emerge and develop.

Taking place dependence seriously suggests that there will be alternative perspectives on what the local causal factors are that influence the creation of new paths, and why these factors are activated in some places and not others. Even in the case of Silicon Valley, for example, there is difficulty and disagreement about the identification and timing of the initial causes. Kenney and Burg (2001) suggest that the cluster's emergence can be traced to small contingent decisions such as Shockley's move to Palo Alto and the founding of Fairchild.⁴ Sturgeon (2000), however, argues that the emergence of the Valley can be traced back much further, to the development of the electronics industry during the interwar period. Yet another example is the Cambridge high-tech cluster (covering scientific instruments, software, and biotechnology) in the UK. The origins of this are usually traced to the establishment of Cambridge Consultants in 1960 (a group of chemistry graduates concerned to foster research links between the University and local industry in the Cambridge area), or to the establishment of a science park by Trinity College in 1970. But it could equally well be traced back to antecedents in the 1930s, such as the existence of Cambridge Instruments (a specialist aeronautical instrument firm) or the local agro-chemical industry. The notion of a regional path is of course an irredeemably metaphorical idea so that it is unlikely to have unambiguous and precise origins. Once again this raises the question about the exact meaning of a regional path. Can it be identified through performance measures, use of technologies, and product forms, or do

³ Arthur's 'third' model of industrial location does in fact seek to merge the effects of 'chance' with those of 'necessity'. Elsewhere, however, Arthur appears to deny that such a compromise between deterministic and random causality can be found, and in effect argues it is either one or the other: "Causality resides either deterministically within the given economic structure, or "randomly" in the small events and circumstances outside the given structure (1994, p. 27).

⁴ According to Arthur (1994, p 100) if the early entrepreneurs had other predilections "Silicon Valley might well have been somewhere else".

we have to understand the regularities and structures in the untraded interdependencies and interactions between institutions, networks, ideas and agents before we can confidently claim to have traced a regional path (as indeed Storper, 1999, argued)? In the absence of a clear explanation of what we mean by a regional economic path it is virtually impossible to distinguish bounded and intra-path change from radical and path breaking departures. Furthermore, given the uncertainty and unpredictability of path emergence this may only be possible with the benefit of hindsight.

What we are arguing, then, is that path dependence models do not justify a resort to explaining the emergence of industries and regional technological and industrial paths simply in terms of random, chance or spontaneous events. As David (2005) himself has recently emphasised, the whole point of path dependence is to restore the importance of causal, historical economic explanation involving sequential actions, and placing too much emphasis on random accidents as the sources of path creation constrains and undermines such causal explanation. Rather, path dependence should highlight the interactions between purposeful action and positive unforeseen feedbacks (Puffert, 2001). But if this is so, does it make sense to distinguish on-path change from off-path change when both may be to some degree present in a new entrepreneurial venture? Path dependence, we suspect, has tended to over-emphasise the replication function of economic reproduction mechanisms and to downplay their simultaneous innovative role. Moreover, it is not just strategic agency among entrepreneurs that is important in path creation. As the ‘economic miracles’ of Ireland and Finland have demonstrated, we also have to examine the strategic decisions made by policy-makers, including the nation-state, if we are to properly understand regional path creation.

5. Regional Lock-In Versus Regional Adaptive Capability

While the creation of regional paths remains relatively unexplored, discussions of path dependence within economic geography have been overwhelmingly concerned with the notion of ‘lock-in. The reasons are clear enough. As noted earlier, the notion or metaphor of ‘lock-in’ seems to capture well the observed tendency for the geographical structure of the economy to exhibit historical ‘quasi-fixity’ – for urban and regional patterns of economic specialisation and uneven development to be self-reinforcing and self-reproducing over quite long spans of time, even extending and lingering into

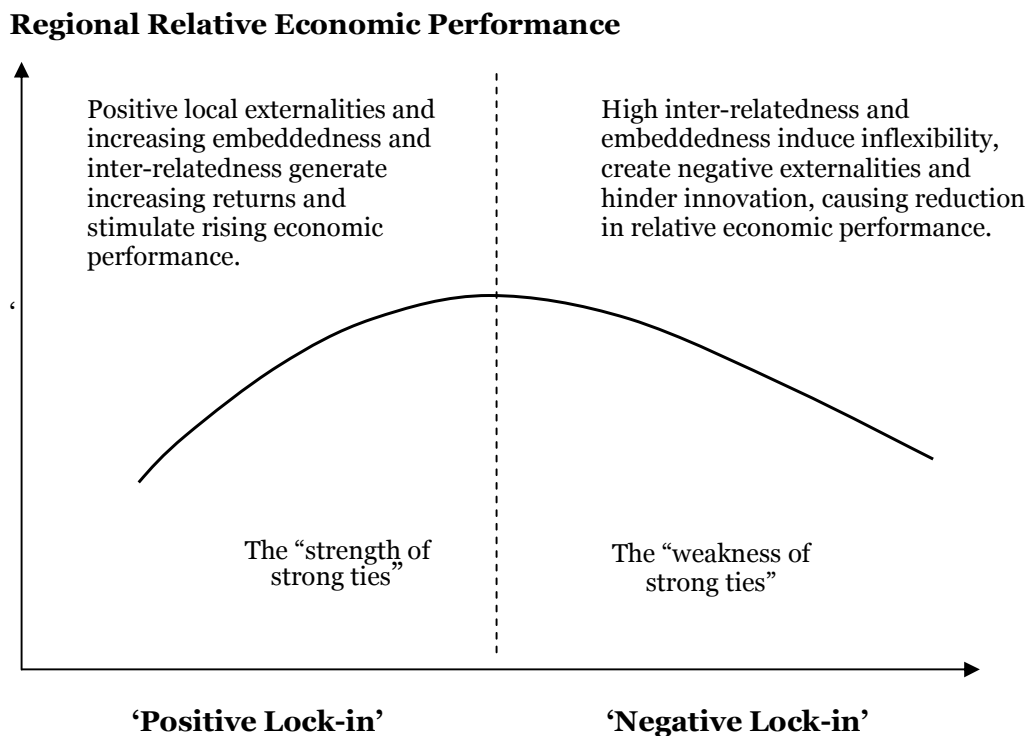
periods when they no longer appear to be wholly consistent with the economic conditions and circumstances of the day, which is, of course, precisely why a path dependence perspective is particularly relevant to an understanding of how an economic landscape has come to be what it is. Our argument here is that we need to understand regional lock-in as a multi-scaled process, and one which also has a high degree of place-dependency, rather than as a universal principle that applies everywhere and anywhere and that is inexorable in its emergence and consequences. This is not to deny its importance, nor its relevance to discussions of regional path dependence, but rather to emphasize the need to examine the processes and conditions under which regional 'lock-in' occurs, and hence its uneven and contingent realisations, rather more carefully.

Recall that, despite David's protestations to the contrary, the idea of 'lock-in' has usually been assigned a negative interpretation, to describe the situation where a technology, industry - or in our case, a regional or local economy - has become stuck ('trapped', to use David's own phrase) in a particular trajectory or path that has become sub-optimal or inefficient in some way. Martin (2006) argues that we need a more nuanced perspective. He suggests that the evolution of a regional economy may involve a transition from a phase of 'positive lock-in', in which increasing returns and positive externalities reinforce local industrial dynamism, to a phase of 'negative lock-in', in which the very processes and structures that underpinned the region's self-reinforcing development have become a source of increasing rigidity and inflexibility that together undermine its productivity, adaptability and competitiveness (see Figure 1 for a schematic representation).

Initially, the various increasing returns effects that produce path dependence have positive development and growth effects: indeed, such it could be argued that 'positive lock-in' is necessary for such reinforcing regional growth to take place. This can be observed in numerous examples of regional development, both in the past and in the contemporary era. Regional growth becomes established around an expanding industry or set of inter-related industries that stimulate and benefit from emergent external economies. This phase of growth and success - of positive lock-in' - may last for decades. But economic history also shows how many such regions, as their lead industries and technological systems mature, tend eventually to lose their former growth dynamic, and enter a phase of 'negative lock-in' and relative economic decline. In this latter case, the regional economy becomes stuck in

established practices and ideas, and networks of inter-relatedness and embeddedness that no longer yield increasing returns and may even induce negative externalities. The ‘strong ties’ that were previously a source of cumulative economic success become a source of weakness. In Grabher’s (1993) account of the Ruhr, for example, it was precisely the strength of local inter-firm relations and networks and the specialized nature of local institutions that caused the coal mining and steel complex to become inflexible, unable to absorb new ideas, and ultimately unable to respond to competition. Grabher (1993) distinguished ‘functional’ lock-in (based on hierarchical firm relations), ‘cognitive lock-in’ (consisting of a common world-view), and ‘political lock-in’ (a thick and dense institutional structure that hampers restructuring) (see also Glasmeier, 1991), all of which contributed to negative lock-in.

Figure 1: From ‘Positive’ to ‘Negative’ Lock-in in Regional Path-Dependent Economic Development



Yet while there is much evidence that 'lock-in' is important in many cases of regional economic decline, we cannot assume that it provides a universal and sufficient explanation. As Hassink (2005) argues, 'regional lock-in' has become a largely inductive notion that has been inadequately theorised and subject to too few comparative evaluations. Many accounts of lock-in tend to emphasise the endogenous causes of stasis and contrast these with exogenous causes of dramatic change. As we have seen, according to David, an economic system trapped in 'lock-in' cannot escape except through the intervention of some external force or shock or an injection of outside energy that shakes the system into a new configuration or path. However, it is not always endogenous events that are primarily responsible for decline. Indeed, there are numerous examples where the disruptive growth of competition from other regions has undermined the success of hitherto successful industrial regions. In the case of British cotton textiles, for example, the rise of Lancashire in the 19th century gradually undermined the position of the Scottish industry, before Lancashire in turn fell victim to the rise of US and Asian producers in the 20th century. In this and many other cases, the primary cause of decline is the inability or slowness of a region's industries to respond to the rise of major new competitors and technologies elsewhere. According to the path dependence model, external shocks of this sort should stimulate a region's economy to 'break free' from its locked-in path of development and move to another, more competitive configuration. Instead, however, as many examples testify, such shocks may merely set off a spiral of negative lock-in effects whereby the region's firms react in terms of defensive cost-cutting and quality reduction rather than by innovative investment or moving into new productive fields. In such cases of inter-regional competitive exclusion and 'lock-out', the occurrence of crisis and loss of competitiveness can be a gradual process extending over several decades rather than a dramatic collapse and reconfiguration during a critical juncture.

What is clear, then, is that exogenously originating shocks and crises do not always act to free regions from negative path dependency but may in fact have the opposite effect. As another example, major regional recessions frequently have hysteretic effects in that sudden, large-scale industrial decline can overwhelm those institutions responsible for adaptation and the redeployment of resources, as well as acting to de-motivate and demoralise economic agents. There may be few resources left to redeploy or mobilise into new paths of development, and the region fails to recover from the external

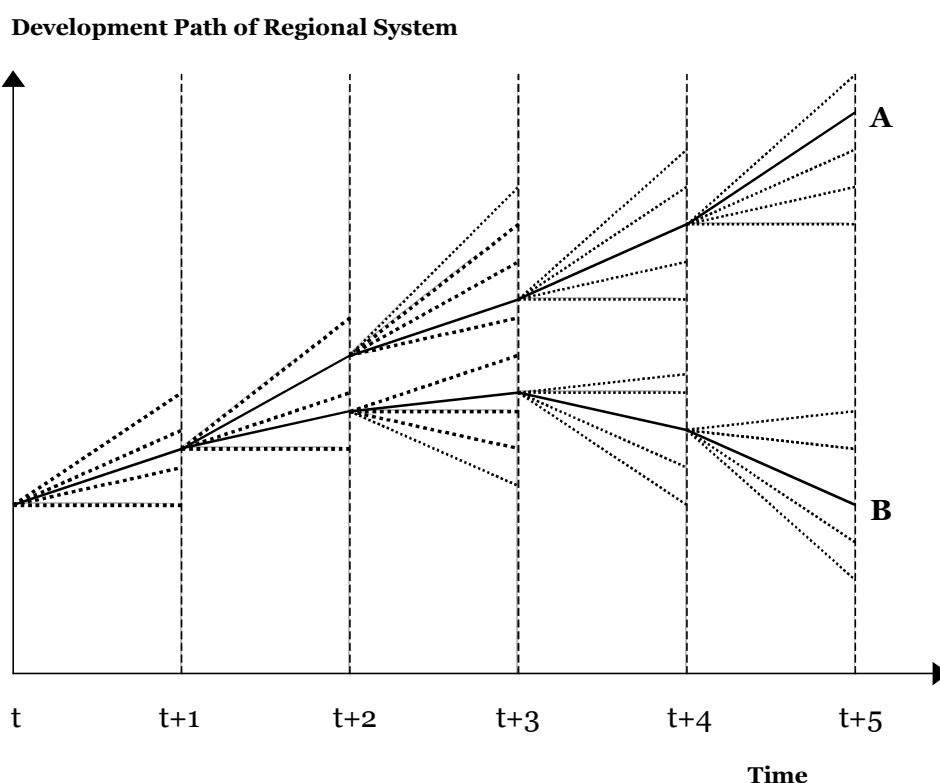
shock. The impacts of regional crises and external shocks are clearly indeterminate in themselves, and different regions will have different vulnerabilities both to endogenous processes of negative lock-in and to externally originating shocks (Thelen, 1999). What is at issue is why it is that some regions seem to experience the onset of negative lock-in and problems of long-run relative decline, while others appear much more able to adapt and avoid pronounced negative lock-in, in effect to undergo sequential phases of positive 'lock-in' (compare the contrasting regional development paths, A and B, in Figure 2). In short, we need to know much more about what determines the ability of regional economies to adapt.

In some early regional applications of path dependence, eventual lock-in appears as an inevitable consequence of path dependence. However, this view may have been a misperception. According to David (2005, p 183) "We know that path dependence is neither a necessary nor a sufficient condition for market failure, non-ergodic systems can settle into basins of attraction that are suboptimal. Yet we also know that perturbations and shifts in the underlying parameters can push such systems into the neighbourhood of other, quite different attractors". In similar fashion, Setterfield (2001) argues that lock-in only occurs if the level of interrelatedness in an economy reaches a critical threshold value *before* an economy needs to change its technological, organisational, and output regimes (our emphasis). This threshold, he continues, depends on expectations about the profitability of new structures being contemplated. In his words, "Moreover, the lock-in threshold is also sensitive to the precise nature of the technological, organisational and output regimes in the context of which the economy is currently growing, because some regimes may be more susceptible to lock-in than others" (p. 110). The identification of such variable thresholds amongst regional economies remains unclear.

Generally, the liability of path dependent systems to become locked in is explained only in rather vague terms, such as due to their susceptibility to perturbations and shocks. Arthur (1994) suggests that exit and escape from lock-in are more difficult in cases where learning effects and specialized fixed costs are the sources of self-reinforcement, and easier where co-ordination effects are the source. Co-ordination is transferable even though it is obstructed by uncertainty among agents about each other's intentions. In such conditions negative lock-in cumulatively increases the probability that actors will make choices that lead to regional economic decline. What this implies is

that either partly rational actors do not foresee the collective impacts of their choices, or that somehow path dependence is operating ‘behind their backs’ (through forms of bounded learning and cognitive framing) so that it

Figure 2: Alternative Path Dependent Regional Development Trajectories



A – Development path with sequential phases of ‘positive lock-in’
B – Development path in which ‘positive lock-in’ becomes ‘negative lock-in’
 Dashed lines represent fields of possible contingent paths, while solid lines are the realised actual paths

confines their understanding of problems and search for solutions, or that the immediate costs and risks of making alternative courses of action are too high. All of these are possible, but we need to know where and why each operates. A further issue here is that path dependent models are indeterminate in that they explain both negative lock-in and positive increasing returns in terms of the same factors. The same self-reinforcing mechanism may have positive and negative impacts so that it is vital to examine their contingent grounded

effects. Further research needs to clarify when, and under what conditions, such mechanisms have quite contrary outcomes. Setterfield (2001), for instance, argues that it is when techniques and output structures need to change that specialisation and interrelatedness becomes problematic and that negative feedback becomes potentially relevant. This often seems to be what happens where a region's lead industry comes under intense competition from other regions elsewhere (as the Lancashire textile example referred to above illustrates; another example would be the impact of Korean shipbuilding on a number of European shipyards, such as Tyneside and Clydeside in the UK).

As this suggests, a further question relates to the importance of constant and negative returns relative to lock-in as causes of regional economic decline. Arthur (1994) himself notes that agglomeration economies are frequently bounded. In this case inflationary spirals stemming from the exhaustion of the local labour supply and infrastructure, and other forms of diseconomies of scale, may well be just as important as lock-in. In these cases a region's trajectory may move incrementally and almost imperceptibly from the path dependent world of increasing returns to the more traditional world of constant and declining returns. But once strong negative returns are established path dependence no longer applies, as the outcome of the process is deterministic. And to complicate matters even further, if an external economic environment is turbulent and discontinuous then it may be that regional economies have to change repeatedly in order to maintain the same path.

Some regions do indeed appear to be able to avoid long-term decline through lock-in, so that they escape from a tendency towards asymptotic steady states. Bassanini and Dosi (2001), for example, argue that "Actually many examples from the evolution of institutions, organizations, and technologies suggest a world wherein temporary 'resting' states are 'metastable' in the sense that on longer time scales they are persistently overcome by new developments leading to new 'temporary' resting states (pp. 14-15). To use these terms, what are the processes that cause some regional economies to be metastable and thereby avoid negative lock-ins and long term decline? There are several ways in which regional economies may escape negative lock-in. Castaldi and Dosi (2004) highlighted a number of generic features that are associated with the breaking of particular system paths and each of these can be applied to regional economies (see Martin, 2006; and Table 4).

First, the appearance of a new technological paradigm may allow regions to establish a *new indigenous development path*. In some cases regions can use these ‘windows of locational opportunity’ to establish industrial sectors without local technological antecedents. But we clearly need to know why these new paths emerge only in certain regions. For some years now it has been argued that old industrial regions exert a negative shadow on start-ups in newer sectors, (what Checkland, 1976, in the case of Glasgow’s heavy industry and shipbuilding, called the ‘Upas tree’ effect), so that tomorrow’s industries tend not to emerge in ‘yesterday’s’ regions. But, clearly, this is by no means inevitable. The key research question is why some regions are capable of renewal and transformation while others are not. There are a number of alternative views of the key determinants. Lazerson and Lorenzoni

Table 4. Escaping Regional Lock-in: Some Possible Scenarios

| Sources of New Path | Characteristics |
|---|--|
| Indigenous creation | Emergence of new technologies and industries from within the region that have no immediate predecessors or antecedents there. |
| Heterogeneity and diversity | Diversity of local industries, technologies and organisations promotes constant innovation and economic reconfiguration, avoiding complete adaptation and lock-in to a fixed structure |
| Transplantation from elsewhere | Primary mechanism is the importation of a new industry or technology from elsewhere, which then forms basis of new pathway of regional growth. |
| Diversification into (technologically) related industries | Transition where an existing industry goes into decline but its core technologies are redeployed and extended to provide the basis of related new industries in the region. |
| Upgrading of existing industries | The revitalisation and enhancement of a region’s industrial base through the infusion of new technologies or introduction of new products and services. |

(1999), for example, suggest that, in the Third Italy, larger leading firms with good information and strong finances have shaken smaller firms out of their torpor and steered restructuring through the use of contracting, while local districts made up of small firms are more likely to suffer from lock-in, as in the case of the Lancashire cotton districts. In another case, Zeitlin (1995) argued that the demise of Britain's industrial districts in the postwar era had more specific causes than simply firm size. In his view, it was because they lacked a collaborative culture of reciprocity, trust and co-operation expressed through local associations. Others, however, have put more emphasis on the importance of human capital and the ability of regions to retain skilled and educated labour even in the immediate aftermath of a recession. In support of this, Glaeser (2005) traces a large part of Boston's long-run ability to 'reinvent' itself economically to the fact that it has been able to attract residents for reasons other than high wages: "Reinvention depends critically on how people respond to crisis by innovating, not fleeing. The innovation response is itself, far more likely, if residents actually want to stay in the region for non-economic reasons" (p. 152). Perhaps, then, the residential preference of the 'creative classes' (Florida, 2002) helps to explain path re-emergence.

One of the key questions here is whether we can identify adaptive capabilities that are shared amongst firms in particular regions, making the regional economy better equipped to respond to change. Best (2001) argues that this is just what has happened in Massachusetts where the regional system has developed a particular technological capability dependent on the interaction between entrepreneurial firms, a particular production regime and a region-specific skill formation system. In his view, regions can be thought of as developing specialized and distinctive technology capabilities through a cumulative and self-renewing process. "In the process the region's technological capability itself is revitalized by the ongoing, self-organizing activities of its inhabitants. It can be a virtuous circle. Regional technological capabilities spawn entrepreneurial firms, which upgrade regional technological capabilities, which spawn more entrepreneurial firms." (2001, p. 132). In the case of Massachusetts, he suggests that these capabilities lie in precision machines and complex products and that specialisation within an 'open system' model of production has allowed new spin-offs to repeatedly increase the region's industrial-technological diversity. However, several questions about these regional capabilities remain unanswered. In particular,

what are the relations between generic adaptive capabilities that allow response to unexpected shocks, and the more specialised and dedicated capabilities specific to particular types of industry? As Pavitt (2005) has recently explained, technological innovation is increasingly based on specialised and complex knowledge bases specific to particular artifacts and sectors, and this means that the only types of generic capability may lie in the co-ordination and integration of specialised knowledge and learning under conditions of uncertainty. To what extent then can these translate into regional capabilities? The argument that they do is close to the competence theory of regions developed by Lawson (1999) and others, but this view suffers from a certain ambiguity about where and under what conditions shared regional competences emerge and really become important (Boschma, 2004)..

A second possible source of adaptation is *heterogeneity among agents, technologies, institutions and social networks*. As Crouch and Farrell (2004) have recently argued, path dependence implies that alternatives exist within agents' repertoires but that these may have been forgotten or hidden through disuse. However, redundant capacities may act as the seed of new paths and slack capabilities may prove useful in adapting to unexpected environmental change (Grabher, 1993; Rantisi, 2002). Several accounts argue that the art of avoiding lock-in lies in the recombination and reworking of residuals and legacies from preceding rounds and phases of economic growth. In addition, agents may learn from practices and solutions used in adjacent fields or in subordinate activities, as in every institutional set up there will be sub-dominant organisational and technological forms (Crouch and Farrell, 2004). The emphasis on the value of heterogeneity suggests that in the long run regional economic diversity may be more conducive than specialisation to escaping from negative lock-in. One popular view is that there is a trade-off between specialisation and a short-lived burst of fast regional growth on the one hand, and diversity and continual regional adaptability on the other (for example, Essletzbichler, 2005). So-called 'Red Queen evolution' may lead to strong competitive pressure and rapid learning among groups of similar rivals, but that this can make entire cohorts of competing organizations vulnerable to competency traps (Barnett and Sorenson, 2002). But other theories suggest that industrial diversity within a city or region is actually conducive to higher rates of growth through path creation and innovation by means of Jacobsian externalities. Audretsch et al (2004) for example suggest that diverse economies have higher rates of firm start-ups as such areas attract a wider

range of entrepreneurial individuals (and, one might add, offer more scope for the creation of new markets). Boschma and Weterings (2005) argue that the agglomeration of related sectors leads to faster productivity growth, as a result of spillovers across these sectors, but that the agglomeration of unrelated sectors may reduce the risk of rapid decline. What these approaches do not explain, however, is whether rapid learning in specialised areas can generate high adaptive capabilities. But as Best's (2001) study of Massachusetts suggests, in certain circumstances dynamic specialisation can lead to increased diversity so that the two are not always contradictory. It may well be that the most dynamic regions appear as fairly diversified economies but are made up of numerous, highly specialised clusters of activity, and that through such 'clustered diversity' can benefit from both rapid learning as well as resilience to cluster-specific shocks. The fact that path creation occurs in regions located in quite different positions on the continuum between diversity and specialisation suggests that we know relatively little about why some places are more genuinely innovative than others and where novelty comes from.

Another possible generic mechanism of 'delocking' identified by Castaldi and Dosi (2004) is what they term 'invasion', or what we might term *transplantation*. This refers to the importation and diffusion of new organisational forms, radical new technologies, industries, firms or institutional arrangements, from outside. It is obviously possible to think of several examples where such invasions have triggered a reconfiguration and renewal of regional economies, or an upgrading of their technological and production capabilities. What is less easy to explain is the different receptivity of industrial regions to such transplantations. In order to problematise this, several authors have argued that regional economies have different levels of 'absorptive capacity'. For instance, Niosi and Bellon (2002) suggest that regional innovation systems build industry-specific absorptive capacities in a path dependent process that starts with the creation or attraction from outside of 'engine' innovative organisations, followed by the establishment of other knowledge diffusing organisations either by means of attraction or spin-offs. Many accounts of such regional capabilities argue that learning is the key to avoiding lock-in, presumably by increasing actors' foresight and their understanding of the benefits of co-ordination. However at the same time learning is one activity that is widely argued to be strongly path dependent. How is it that learning can be both path-dependent and essentially path-breaking and delocking? It may be, of course, that there are different types of

learning so that some types are more reflexive. But how do we distinguish these types in regional economies and explain the conditions for their existence? How do actors' involvements in different forms of regional and extra regional social networks shape the nature of the learning process? Crouch and Farrell (2004) argue that embeddedness in networks may be a means in which actors can break paths. Where agents have regular interactions with agents embedded in other institutional contexts then there may be a greater opportunity for these invasions to occur as their knowledge of, and capacity to use, innovations are increased. Interestingly, this returns us again to Garud and Karnoe's (2001) notion that entrepreneurs are neither completely inside nor outside of a path, but that they are rather 'boundary spanners'. At present, however, the paradox of path dependent learning in regional economies is something that we have only barely begun to address.

A further related set of research questions surrounds the distinctive impacts of invasions of new scientific knowledge on regional economies. Much of the path dependent literature emphasises the classic evolutionary view that learning and knowledge accumulation are heavily path dependent as they rely on tacit knowledge and learning by doing and learning through practice. Whether this approach to knowledge can adequately represent the rapid progress and development of more science-based analytical knowledge is an open question. There is increasing evidence that what often matters in contracting dynamic regions and localities is the ability of local firms to access and learn from knowledge gained outside the immediate area, often from firms in distant locations (such as through strategic alliances, joint research and product development arrangements, etc). Equally, new knowledge brought into a region by the inward transplantation of firms from elsewhere (through FDI or takeover or merger) may be critical in initiating a new technological or industrial path locally, though this will depend on the absorption capabilities and competences of the existing industrial base, on the scope for local sourcing of inputs, and the like. The so-called 'branch plant economy' that some regions have sought to use as the basis of a new path of development carries its own potential dangers, of course, as many examples attest: transplant branches of overseas firms do not always become embedded into the local economy, but merely add to its vulnerability. On the other hand, there are instances where a transplant firm has had a major local impact: one example where local industrial transformation has occurred would be the

development of a strong automotive cluster in South Carolina, USA, after a major BMW facility was established there.

Two other possible forms of regional 'de-locking' involve the restructuring of a region's industries from within, either through *diversification* from what were once core industries and technologies into related or derived industries and technologies that provide the foundations for a new trajectory of regional development and growth; or by a radical *upgrading and enhancement* of a region's industrial base through the infusion of new technologies, or by introducing new products and services. A classic example of the former would be the development of a polymer engineering and manufacturing industry in Akron, Ohio, using the technological know-how that underpinned the tyre-making industry that for several decades made the city world famous, but which has since disappeared altogether. An example of escaping lock-in by upgrading is the revitalization of the industrial machinery sector in Tampere, Finland, where the integration of electronics, control and communication technologies into traditional mechanical engineering product systems has helped a group of local manufacturers achieve global competitiveness in the highly specialized industrial machinery markets serving the paper, forestry and transportation industries.

These different 'escape' routes from regional lock-in are of course not mutually exclusive, and in any given regional setting two or more different mechanisms may be at work, and may in fact interact in a mutually reinforcing way. Geographers have tended to focus their attention almost exclusively on the first of these mechanisms, on those regions that seem to be the loci of indigenous innovation and technological development. But clearly we need also to direct our analytical lens at other types of path creation and other types of region. All four other forms of de-locking summarised in Table 3 involve the application and absorption of new technologies, yet by comparison with innovative, high-tech regions we still know relatively little about how these (and other) routes to regional de-locking come into being, how they progress, or why they are more successful in some regions than in others.

Once we shift attention from path dependence to path destruction and path creation, and from lock-in to de-locking processes, it is clear that two somewhat complementary, if opposed, mechanisms are always at work. On the one hand, mechanisms of convergence to dominant technologies and

institutional arrangements, mechanisms of alignment of individual and organizational decisions, and the plethora of increasing returns associated with learning, agglomeration and inter-relatedness, tend to impart path dependence and lock-in to the development of the economy in general and to the economic development of specific places and regions more particularly. Yet, on the other hand, place-specific histories and possibilities of capabilities and competence building, expectation formation, and organizational and institutional formation, produce variety and heterogeneity into the economic landscape, and hence constant pressure for path destruction and opportunities for new path creation. How these opposing tendencies originate and interact across regions is at the heart of how the economic landscape evolves.

6. Conclusions: Towards a Research Agenda

In a recent review, David (2005) has argued that the intellectual traditions within economics can themselves be interpreted as paths with their own trajectories shaped by the sequence of preceding events and accumulated learning (see also Garrouste and Ioannides, 2001; Jolink and Vromen, 2001). Applying this idea to the notion of evolutionary economic geography, this micro-school of thought might be described as a relatively youthful, immature and emergent intellectual path. To a large degree it has been successful through the diffusion of metaphorical ideas that suggest new avenues and lines of research. At the same time, however, it seems undeniable that this new path is clouded by a certain vagueness and lack of clarity about its key concepts. As the notion of path dependence illustrates, many of evolutionary economic geography's central ideas remain under-researched and contain key areas of ambiguity. As the path dependence debate also warns, if ideas are used in inconsistent and increasingly stretched ways, then they face the risk of being rejected on the basis of misunderstandings and superficial readings. In our view it is vitally important that evolutionary economic geography continues to research and explore questions of path dependence, not least because the topological snapshots of much current relational economic geography can easily lose sight of history dependence and historical explanation. The proper response then, is to address these ambiguities by further research into historical causal explanations of the mechanisms producing evolutionary economic change in space.

In this paper we have accepted and replicated the case that our understanding of path dependency should be modified to incorporate purposeful human agency as well as the structural preconditions and contextual influences that shape its emergence and operation. Given the nature of human agency, path dependence is never automatic but always contested and resisted, and new path creation is as important as path dependence. If path dependence is a contingent and place-specific outcome and event sequence then further research needs to clarify how and why the mechanisms that produce path dependence operate to different degrees in different places. In some ways it is quite surprising that there has not been more discussion of the exact meaning of path dependence in regional economies. Should we focus primarily on technological regimes and productive knowledges, or should we look for broader, if harder to trace, ensembles of regional capabilities and forms of interaction and linkage? It is clear that there are a number of specific mechanisms that, in the context of certain behavioural and knowledge conditions, can produce path dependency and lock-in. However, we know much less about the relative importance and prevalence of these potential mechanisms. Hence their relative importance, both with regard to each other and to negative and constant returns, continues to be largely a matter of informed speculation. A key question for research, then, is how we can identify these mechanisms in regional economies, and how we can identify the thresholds in linkages that determine whether path dependence emerges at aggregate levels. Furthermore, we need to know more about what determines the strength of these processes in different locations as well as the contingent outcomes of the mechanisms involved. How does path dependence translate into negative lock-in? If we know that this is usually in the context of external or environmental change, how radical and significant does such change have to be before path dependent mechanisms engender negative lock-in? There also are many unresolved issues about the origins of new regional paths: are selection pressures really as weak as some suggest during the initiation of new paths? Similarly, as we have already argued, we do not know a great deal about the adaptive capabilities of regional economies at present, although there is a growing consensus on the importance of structural diversity in this regard.

One of the themes of this paper has been to argue that place dependence is an important dimension of path dependence. This implies that forms of co-evolution in which there are mutually constitutive interactions and

feedbacks between firms and other institutions are to some degree place-specific, and that these interactions occur simultaneously across several different scales. Further research needs to clarify the implications of such co-evolution for path dependence. Does the existence of multiple interactions and multiple types of selection sources of path creation act to reduce the likelihood of path dependence? Or does co-evolution mean that complex correlations between regional economic traits are in fact increasingly path dependent? One of the underlying questions here is whether we need to historicise the prevalence and strength of path dependence itself. Arthur (1994) of course saw the contemporary era as a new business world of increasing returns based on knowledge, but it is possible to argue that this new world of knowledge capital carries quite different implications. Does the growth of open and co-operative network forms of economic organisation in regional economies actually reduce liability to path dependence and provide stronger insurance against lock-in? Is the shift to entrepreneurial styles of 'new economy' growth involving higher rates of new firm formation leading to the increased creative and innovative diversity of regional economies? If new forms of economic organisation allow firm adaptive capabilities to be raised to a new level, perhaps regional lock-ins are less much likely to occur in future. And related to this, does the global intensity of knowledge transfers and the increasing reliance on rapidly developing forms of scientific analytical knowledge mean that there are now more frequent opportunities for industrial path creation? While it would be foolish to suggest that regional path dependence is a thing of the past, is it possible that the strength of path dependence has been reduced by the new technological-institutional regimes evident in leading and emerging economies? Or will history, once again, have the last word?

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