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Rethinking Regional Path Dependence: Beyond Lock-in to Evolution

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The 2009 Roepke Lecture in Economic Geography

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Abstract:

This paper argues that in its 'canonical' form, the path dependence model, with its core concept of 'lock-in, affords a very restrictive and narrowly applicable account of regional and local industrial evolution, an account moreover that is tied to problematic underpinnings based on equilibrist thinking. As such the canonical path dependence model actually stresses continuity rather than change. The paper goes on to explore recent developments in historical sociology and political science, where there are active attempts to rethink the application of path dependence to the evolution of institutions so as to emphasise change rather than continuity. These developments are used to argue for a rethinking of path dependence ideas in economic geography.

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Introduction

It seems fitting in the year that marks the bicentenary of Charles Darwin's birth, and a century and half since the publication of his landmark treatise on evolution, *On the Origin of Species*, to devote this lecture in economic geography to a consideration of a notion that has figured prominently in recent discussions within the discipline about how the economic landscape evolves over time. I refer to the notion of 'path dependence'. It is now more than two decades since the concept of path dependence entered the economics lexicon, championed especially by Paul David (1985, 1986, 1988, 1992, 1993a, 1993b, 1994) and Brian Arthur (1988, 1989, 1994a, 1994b, 1994c, 1994d). Though introduced by these authors (and particularly David), as a way of characterising the evolution of technologies and technological standards, the idea has since been adopted and applied in a whole variety of other social science disciplines, as a model of social, cultural, institutional, organisational, and political as well as economic and technological evolution. In a certain sense this spread of the concept can be viewed as part of a more general 'evolutionary turn' across the social sciences, of a growing interest in how socio-economic systems change over time and a corresponding exploration of ideas, models and metaphors drawn from modern evolutionary sciences, including evolutionary biology (or more precisely Generalised Darwinism), complexity theory, panarchy and other such fields (see, for example, Gunderson and Hollinger, 2002; Garnsey and McGlade, 2006; Wimmer and Kössler, 2006). Thus the notions of 'inheritance' and 'retention' from evolutionary biology, that of 'hysteresis' from complexity theory, and 'adaptive cycles' and 'resilience' from panarchy, have affinities with the basic idea that underpins the concept of path dependence, namely that, in a nontrivial sense, 'history matters'.

For their part, economic geographers have become increasingly caught up in this 'evolutionary turn' (Boschma and Martin, 2007; Grabher, 2009; McKinnon et al, 2009). As part of this project they have been highly receptive to the concept of path dependence. Richard Walker (2000), for example, has referred to the notion as "one of the most exciting ideas in contemporary economic geography" (p.126), while Allen Scott (2006) has explicitly called for

"an ontology of regional growth and development that is rooted in the idea of path dependent economic evolution" (p. 85). Perhaps most significantly, Ron Boschma and Koen Frenken, major exponents of the newly emerging paradigm of evolutionary economic geography, see the idea of path dependence as fundamental to their approach. Thus according to these authors, the defining characteristic of an evolutionary economic geography is

> ... that it explains a current state of affairs from its history... Thus the current state of affairs cannot be derived from current conditions only, since the current state of affairs has emerged from and has been constrained by previous states of affairs. Evolutionary theory deals with *path dependent* processes, in which previous events affect the probability of future events to occur (Boschma and Frenken, 2006, pp. 280-281, original emphasis).

However, despite their increasing invocation of the notion, economic geographers have directed surprisingly little detailed critical attention to the assumptions, implications and indeed limitations of path dependence theory and its key idea of 'lock-in'. As Glasmeier (2000) rightly complained, to argue that a region's industrial experience can be explained in terms of path dependence and 'lock-in' begs a whole series of questions, most of which typically go unasked, let alone unanswered. But if path dependence is to function as a core notion in evolutionary economic geography (Boschma and Frenken), and to serve a key ontological role in theorising regional economic evolution (Scott), then we need to be clear as to how far and in what respects it can fulfil these tasks, and whether and in what ways it may need to be rethought in order to do so. These are the issues I seek to address here.[1]

In so doing, my aim is to build on and go beyond my previous paper (Martin and Sunley, 2006). That paper focused primarily on identifying the possible sources of regional path dependence, and setting out why and in what ways path dependence is a place dependent process. And while it raised the question of what sort of regional economic evolution is implied by the concept of

[1] When I was invited to give this Roepke lecture, I was urged to speak to a conceptual issue, and to be provocative. This is what I have tried to do. If the paper stimulates debate, regardless of the nature of the reaction, then at least that aim will have been achieved. The danger, of course, is that such a paper can provoke quite varied, divergent and even critical responses: it can become the victim of its own contentiousness.

path dependence, this issue was not explored in depth. This is what I want to try to do here. To this end, I have gone back to the 'canonical model' of path dependence, as set out by David and Arthur, in order to avoid the complaint often voiced by David that those who invoke the idea of path dependence frequently misunderstand, misuse or even abuse the notion. We obviously need to ensure that we know what it is that we are discussing. This precaution applies especially to the notion of 'lock-in', arguably the core concept of the path dependence model. It is this notion that most fully captures the idea that the combination of historical contingency and the emergence of self-reinforcing effects, steers a technology, industry or regional economy along one 'path' rather than another. It is the idea of 'lock-in' that does the 'evolutionary' work in the path dependence model. My argument, as it unfolds in the first half of the paper, is that the concept of 'lock-in' actually serves as a rather limited and restricted way of thinking about path-dependent economic evolution. The idea of 'lock-in' emphasises continuity and stability rather than change. Indeed, in his recent work, David has been at pains to reassert his own strict definition of path dependence and to give the core notion of 'lock-in' a specifically equilibrium interpretation. This, I suggest, raises serious questions about how the model can function as an evolutionary construct, and for this reason I contend that a rethinking of the model is required. To assist in this process, I suggest we look outside economics to explore some recent debates and developments occurring in political science and historical sociology, where a similar concern over 'lock-in' as a model of institutional evolution has stimulated attempts to recast path dependence theory so as to give emphasis to change as well as continuity. Drawing on this suggestive literature, I offer some ideas for a more general model of regional path dependent industrial development that likewise seeks to escape the limitations of the concept of 'lock-in', and which allows for a broader set of evolutionary processes and possibilities, of the sort often observed in real-world regional and local economies.

The Canonical Model of Path Dependence: Key Features and Problems

Following Harris (2004) and Page (2006), a path dependent process might be thought of in the following way. Let x(t) be the economic outcome or phenomenon of interest: for example, this might be a product's or technology's share of the market, the number of firms of a particular industrial type in a region, or a region's share of a particular national industry, and so on. Then the notion of path dependence can be expressed in general form as

$$\textit{Path Dependent Process:} \qquad x(t+1) = F_X(t)(h(t)x) \qquad (1)$$

where $h(t)x = \{x(t), x(t-1)\ldots x(0), y(t+1), y(t), y(t-1)\ldots\}$ is the history of past outcomes of x from some initial time (t=0), when the activity in question first emerged, up to the present time t, and any other factors, say y, that also shape the development of x over time; and $F_X(t)$ is the 'outcome function' that maps the history h(t)x into the next outcome. The outcome function is of key importance since it determines the extent to which – and manner in which – the previous history of x conditions its future trajectory, that is, its evolution.

Although David's formulation differs in certain respects from that of Arthur, both share some key fundamental ideas that can be thought of defining a 'canonical model' of path dependence. Three such basic commonalities stand out. First, path dependence is viewed as a non-ergodic stochastic process in which initial small 'random' or 'chance' events, or 'historical accidents', have significant long-run effects on the technological, industrial and institutional structure of an economy. This immediately distances the notion from standard equilibrium economics, where the past has no influence on outcomes, and the economy is assumed to converge (typically instantaneously) to a unique equilibrium state regardless of where it starts from. [2] Second, according to the

[2] As such, the path dependent process in (1) can be contrasted with the conventional equilibrium process of mainstream economics, which can be represented as

$$\textit{Equilibrium Process:} \qquad x(t+1) = F_x^e(x(t))$$

where F_x^e generates a unique equilibrium state or outcome, regardless of where the system starts from or the adjustment path followed.

model, once a chance technological, industrial or institutional 'accident' gets contingently 'selected', path dependence is said to occur if that initial accidental event then becomes progressively 'locked-in' through the emergence and operation of various auto-catalytic 'network externalities' (David's phrase) or 'increasing returns effects' (Arthur's phrase) (see Table 1). And, crucially, the third feature of the standard model is that once 'locked-in', a technology or industry or industrial location pattern is assumed to persist and remain stable until it is disrupted or dislodged by an 'external shock' of some kind. David's development of this model has focused mainly on the 'lock-in' of technologies and technological standards, while Arthur has used his model to explain the 'lock-in' not only of technologies but also industrial locations patterns. The Arthur version of the model as he has applied it to the study of industrial location, is set out in stylized fashion in Figure 1.

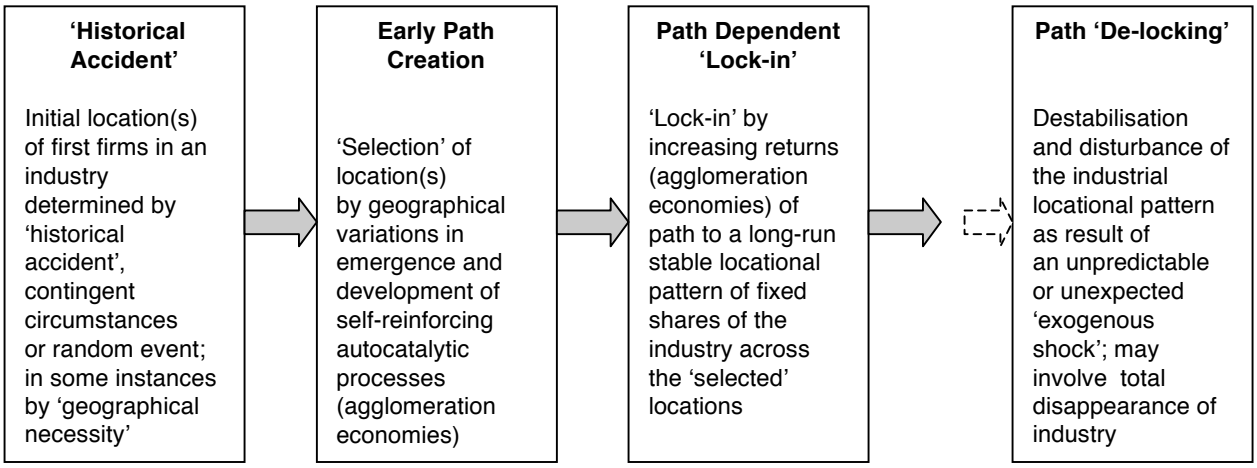
Table 1: Processes Generating 'Lock-in' in the Canonical Path Dependence Model

David's Model ('Network externalities')	**Arthur's Model ('Increasing Returns effects')**
1. **Technical interrelatedness** (the reinforcing effects of complementarity and compatibility between the different components of a technology and its use)	1. **Large initial fixed set-up costs (**in effect the inertia of sunk costs).
2. **Economies of scale** (the benefits associated with the increasing use of a technology - such as decline in user costs – as it gains in acceptance relative to other systems)	2**. Dynamic learning effects** (learning by doing or using and learning by interaction tend to entail positive feedbacks)
3. **The quasi-irreversibility of investments** (the difficulties of switching technology-specific capital and human skills to alternative uses)	3. **Coordination effects** (which confer advantages to 'going along' with other economic agents taking similar actions)
	4**. Self-reinforcing expectations** (where the increased prevalence of a product, technology, process or practice enhances beliefs of further prevalence)

Numerous geographers have appealed to this model and its core construct, lock-in', to characterise the evolution of industrial districts, clusters

and other localised forms of industrial specialisation (for examples see: see Storper, 1995, 1997; Cooke and Morgan, 1998; Bode, 2001; Kenney and von Burg, 2001; Boschma, 2004, 2005; Bathelt and Boggs, 2003; Fuchs and Shapira, 2005; Gertler, 2005; Hassink, 2005a and 2005b, Hassink and Shinn, 2005; Lagerholm, and Malmberg, 2009). In so doing they have pointed to the localised nature, or to local variants, of the sorts of increasing returns effects cited by David and Arthur, together with others not mentioned by these authors, such as the build-up of a local pool of specialised labour, local knowledge spillovers, the development of a local inter-firm division of labour, various traded and 'untraded' inter-firm dependencies, and so on. Further, they have interpreted the decline of former industrial districts and clusters as arising from the way that 'lock-in restricts their ability to adapt in the face of external 'shocks' (such as the rise of major competitor districts), thus bringing about their relative or even absolute demise.

Figure 1: The Canonical Path Dependence Model of Spatial Industrial Evolution



However, each of the three defining features of the path dependence model - the 'accidental' origin of new paths, the notion of 'lock-in', and the appeal to 'exogenous shocks' to 'de-lock' paths – is problematic. Presumably, a

convincing model of local industrial evolution would attempt to provide some explanation of why and how new local industrial and technological paths emerge where they do. The canonical model offers little insight into this question: that is to say, it says nothing about the origins of x(0) in the model in (1). To regard path creation as an 'accidental', adventitious or serendipitous event is not particularly revealing. The evolutionary economist, Ulrich Witt (2003) has likened this aspect of the path dependence model to what he calls a 'virgin market assumption', the idea that the emergence of a new technology or product, and any competition with other emergent rivals, takes place without reference to, and uninfluenced by, inherited market conditions. A not dissimilar 'virgin landscape assumption' could be said to characterise some uses of path dependence in economic geography, in that *where* a new industry or technology emerges is often regarded as essentially a 'random' or 'accidental' event, and pre-existing regional economic and technological structures, and historical legacies of past developments, are considered to be all but irrelevant in determining where new industrial and technological paths appear and become established. This 'virgin landscape assumption' seems quite explicit in Arthur's work,[3] and also appears, for example, in Boschma and Frenken's (2003) argument that 'windows of locational opportunity' are essentially open when it comes to the 'selection environment' of a new technology or industry:

> … 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 (Boschma and Frenken, 2003, p. emphasis added).

[3] Arthur distinguishes between two kinds of industrial location process: the case of 'pure necessity', where the location of a new industry is tied to particular and unique input needs (such as raw materials) only available in certain locations, so that the long-run outcome is predetermined; and the path dependence case where the long-run locational pattern of an industry depends on 'historical accident' - the 'chance' location of the initial firms - plus the emergence of agglomeration economies.

There is thus a curious contradiction in the model, in that path dependence seems only to matter *once* a new industry or technology has emerged, but plays *no* part in shaping that emergence or *where* it takes place. This is at variance with other work in economic geography that argues that the pre-existing industrial structure of a region or locality does have an influence on whether a particular new industry develops there. In some cases the influence is positive, in other cases negative (the 'new industries don't locate in old regions' argument).

Likewise, to attribute the 'de-locking' of an industrial or technological path to the impact of some unexpected or unpredictable 'exogenous shock' is not especially enlightening. To be sure, a local industry is not a closed system, and is subject to a variety of external pressures (and new opportunities), for example the emergence of new competitors, shifting markets, technological advances and the like. But such pressures and challenges are more or less constant features of modern economic life, and not necessarily spasmodic infrequent events.[4] What matters, therefore, is the nature of the pressures that impinge on a local industry, and how it reacts to them, which in turn depends on its resilience and adaptability. Furthermore, the 'de-locking' of a local industrial path may arise endogenously. It could happen, for example, because of the onset of agglomeration diseconomies - such as high congestion and other costs which force firms to move to other, cheaper locations, leading to the rundown and perhaps ultimate abandonment of the original location(s). It might arise because of the exhaustion of innovation by local firms, which then become uncompetitive and decline, so the industry shrinks. It might also occur if local firms switch into a different, perhaps related sector of activity, that is onto a new path, which is perceived as affording more profitable opportunities. The fact of the matter is that in reality, the relative role of exogenously-induced and endogenously-initiated change may be difficult to draw. Martin and Sunley (2006) suggest a number of possible mechanisms by which a local industrial

[4] This is not to deny that occasional major 'shocks' can and do occur (witness the current global financial crisis and associated recession), or that such disturbances can produce a 'gale of creative destruction'. It is rather to highlight the fact that change is not confined to such 'critical junctures', but is an incessant process, as Schumpeter himself stressed.

path may be 'de-locked' or disrupted, even destroyed, most which revolve around the interaction of exogenous and endogenous forces. Yet, their analysis, like that of Castaldi and Dosi (2006), and indeed like many of those in economic geography, is founded on the assumption that the problem is one of identifying the mechanisms by which a 'locked-in' stable state can be 'de-locked' (see for example, Hassink, 2005; Hassink and Shin, 2005). This assumption in turn rests on acceptance of the very notion of 'lock-in', or at least a particular interpretation of the notion. In seeking to advance our understanding of the evolution of regions, clusters and industrial districts, Hassink and Shin (2005) claim the "'lock-in' concept" to be "one of the few promising modern concepts" with the potential to explain such phenomena, and thus should be the "theoretical core" of an evolutionary perspective in economic geography (ibid, p. 571). It is indeed the core notion in the path dependence model; but whether it affords an adequate concept of spatial economic evolution is in fact questionable, as I now want to argue.

The Problem of 'Lock-in': Equilibrium Versus Evolution

Despite David's oft-made claim that the appeal of the path dependence model is that 'by taking history seriously' it moves beyond the ahistorical character of standard equilibrium economics, the notion of 'lock-in' in fact remains equilibrist in conception. Indeed, David (2005, 2007) has recently called his approach 'path dependent equilibrium economics', a move that serves to entrench this problem. More specifically, he defines path dependence as the historically-contingent *lock-in to one of a multiplicity of possible equilibrium states* (or 'basins of attraction' as he also calls them):

> The elaboration of theories around the core concept of path dependent dynamics… encourages and enables economists to entertain the possibility that, in place of a unique equilibrium-seeking dynamic, they should envisage a process that is seeking an historically-contingent equilibrium… (David, 2005, p.2)
>
> Small events of a random character - especially those occurring early on the path - are likely to figure significantly in 'selecting' one

> or other among the set of stable equilibria, or 'attractors'... (David, 2007, p.151)

Formally, he identifies these multiple equilibria with the 'absorbing states' of non-ergodic Markov process. An absorbing Markov process has one or more states from which, once entered, it is impossible to move to some other state. Such a system has multiple long-run equilibrium outcomes, depending on the number and identity of the absorbing states and initial state of the system: hence which equilibrium state the system ends up in will depend on where it started - thus the idea of the historically contingent 'selection' of one or another from a set of multiple equilibria. In similar vein, Arthur's Polya probability models of path-dependent industrial location also generate multiple possible stable long-run patterns, with the selection from these depending on the 'chance' location of the initial firms.[5] It is not easy to reconcile this feature with his claim that his approach is "more Darwinian than equilibrational".

As Page (2006) points out, path dependence can be of two main types. A process is 'outcome-dependent' if the outcome in a period depends on past outcomes. A process is 'equilibrium-dependent' if there is convergence to a long-run stable distribution over outcomes, and this long run distribution depends on past outcomes. Equilibrium dependence implies outcome dependence; but outcome dependence does not necessarily imply equilibrium dependence. The 'canonical' path dependence model is clearly of the equilibrium dependence type and the notion of 'lock-in' becomes defined as the self-reinforcing process of collective behaviour by which an economic system converges to a history-dependent equilibrium state from which it cannot escape. Once in that state it is as if history comes to an end, and stasis rules, until such time that an exogenous disturbance moves the system onto another structural or technological path. To be sure, David acknowledges that where an economic system consists of an extremely large number of interacting agents, these agents "should not be expected to become inextricably 'locked in' to one of a number of

[5] Page (2006) gives a useful account of Polya and other probability models of path dependence, and shows how such models characteristically converge to a stable, 'equilibrium' outcome. While he acknowledges that 'outcome-dependence' need not imply convergence to any equilibrium state, the whole thrust and focus of his discussion is on path dependence models that do lead to equilibrium outcomes.

locally stable equilibria…". However, he then goes on to say that nevertheless "… they may linger for many periods of time in those neighbourhoods" (ibid, p. 167), that is, near to one of those multiple equilibria. Furthermore, this interpretation of 'lock-in' implies a 'punctuated equilibrium' view of economic history, in which long periods of industrial and technological stability ('equilibrium') are punctuated by shorter spasms of externally-induced (path-breaking) technological/industrial change. In fact, David claims that this aspect of path dependence "may open the way for the formulation of dynamic models that are compatible with 'stage theories' of development" (2007, p. 187).

Ironically, invoking the idea of multiple equilibria renders the whole idea of path dependence amenable to capture by mainstream economic theory, where multiple equilibrium models are becoming increasingly common.[6] And it is precisely the idea of multiple equilibria that has allowed New Economic Geography (NEG) theorists to claim that their formal mathematical models of the economic landscape are able to incorporate 'path dependence' and 'history'. Indeed, there is a close affinity between some of Krugman's work (for example, 1996) and that of Arthur. NEG location models derive equilibrium patterns (distributions) of regional agglomeration, specialisation and trade based on the operation of local self-reinforcing increasing returns effects in the presence of transport costs and mobile factors of production. Which equilibrium pattern emerges (becomes 'locked-in') depends (is 'contingent') on the model's 'initial conditions' (level of transport and transactions costs, extent of labour and capital mobility, extent of knowledge spillovers, initial regional distribution of economic activity): hence NEG theorists argue that 'history matters' in their models. Further, a change in any of the model's 'initial conditions' - interpreted either as a 'different history' or an 'external shock' - will give rise, via self-reinforcing effects, to a new equilibrium economic landscape. Which new equilibrium emerges depends on the nature and direction of the change in the 'initial conditions' – where the system was previously. In this way, NEG claims

[6] I say ironically because David has always been at pains to present his path dependence theory as a counter to mainstream economics. On the other hand, one wonders whether, by calling it 'path dependent equilibrium economics', and by invoking the device of multiple equilibria, his purpose has been to make it easier for mainstream economists to accept the role of 'history', and thereby to gain disciplinary acceptance of the path dependence notion.

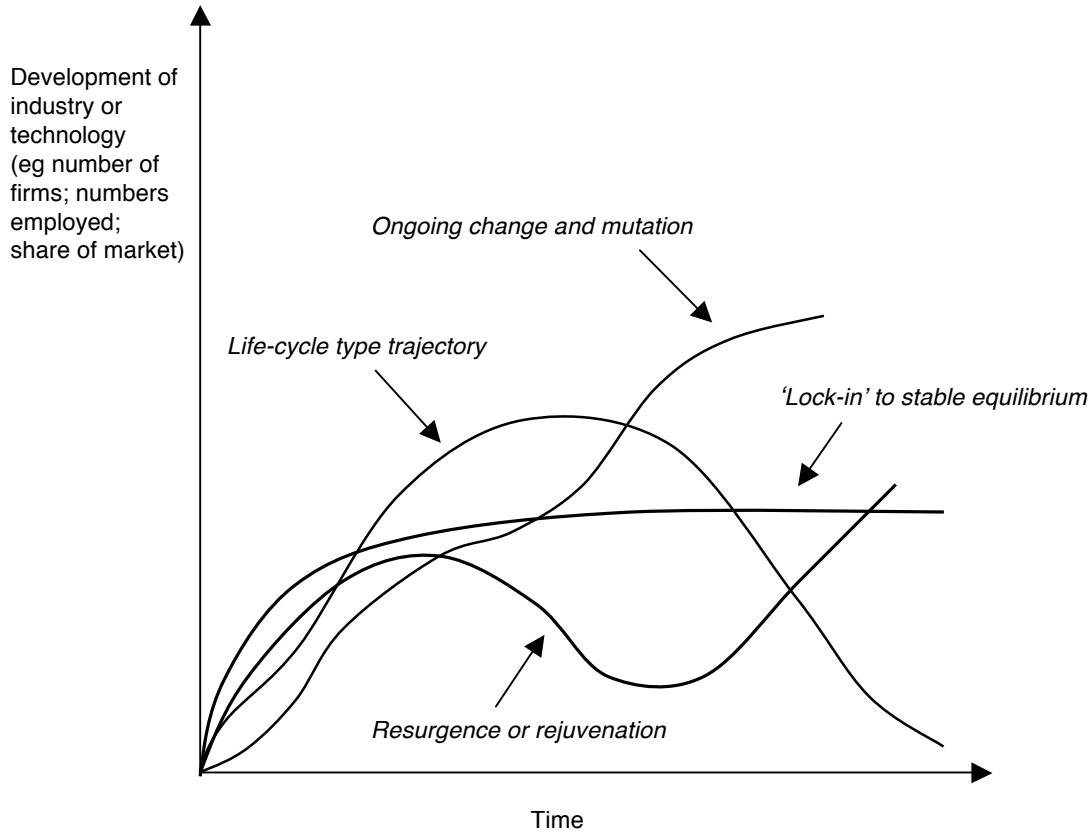
to incorporate regional 'path dependence'. However, few economic geographers would regard these models as evolutionary, as depicting a plausible representation of how the economic landscape evolves over time: what they are in essence are exercises in spatial comparative statics, not evolutionary dynamics (Boschma and Frenken, 2006; Martin, 2009; Garretsen and Martin, 2009).

The interpretation of 'lock-in' as a process of 'convergence to a history-dependent equilibrium' severely constrains the path dependence model as a conceptualisation of economic evolution. It is difficult to think of many local industries or local economies that 'converge to a stable equilibrium state', or what such a state actually means in a local industrial setting. Does it mean that a local industry grows until it reaches a certain size - number of firms, share of national employment in that industry, share of the market for the good or service it produces – and remains in that stable state thereafter, until disturbed or disrupted by some external shock? Such a situation is hardly common. It might apply to a natural resource-based extractive industry cluster, such as a coal-mining or perhaps a steel-producing community. Or it might possibly describe an instance where a highly specialised industrial district or business cluster is composed of closely-interrelated and coordinated firms, with a detailed inter-firm division of labour, and where all such firms of adhere to an unchanging technology, and no one firm can change its technology without all firms so changing. But such cases are hardly the norm. We know that firms in the same industry may cluster in just a few particular locations, and that these clusters of can persist over quite long periods. In this sense there is a certain continuity even stability in the economic landscape. And it is understandably tempting to describe this as evidence of 'lock-in'. But do such patterns necessarily represent equilibrium states? From complexity theory we know that a system can exhibit a high degree of self-organisation or structuration, but be far from equilibrium (see Foster, 2005; Martin and Sunley, 2007). The distinction is crucial: for a self-organised system need not tend to any long-run configuration, but can evolve incrementally whilst remaining self-organised.

Thus the fact that the spatial distribution of a particular industry may persist over an extensive period of time clearly does *not* mean that the industry has stopped evolving. The nature of the industry - in terms of technologies used, commodities or services produced, form of competition, etc – may change quite significantly, and in different ways and to different degrees from one firm to another, and from one locational cluster of the industry to another. New clusters may also arise that challenge existing ones. Competition between firms and between clusters in the same industry drives a process of ongoing change. How fast change occurs, of course, will depend on a variety of circumstances and conditions. An equilibrist interpretation of 'lock-in' would seem to imply that such 'on-path' evolution is not occurring, that what is being observed is simply 'more of the same' or the simple 'reproduction of what is already there'. In reality, we encounter a wide range of developmental trajectories, as much empirical work in economic geography testifies. This is especially so in many of today's knowledge-based high-technology clusters, where constant innovation and not periodic 'punctuated equilibrium' appears the norm. Even more traditional specialised industrial districts or cluster-based economies, such as those in the Third Italy, exhibit considerable diversity in their evolutionary trajectories (see Belussi and Sedita, 2009). We know, for example, that many industries and technologies trace out some sort of 'life-cycle' pattern over time, and that the shapes of these vary markedly from industry to industry, from one industrial district to another, and from one business cluster to another; whilst still others follow a pattern that involves path renewal or rejuvenation, or even more or less continuous change and mutation (see Figure 2). Such patterns do not exhibit 'lock-in' to a stable 'equilibrium' or state, but all can be path dependent nevertheless, in terms of being 'outcome dependent', as defined above.

The problem is that retaining notions of equilibrium in defining path dependence and 'lock-in' seems to run counter to the key tenets of evolutionary economics, especially the ideas of endogenous change, constant transformation, and the role of novelty. In fact, there is a curious lack of engagement with evolutionary concepts in most discussions and applications of path dependence.

Figure 2: Some Stylized Alternative Evolutionary Paths of an Industry or Technology



Indeed, Ulrich Witt also makes this point, that the notion of 'lock-in' is antithetical to industrial and technological evolution:

> ... some doubts should be raised about the plausibility of both the theoretical underpinnings of, and the empirical evidence for, technological or industrial 'lock-in'... sooner or later there will always be new rivals who threaten the market dominance of a technology or variant. The erosion of market dominance under competitive pressure by new technologies supports Schumpeter's empirical generalisation that an incessant process of creative destruction characterises modern industrial capitalism (Witt, 2003, p. 124).

Yet, disappointingly, Witt also seems unable to cut himself free from the umbilical cord that ties so many economists to the concept of equilibrium. He too ultimately invokes the notion of multiple equilibria in his characterization of

'lock-in', his only concession being that such lock-in "is by historical standards a transitory state of affairs" (ibid, p. 125).

And somewhat similarly, Setterfield (1997) in his discussion of path dependence and 'lock-in' begins by arguing convincingly that multiple equilibrium is incompatible with historical change:

> One characteristic property of an equilibrium time path is that once it has been reached, a system will display no endogenous tendency to deviate from it... Once reached then, equilibrium implies a state of extreme stasis – an 'end to history', as it were, since in the absence of shocks any subsequent evolution of the system is pre-determined by the equilibrium time path that has been achieved. Along this time path the precise sequence of events of which economic activity over time is comprised does not matter, since it will have no effect on the subsequent outcomes of the system. It appears, then that the invocation of equilibrium as a solution concept – even qualified by the caveat that any equilibrium achieved is path dependent - entails an intolerable departure from the strictures of historical time, according to which sequential patterns of activity *do*, in principle, matter (p.66).

But then he too end ups suggesting that, for heuristic reasons, we treat equilibrium as a 'temporary' outcome of path dependent processes that may "yet give rise to a subsequent endogenous process of 'innovating out' of equilibrium" (ibid, pp. 67-68). But just what do 'transitory' and 'temporary' mean in this context? The more we think of these as short-run in nature, the less relevant the idea of any equilibrium becomes.

Now it might be argued that this critique is rather academic and misdirected. For example, it could be countered that equilibrium is just an heuristic device, a simplifying abstraction or starting point for analysis, without which we would be unable to build an equation or model. That a debate has raged in economics for the best part of a century over whether economics needs the concept of equilibrium, and over the incompatibility of equilibrium and history, suggests that the matter is not merely one of heuristics (for recent contributions to that debate see Setterfield, 1997; Backhouse, 2004; Harris, 2004; Lang and Setterfield, 2006). Equilibrium can be viewed either as a methodology for investigating path dependence or as a path dependent property of the system under investigation. If we stress the former, we are back to the problem of having to pre-specify the possible path dependent multiple

equilibria from which historical contingency 'selects'. If we opt for the latter, then we have to confront the ontological issue of whether we really do believe that the firms in a local industry behave so as to produce some collectively stable and self-reproducing equilibrium state or path in the industry concerned (Castellaci, 2006). Neither approach seems convincing.

A second rejoinder might be to argue that economic geographers do not necessarily view 'lock-in' in equilibrium terms, even implicitly, when they use the notion in their work, so that, again, the above critique is not relevant. But this then raises the question of how, precisely, they are using the term. If it is just a metaphor for the progressive establishment of a local industrial specialisation, then it is difficult to distinguish from outcome path dependence and adds little to the analysis. In fact, many applications or invocations of the notion in economic geography do seem to use the term to imply that a local industrial path or structure has reached some form of stasis, or 'groove', which is self-reproducing and difficult to alter. At the very least, most economic geography applications of the notion use it to emphasise *continuity* (or more of the same) rather than *ongoing change*. Should it then be reserved only for those instances where it can be shown that there is local industrial stasis? And how common are those? Or should the term be used only when a local industrial specialism fails to change even in response to new competitive, technological or institutional opportunities or challenges? Setterfield (1997b), for example, suggests that the condition (and notion) of 'lock-in' *only* becomes meaningful when an industry fails to adapt in response to an external shock. In which case it has only negative connotations, and still tells us little about path dependent evolution more generally. In Martin and Sunley (2006) it was suggested that 'lock-in' might be thought of as a process, itself subject to evolution, rather than as a state. A simple evolutionary pattern was proposed there, namely that in the early stages of the development of a local industrial cluster or specialism, 'lock-in' is a positive process that derives from the external increasing returns effects and agglomeration economies that benefit the industry. But in later stages different, negative 'lock-in' processes increasingly offset the positive ones and hinder the continued growth and development of the industry, causing it to lose

competitiveness and go into relative or even absolute decline. Whilst such a conception of 'lock-in' is non-equilibrist, and obviously resonates with, and lends itself to ready integration into, standard life-cycle-type models of industrial evolution (see Popp and Wilson, 2007, for example), it fails to allow for a richer repertoire of path dependent evolutionary possibilities. That requires an alternative conceptualization of path dependence.

Towards an Alternative Model of Path Dependence: Beyond 'Lock-in'

A basic issue is that local and regional economies, and the industries of which they are composed, differ in substantial and significant ways from the technologies and examples discussed by David and Arthur. The 'canonical' model may best fit the historical trajectories of what are often called 'radical' technologies, the occasional innovations that define critical junctures in the history of economic development, that transform the whole economy, that entire markets become 'locked' into, and which last unchanged (in a sort of stable equilibrium state) for considerable periods of time, until they are replaced by another radical new innovation. Most so-called 'general purpose technologies' (such as steam power, electricity, the computer, and the like) would fall into this category.[7] But the basic model makes no allowance for the heterogeneity (variety) that typifies the majority of technologies, and almost all industries, and local and regional economies.

Local industries are complex systems, composed of numerous firms that face more or less continual competitive pressure, and which can respond to such pressures at different rates and in different ways, thereby allowing both continuity and change in the industry, the industrial district or the business cluster as a whole. That is, a local industrial path may itself evolve. Further, in most local industrial districts, clusters of agglomerations, even those that have a

[7] Though even some of these actually evolve and do not remain stable. For example, the internet – arguably a general purpose technology – has not become 'locked' into a stable equilibrium state, but can be shown to have evolved more or less continually since its initial development (see Boas (2007).

high degree of specialisation, there are a number of industries and activities, each with its own evolutionary path. These paths maybe linked to one another to a greater or lesser degree, so that path dependent co-evolution may occur (Martin and Sunley, 2006). Likewise, a complex entity like a local industry, and the local network externalities that develop around it, may promote new technological and industrial paths to emerge out of and alongside the original. In short, the basic model needs reworking to accommodate the empirical variety and complexity found in the economic landscape.

Interestingly, a not dissimilar search is underway in political science and historical sociology. Over the past couple of decades, the path dependence model has been widely applied in these disciplines as a way of characterising and explaining the evolution of institutions, legal systems and other regulatory frameworks. Key authors such as North (1990), Collier and Collier (1991), Pierson (2000), Mahoney (2000) and others, were all drawn to David-Arthur economic path dependence models to emphasise how institutions can become 'locked-in' and stabilised for considerable periods of time by various self-reinforcing and self-reproducing effects closely akin to the increasing returns effects emphasised by David and Arthur in their application of the model to economic phenomena. Pierson (2000, p. 262), for example, maintains that all of the increasing returns effects identified by David and Arthur can be invoked to explain the evolution of institutions, and that, similarly, they lead to the 'lock-in' of an institutional form to a "single equilibrium" which "will in turn be resistant to change". Likewise, Mahoney (2000, p. 515) argues that the positive feedback mechanisms sustaining a self-reinforcing sequence often lead to institutional persistence, and that these various mechanisms of reproduction "may be so causally efficacious that they 'lock-in' a given institutional pattern, making it extremely difficult to abolish". As in the case of economic-geographic work, the notion of 'lock-in' appeared to offer political scientists with a powerful concept to explain the development of the institutional landscape.

However, recent research on institutional development has become more critically inclined towards the path dependence model, and has sought to expand and revise it so as to focus ongoing evolution rather than stability. Stark

(1996), Alexander (2001), Stark and László (2001), Thelen (2003, 2004), Hacker (2004), Crouch and O'Farrell (2004), Schwartz (2004), and Boas (2007), for example, have all argued that the prevailing model of path dependence overstates the degree of inertia in political and social institutions. In advancing their own explanations of institutional evolution, some of these scholars have distanced themselves completely from the notions of increasing returns and switching costs that figure so prominently in the path dependence 'lock-in' model. Others, however, have sought not to reject these ideas outright, but to rework and build upon them to derive a richer version of path dependence that incorporates mechanisms by which institutions change over time, and which allows their development to be open rather than constrained to inevitable stabilisation around some 'equilibrium' form.

One of the basic ideas on which this reworking rests is the argument that institutions and socio-economic systems are not like technologies such as the QWERTY keyboard (Stark and László, 2001; Boas, 2007). In the example of QWERTY the stasis-enhancing effect of a rigid standard is clear to see: moving even a single key on the keyboard would necessitate some degree of operator retraining and would reduce the value derived from coordination effects. Being locked into QWERTY means being locked into the same arrangement of keys, an arrangement that has been carried from typewriters to computers. The only realistic potential for change in this case is for the wholesale replacement of keyboards by some successor technology, such as voice recognition (Boas, 2007). In this sense the QWERTY keyboard is a *singular* or non-decomposable system – it cannot be changed incrementally, but only as a whole. In the case of social and political institutions, however, the situation is quite different. The argument is that, in contrast, most institutions are *composite* entities, made up of numerous micro-level institutions: organisational elements, structural arrangements, socio-cultural norms and individual rules and procedures. Further, it is possible for many of these components to change without necessarily requiring change of all of the remaining components. By this process, it is possible for incremental change to occur in an institution as a whole whilst it still exhibits path dependence and a significant degree of

continuity. And, furthermore, while basic path dependence processes, such as increasing returns and network externalities, continue to prevent abrupt, and radical shifts, incremental change at the micro-level can cumulate, resulting in quite fundamental institutional change over the long run, for example in terms of structure, operation, scope, or even function. Once we acknowledge that institutions are composite in nature, and that changes are possible among the micro-components making up that composite without causing coordination or similar failures, then ongoing mutation and adaptation of an institution is possible, and it may never become 'locked-in' to any stable or 'equilibrium' configuration.

This notion of a composite system or entity is obviously not just applicable to institutions. Many technologies are themselves composite, made up of a number of simple or lower-level standards or components as their constituent parts. A local industry is even more a composite entity, made up of numerous individual firms, amongst which there is often detailed product variety, different market orientations, different specific technologies, and different competences, resources, routines, and business models, even though the firms all belong to the same overall industry. It is on the basis of such differences that firms compete, and survive or fail. It is striking how often in cluster theory and cluster studies this micro-level heterogeneity or variety is ignored or assumed away: instead, clusters are often portrayed as if they are internally homogeneous. To the extent that a cluster's internal structure is emphasised, it tends to be in terms of the network of inter-firm linkages, the availability of specialised suppliers, intermediaries, or labour, the nature of knowledge spillovers, the range and type of institutions, etc), rather than the heterogeneity of the firms themselves. And the frequent assumption or claim that clustering increases the innovation and productivity of constituent firms also seems to imply that this is true equally of all firms in the cluster. But such homogeneity is rare, and local firms in a given sector often vary considerably in innovative and productive performance, and in developmental trajectory. The fact that local industries are composite in nature, and decomposable into their constituent and varied firms, means that a local industry (and thus industrial

districts, business clusters and the like), can evolve gradually by a changing mix and orientation of lower level components, that is firms and their activities. Interestingly, Castaldi and Dosi (2006) acknowledge - albeit in a footnote – that "heterogeneity of agents can help… in explaining why 'lock-in' might not occur: instead one might observe sharing of different technologies or organisational forms" (p. 123). And Heerendorf et al (2000) prove that heterogeneity of agents undermines the notion of multiple equilibria.

In historical sociology and political science, three mechanisms have been suggested that operate at the micro-level to impart slow change to path-dependent institutional evolution, namely 'layering', 'conversion' and 'recombination'. In a *layering* process (Schickler, 2001; Thelen, 2003; Boas, 2007), an institution is changed gradually by adding new rules, procedures or structures to what already exists. Each new 'layer' constitutes only a small change of the institution as a whole, but this process can be cumulative so that there is 'on-path' evolution of the institution, leading to mutation or even transformation of the institution's fundamental nature. Boas (2007) cites some examples of this process, as well as illustrating it analytically. He shows, for example (using simple network models), how the addition of a new rule or procedure to an institution not only depends on there being existing network externalities for its success, but in turn how this addition of a new rule changes those externalities incrementally – and sometimes more substantially - in the process. Continuous incremental institutional change is thus both path dependent and path evolving.

By *conversion* is meant a re-orientation of an institution, in terms of form, function, or both. This can occur in two ways. The addition of new layers (new rules, procedures, etc) is itself a source of institutional conversion or re-orientation, since the addition of new rules or procedures typically arises from a need or desire to alter an institution to serve new functions, roles or imperatives. And the addition of a new layer may arise from, lead to, or necessitate, the removal of an old layer. A second source of conversion is where the existing structures and arrangements of an institution are re-orientated to serve new purposes or in response to external pressures or developments or as

part of a learning process by which existing rules are improved. No new rules or procedures as such are added; rather existing rules and procedures are realigned or modified. In some cases, however, the conversion of an institution may only be possible by means of a layering process. What is significant, as Boas (op cit) points out, is that although in the recent political science literature, layering and conversion processes have been proposed as separate and distinct mechanisms of incremental institutional change, they frequently co-exist and interact. Moreover, while these mechanisms have been proposed as alternatives to explanations couched in terms of path-dependence mechanisms, they are in fact consistent with such mechanisms - indeed they depend on them for their adoption and success. But, unlike the' canonical' model of path dependence, a 'composite-standards path dependence model' (as Boas labels it) need not imply that the operation of such mechanisms leads to 'lock-in': rather such a model allows for a wide range of evolutionary patterns. The canonical 'lock-in' model simply becomes a very special case of a more general composite model, and the path-dependent evolution of institutions is no longer relegated to a succession of equilibrium forms forged by periodic exogenous 'critical junctures'.

Allied to this 'composite-path dependence model', two other related ideas emerging in the historical sociology and political science fields are the 'recombinant path dependence model' (see for example, Stark and László, 2001) and the 'structured diversity' or 'structured alternatives' model of path creation, (for example, Schneiberg, 2007). According to Stark and László, "path dependency is a theory neither of determinacy or indeterminacy, but a method for grasping the recombinant character of social innovation" (ibid, pp. 1132-1133; see also Stark, 1996). The basic idea is that any particular existing social-political-economic structure is in effect a system of resources and properties that actors can recombine and redefine, in conjunction with new resources and properties, to produce a new structure. Such recombination is simultaneously a source of path dependence (in that what resources exist shape to some degree what changes can be made) and a source of evolution. This recombination of existing social and institutional resources, the authors argue, also plays a role at times of radical change: "this exploitation of existing institutionalised resources

is a principal component of the paradox that even in instances of transformation are marked by path dependence" (ibid, p. 1132), as they show in their analysis of the multiple paths followed by East European states in their transition to post-socialist systems (Stark and László, .

In a not dissimilar vein, according to Schneiberg (2007), institutional paths are not as 'pure', 'settled', or uniform as some analyses would have us believe. To the contrary they often contain within them 'structured diversity': ambiguities, multiple layers, decomposable elements or competing logics that actors can use for conversion and recombination of existing components, and even for 'off-path' experimentation with new or improved possibilities, that is for the creation of new paths. The approach is essentially an internal structuralist one which looks inwards and backwards at the paths themselves, at what actors can do with existing arrangements and structures, at how paths contain within them, or can generate, the resources for the transformation of a path or the creation of a new one. According to Schneiberg, even the most established paths typically, if not inevitably, contain within them, at least in certain places, elements or fragments of 'paths not taken', former partially successful, incomplete or failed experiments and developments that can serve as resources of knowledge, experience and competences that, under certain circumstances, can be redeployed or rejuvenated to support alternative developments. At the same time, this approach stresses the importance of what Schneibert calls 'cross path effects', where developments in one institutional path influence those in another institutional path: agents borrow, adapt, learn from and experiment with, or recombine, elements or components from other co-existing institutions. This process may itself be a significant force for new path creation.

He gives a striking example of these ideas for the case of the emergence and evolution of various local cooperative not-for-profit forms of production and service provision (from agriculture, to utilities, to insurance) in the United States over the first half of the twentieth century, alongside the institutional settlements that were fixing the dominant 'American path' of markets and corporate hierarchies. Furthermore, he shows how this 'off-path' structured

variety was a distinctly geographical phenomenon, being concentrated overwhelmingly in the north-eastern and upper mid-western states, the very areas that were driving the dominant for-profit corporate path. Schneiberg traces this geographically concentrated development to the re-discovery and revival of fragments of progressive institutional and organisational experiments, movements and knowledges in these areas in the nineteenth century, 'off-path' fragments that came to be mobilised to form distinctive new local paths alongside the dominant corporate form of productive organisation. As Schneiberg puts it:

> The presence of these legacies suggests that change can emerge within existing pathways from a number of endogenous institutional processes, from bricolage, recombination or assembly of fragments of alternative industrial orders, to the borrowing, transposition and elaboration of more or less coherent established secondary paths (ibid, p. 70).

These explorations within historical and comparative sociology, and political science, into alternative perspectives on path dependence that escape the restrictions of the canonical model and its core concept of 'lock-in', are highly suggestive for how we might rethink the idea of path dependence as a model of regional industrial evolution. The notions of 'layering' and 'conversion' have obvious counterparts in a local industrial context. The first is equivalent to a changing mix of firms within a local industry; that is, local firm population dynamics assume key importance. New firms are created or added more or less continuously as the local industry grows and develops: these may be spinoffs from existing firms, entirely new ventures, or implants from outside the locality. At the same time, some existing firms fail, or move out of the locality. As Endler and McLellan (1988) point out, the addition and subtraction of competing entities, and the consequential change in the relative frequency of different entities in a system, are key forces generating variety, and variety is a fundamental principle of evolution. New firms in an industry are likely to employ more advanced techniques, offer competing and perhaps different variants of the industry's product(s), have different productivity and innovation profiles, and so on. The balance between firm entries, exits and survivals may of

course vary as the industry develops, and will be driven by a selection process determined in large part by the relative competitiveness of the firms in their relevant markets. It is often assumed that the balance between firm entrants and exits favours entrants in the early stages of the growth cycle of an industry, or an industrial cluster, and exits in the mature and final stages of that life cycle. Even if this is the case, it does not follow that although the local industry may ultimately begin to shrink in terms of number of firms, it has stopped evolving. Indeed, there are numerous examples of mature or shrinking clusters where the firms that remain are precisely those that are the more innovative and competitive. The critical issue is that the composition of the population of firms making up the local industry changes over time, and this is a potential source of ongoing evolution and change in the local industry as a whole. Even Marshall stressed this in his discussion of industrial districts:

> Every locality has incidents of it own which affect in various ways the methods of arrangement of very class of business that is carried on in it: and even in the same place and the same trade no two persons pursuing the same aims will adopt exactly the same routes. The tendency to variation is a chief cause of progress: and the abler are the undertakers in any trade the greater will this tendency be (1920, p. 355).

Similarly, the idea of 'conversion' has an immediate counterpart in a local industrial context. According to Endler and McLellan (op cit), altering the characteristics of existing entities of a system is also a key evolutionary mechanism. In our case, it would refer to the ongoing innovation by firms in the local industry - in terms of new products, techniques, business organisation and the like – in response to market opportunities, competitive pressures, knowledge spillovers and similar stimuli. The entry of new firms employing newer techniques, different variants of products, and so on, is itself a source of conversion (innovation and product re-alignment), and these firms may in turn exercise a demonstration effect or spillover effect on pre-existing firms (Audretsch et al, 2004). To the extent that these processes operate, the technological and product orientation of the local industry as a whole can

change slowly over time. As in the case of institutional evolution, these local industry 'layering' and 'conversion' processes interact. Further, if they cumulate then the network externalities that support and benefit the local firms in the industry will also change. The skills of the local labour force, the range of intermediaries, of suppliers, of local supporting institutions – in fact, the whole gamut of local network externalities – may slowly evolve as the industrial path evolves.[8]

While it is not possible here to give a detailed empirical examples to illustrate these processes, a very brief example may be useful. Consider the Felgueiras footwear cluster in northern Portugal, one of the clusters highlighted by Michael Porter (1990).[9] This cluster had its origins in a local artisanal craft footwear industry that had existed before the Second World War. It grew slowly in size and activity from the late-1940s to the late-1970s. From then onwards it expanded much more rapidly. Between 1985 and 1997, for example, the number of footwear firms in the cluster grew from around 150 to more than 450 (Figure 3), and employment from around 6,000 to some 14,000. The development of the Felgueiras footwear industry over this period involved considerable flux in the population of firms making up the cluster: between 1985-1997 the number of new firm entrants never dropped below 35 per annum, and the number of exits never less than 15 (see Figure 4). As the cluster expanded, so too did the variation amongst the firm in terms of types of shoes produced, the markets served, and the specific technological processes employed (Corte-Real, 2008).

Further, this was also the time when the industry came under increasing global competition, with the development of cheaper production sites in Russia, the Far East and South America. As global competition has intensified, so different firms have responded in different ways. Some have sought to hold on to their traditional markets and customers (such as overseas multi-store chains)

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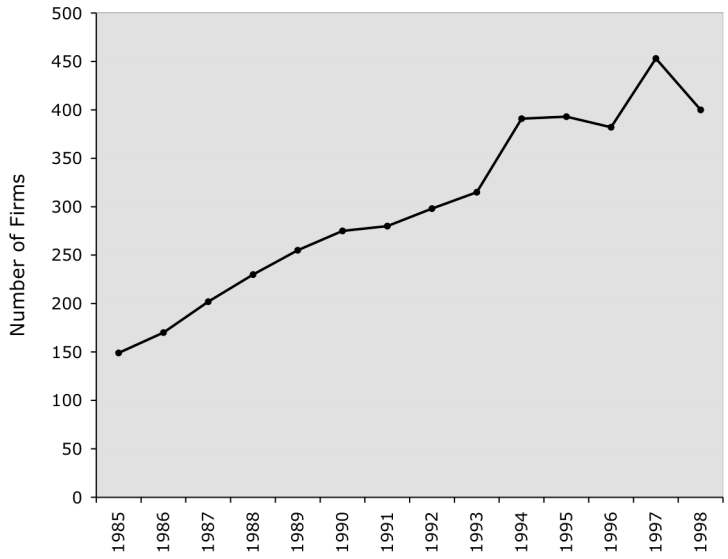
[8] This is precisely what co-evolution means in a regional or local economic context. Of course some of the co-evolving components and externalities need not be local in form or constitution, but may involve relationships, institutions, and organizations at the national or even international scales.

[9] In what follows I draw on PhD research carried out by Maria Corte-Real (2008). I am grateful to her for allowing me to utilise her work in this way.

by adopting defensive low-cost strategies, and are struggling to compete against other lower cost suppliers. Others have sought new mass production markets, where the prospects are also by no means certain. Yet others, however, have opted for an offensive, innovation-based strategy based on sophisticated design, small production niche markets, technological upgrading and new business models. In short, while all the firms in the cluster benefit from the various network externalities that have evolved there - especially a large local pool of specialised labour, and a dedicated technological institute (the Footwear Technology Centre) - and the cluster as a whole exhibits strong path dependent development, there is considerable variety of adaptive response by the firms involved, and the industry as a whole continues to change. Of course, it may be that many firms will not survive, and that the cluster will shrink. It may not necessarily disappear, however, but end up as a smaller, re-orientated and overall more competitive industry: in this sense the future of the cluster is open.

Figure 3: Growth of the Felgueiras Footwear Cluster, Portugal, 1986-1997 (Number of firms)

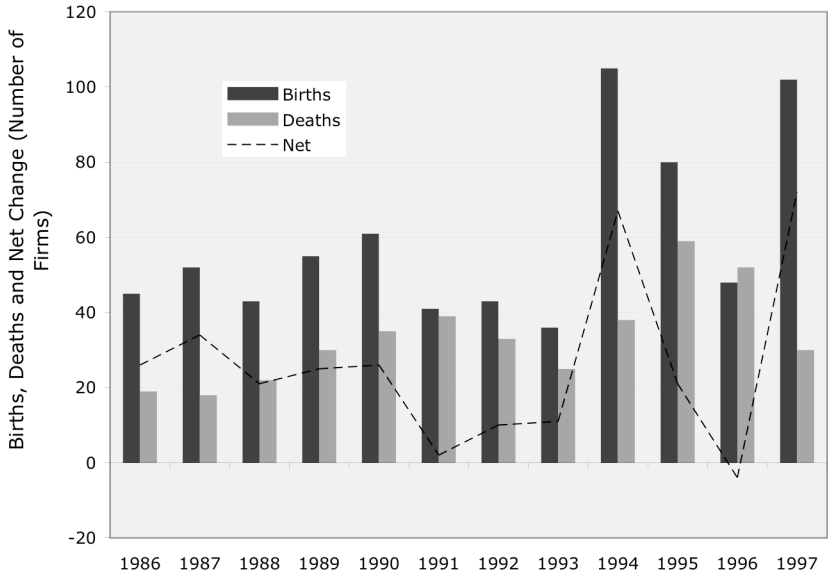
Source: Corte-Real (2008)



Yet further, the ideas of 'structured variety' and 'recombination' lend additional weight to the argument that path dependence theory should give more explicit consideration to path creation and path renewal. They reinforce the idea that new paths may be latent in old ones, or spin out from existing ones. In fact, there is increasing recognition in business studies and industrial organisation

Figure 4: Firm Population Dynamics in the Felgueiras Footwear Cluster, Portugal, 1986-1997

Source: Corte-Real (2008)



research of the ways in which resources and competences acquired and used in previous and existing paths of technological and industrial activity may be recombined to form the basis of purposeful entrepreneurial deviations into new paths (Garud and Karnøe, 2001; Sydow et al, 2005). As Carlsson (2007, p. 265) argues, "the most important aspect of path dependence may be the existing entrepreneurial climate resulting from pre-existing conditions". These pre-conditions, and the resources associated with them, are often place specific, shaped by the characteristics of previous local economic developments. For example, the local inherited knowledge and skill base of an industry can form

the basis of the rise of related new local paths of industrial and technological activity. And local spin-off firms can use the routines and competences inherited from their parent firms to launch new products and processes (Audia et al, 2006; Klepper, 2001, 2007; Brenner and Fornahl, 2008). In various ways, the embedding of local agents in particular paths enables them to accumulate the resources and experience necessary to initiate new technological and industrial paths, whether within existing firms, through spin-offs or via completely new ventures, all processes that involve cognitive recombination (Nooteboom, 2000). And that embedding is frequently place-specific.

As another brief example, several of these processes - 'layering', conversion' and 'recombination' - have been instrumental in the path dependent evolution of the high-tech cluster in Cambridge, UK. Its high-tech development path is usually traced to the setting up of Cambridge Consultants in the early-1960s by some chemical engineering graduates of the University, whose aim was "to put the brains of Cambridge University at the disposal of British industry" (Library House, 2004). Since then, the cluster has grown to encompass 900 or so firms employing upwards of 20,000 workers. The development of the cluster has exhibited some intriguing evolutionary features. The fundamental base of the cluster is generally reckoned to be computing, both 'pure' and applied, a key knowledge resource that has been recombined in numerous ways to produce a high-tech cluster characterised by what evolutionary economic geographers would refer to as 'related variety' (Frenken, et al. 2007). Initially, during the 1970s and early-1980s, the cluster exhibited strong path dependent growth in computing and scientific instruments. From the early-1980s, a software sector began to develop, and by the late 1990s, life science and biotechnology activities had also emerged. It would be difficult to argue that, even after 40 years of growth, the cluster has 'locked into' any stable development path. Indeed, closer examination of the evolution of the cluster suggests a process of on-going renewal, characterised by the increasing proliferation of industrial paths or 'sub-clusters'. From its origins in scientific instruments, there are now reckoned to be some six or more identifiable industrial-technological paths (advanced inkjet technology, telecoms, computing, scientific instruments, software, biosciences).

Local serial entrepreneurs and business angels have been major catalysts for deviating out of existing established paths and opening up new scientific ventures. Inward investment by major foreign and global companies has likewise contributed to the establishment of new laboratories and research facilities, as have major charitable funding organisations such as the Welcome Foundation. And in the past few years, spin-outs from University departments have also played their part in the 'layering' process of new firm formation, as have spin-outs from existing firms. The original 'founding' firm, Cambridge Consultants, is itself a striking illustration of how the Cambridge high-tech industrial pathway has constantly evolved:

> We are a client driven R&D company that originally operated in applied engineering solutions, but which has successively branched into other fields, from wireless, to semiconductors to medical and health care. Our mission is constant innovation to produce competitive products and processes for customers. Over the past two decades we have also spun out more than 40 new ventures. Some of these also operate in the same technological fields as we do, whilst others have taken experience learned with us and applied and re-orientated it to new areas of product and process innovation, from advanced inkjet technology to mobile phone technology to software systems. And some of those companies have in turn spun out others. In this way the technology frontier, so to speak, has moved forward and diversified simultaneously. The same is true for the Cambridge high-tech cluster as a whole: it's vastly different and more diversified than it was, say, twenty years ago. *It's constantly evolving, feeding on and developing on itself…"* (Author's interview with Director of Research, Cambridge Consultants Ltd, 2008, emphasis added).

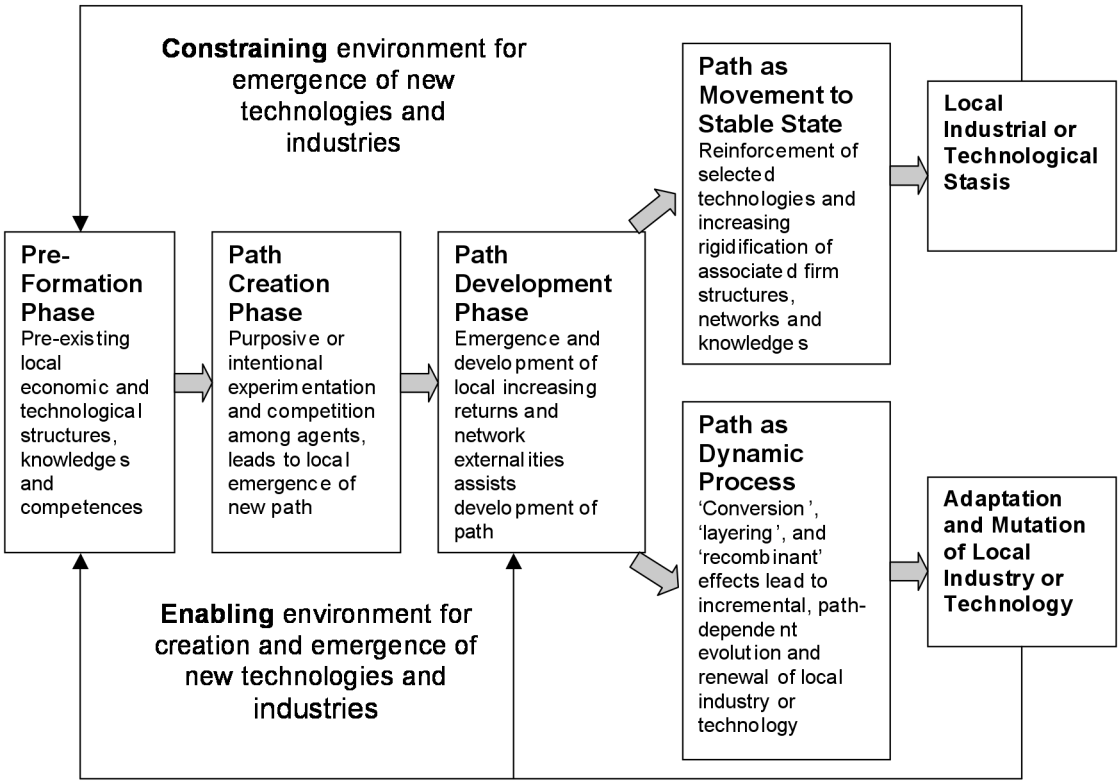
Of course, local economic agents may or may not utilise such locally-based resources and experience to launch new paths or renew existing ones; and new paths may fail to become cumulatively reinforcing. But the fact is that new paths of regional industrial and technological development frequently emerge out of old ones, and that some regions and localities seem more 'enabling' of this process than do others (Stam and Garnsey, 2009, call this 'positive path dependency'). There is, after all, a considerable body of empirical research in economic geography to suggest that innovation is indeed often a highly localised phenomenon, dependent on place-specific factors and conditions.

Those factors and conditions are not simply 'accidental', or random, but are often the product of and reflect the economic, social, cultural and institutional conditions inherited from the previous industrial and technological histories of a locality. New industries can build on the knowledge resource base that has been built up in existing local industries, through processes of organisational birth and heredity (Audia et al, 2006; Klepper, 2007; Brenner and Fornahl, 2008) and cognitive recombination (Nooteboom, 2000). To be sure, in other places – precisely for reasons arising from the specifics of their past economic development - the local environment may be less conducive to, perhaps even a 'constraining' force on, the emergence of new technologies and industries (Stam and Garnsey call this 'negative path dependency'). This might arise, for example, because the specific inherited knowledges and resources are not easily recombined or converted into new into new competences (Maskell and Malmberg, 2007); or it might even happen where precisely because of their previous success, existing industries have bid up local land rents, prices, and wages to levels that deter new entrepeneurial activity (Brezis and Krugman, 1997). The basic point is that path dependence need not lead to or involve 'lock-in', nor indeed lead to any form or equilibrium or stable state or trajectory. In this sense, David's insistence that path dependence is about the processes that select a history-contingent equilibrium seems to rule out much of what we actually observe in the real-world economic landscape.

What I am arguing for, then, is an alternative model of path dependent evolution along the sort of lines depicted in Figure 5. The emergence of a new local industry may not be due to 'chance' or 'historical accident' but stimulated or enabled – at least in part – by the pre-existing resources, competences, skills and experiences inherited from previous local paths and patterns of economic development. These inherited conditions shape the environment in which purposive or intentional experimentation and competition occurs among local agents (or shapes its attractiveness to agents from elsewhere). Once a local industry begins to emerge, then provided sufficient critical mass develops, this will stimulate the sort of autocatalytic network externalities that drive path dependent growth. Simplifying, this growth may then take one or other of two types of path. One type of path is that emphasised by the standard canonical path dependence model: convergence to a stable, self-reproducing form with

reinforcement of existing technology, little or no innovation, and little if any endogenous change – in effect, continuity and stasis. Such an outcome would render the industry highly prone to shifts in markets, the rise of more

Figure 5: Towards an Alternative Path Dependence Model of Local Industrial Evolution



productive (or cheaper) competitors elsewhere and to atrophy, even decline. It is also likely to create a local environment that is inimical to entrepreneurial experimentation of new local industrial paths. The second type of trajectory is more open, and allows for endogenous change and for evolution. As a result of processes of 'layering', 'conversion', and 'recombination', the industry changes slowly over time, and traces out a developmental trajectory that is both path dependent *and path evolving*. Of course, in reality, the speed or pace of

adaptability will vary from one local industry to another, and may change over time. And an industry may over time become less adaptive and tend to stasis, that is move from the lower developmental path portrayed in Figure 5 to the upper path. If the idea of 'lock-in' is to be used, then I would argue it is relevant only in relation to the sort of local industrial development described in that upper path. It has little meaning in relation to the sort of dynamic portrayed in the lower path of Figure 5. Admittedly, a key question is how common is the case of local industrial 'lock-in' or stasis? And indeed, is a case of pure stasis actually likely? These are basically empirical issues. The model in Figure 5 allows for such possibilities, but as special – and in all likelihood, relatively rare – cases. The advantage of the model is that it focuses on path dependence as an enabling rather than constraining process, and thus assigns it a key role as a mechanism of economic evolution.

Conclusion

The idea of path dependence has rightly attracted increasing attention from economic geographers as part of their growing interest in the evolution of regional and local economies. The question, however, is precisely what sort of evolution is implied by path dependence. To investigate this issue, I have gone back to the canonical model, mainly because Paul David, one of its prime architects, has recently explicitly conceptualised the model in equilibrist terms (as 'path dependent equilibrium economics'). The core notion of 'lock-in' plays a leading role in this conception. My argument here has been that this raises real problems for how the model is supposed to function as an evolutionary construct. The difficulty with the notion 'lock-in' is that it speaks to the reproduction of what exists, to yet more of the same, and not to evolution. As such, the idea of 'lock-in' significantly circumscribes the potential usefulness of path dependence theory as a framework for giving evolutionary intent to the study of the economic landscape. This is not necessarily an argument for jettisoning the idea of 'lock-in' altogether. However, it is an argument for rethinking path dependence so as to focus on evolution rather than inertia or

continuity. It is also an argument for looking outside of economics, to escape the equilibrist thinking that continues to dominate that discipline.

In this context, critical discussions of the notions of path dependence and 'lock-in' have been emerging in several areas of the social, historical and political sciences. In this paper I have argued that some of the ideas being developed in these disciplines are highly suggestive for how we should think about path dependence in economic geography. In particular, the concepts of 'layering', 'conversion' 'structured variety' and 'recombination' have been proposed by historical sociologists and political scientists as mechanisms that can operate alongside typical path dependence processes, such as increasing returns and network externality effects, to produce slow, ongoing institutional change and thus prevent institutions from becoming 'frozen', or 'locked' into stable, 'equilibrium' forms. These processes have readily identifiable counterparts in local industrial and technological development, and connect with ideas such as firm heterogeneity, firm birth and death dynamics, the innovation process, and the like, ideas which though often studied by economic geographers have not thus far been used to underpin their studies of path dependence. Furthermore, the processes of layering, conversion, recombination and structured variety resonate closely with many of the concepts and principles that help define a genuinely evolutionary perspective on the economic landscape, such as variety, novelty, selection, fitness, mutation and adaptation.

Thus far in economic geography, the path dependence notion has not been infused with such evolutionary concepts in any concerted or coherent manner. Yet the gains could be considerable – in both directions. On the one side, an understanding of the role that variety, novelty, selection and fitness play in fostering local industrial change (within and between constituent firms) could help inform our conception of how path dependent evolution comes about. By the same token – on the other side - those same processes are themselves likely to exhibit and be shaped by local path dependence. Ultimately, local industrial evolution is about adaptation, in response to an ever-shifting market, competitive, and regulatory environment. The role of competition is especially formative. The constant pressure of competition shapes the selection processes

determining the success and survival of firms, and it drives innovation and hence the production of variety. In short it promotes evolution. As Metcalfe (1998) argues, competitive advantage is not a state but a process, and moreover a process that is path dependent. The path dependent evolution of local industries and local economies cannot be fully grasped or understood unless full consideration is given to the impact of competition on the firms concerned, and how far and in what ways those firms adapt in response. There has perhaps been too much emphasis on 'increasing returns effects' and 'network externalities' as mechanisms imparting local path dependence. While these are important, and although they also help shape the competitive advantage of local firms, they tell us little or nothing about the evolutionary dynamics of those firms or the industry concerned.

Integrating path dependence into a more general theory of local and regional economic adaptation would not only liberate the notion of path dependence from an overly restrictive association with 'lock-in', it would also move us nearer to the sort of regional evolutionary ontology asked for by Scott. For such an ontology cannot be constructed on the idea of path dependence alone; it requires a theoretical framework that integrates various evolutionary mechanisms, processes and insights. I have used developments in historical sociology and political science to identify some possible directions in which this task might be taken. Others are to be found in evolutionary economics. Still others can be found in disciplines such as ecological dynamics and panarchy. A rethinking of path dependence is underway across many disciplines, a rethinking that is not only highly relevant to economic geography, but also one to which economic geographers could usefully contribute.

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