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Ron Martin and Peter Sunley

Utrecht University
Urban & Regional research centre Utrecht

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Ron Martin* and Peter Sunley**

*Department of Geography, University of Cambridge, UK
(rlm1@cam.ac.uk)
** School of Geography, University of Southampton, UK
(P.J.Sunley@soton.ac.uk)

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Abstract

Over the past two decades, the notion of 'emergence' has attracted increasing attention and controversy across the social sciences, as par of a growing interest in the applicability of complexity theory to socio-economic-political systems. Within this context, as economic geographers, our concern in this paper is with the usefulness of the idea of emergence for studying the economic landscape and its evolution. We examine three 'orders' of emergence, and focus attention especially on the third type, 'developmental or evolutionary' emergence. Despite its limitations, the notion of third order emergence is a potentially valuable organizing concept in economic geography. It provides a framework for exploring how it is that the spatial forms of the economy - clusters, regions, firm networks and so on – are recursively related to economic action.

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> Like alcohol, [the theory of emergence] is a stimulant only in proper doses; many who have used it have gotten drunk in the attempt to apply it to everything (Reuben Ablowitz, 1939: The Theory of Emergence, *Philosophy of Science, 16*).
>
> There is a glaring absence of bold social theories which uncompromisingly make 'emergence' their central tenet (Margaret Archer, 1995: *Realist Social Theory: The Morphogenetic Approach*).
>
> The emergent properties of the entirety and the laws for its causal interactions are determined by the spacing and timing of the parts as well as by the properties of the parts themselves. The very essence of evolutionary progress is in the new timing and new spacing of the parts (Roger W. Sperry, 1986: Macro- versus Micro-determinism, *Philosophy of Science, 53*).

1. Introduction

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

Within this context, as economic geographers, our concern in this paper is with the usefulness of the idea of emergence for studying the economic landscape and its evolution. During the past few years, economic geographers have begun to explore a wide range of evolutionary ideas, metaphors and

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

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

agents.[1] In this sense, Krugman sees emergence and self-organisation as central to his and others' work in the so-called 'new economic geography'. Of course, this is not to deny that in certain cases particular features of the economic landscape do not emerge and self-organise 'spontaneously', but are the product of deliberate design, and purposive action, sometimes by policy-makers (examples of such 'planned organisation' might include designated industrial zones, enterprise zones, business clusters, even whole cities); nor that, on occasion spontaneously emergent spatial structures and features may have been deliberately altered or manipulated to avoid adverse unintended effects and consequences. However, the fact remains that many urban, regional and local economic forms are not the result of conscious design or policy intervention, but would appear to be self-organising, emerging in an unplanned and uncoordinated way from the behaviours of myriad economic agents, in the sense that Krugman suggests.

Potentially, then, emergence would seem to be one way of explaining how structure and form arises in the economic landscape, and why 'place matters' in processes of economic change and evolution. Contextual combinations of processes in particular places can be said to have emergent effects that produce particular spatial forms which then feedback to shape the operation of those same processes. The argument is undoubtedly intuitively appealing. But, in fact, it masks several questions about what emergence actually means and whether and in what ways it can be applied to economic spaces and systems at various scales. Our aim in this paper is to scrutinize the notion of emergence and to examine its potential contribution to the analysis of economic geography.[2] The paper considers in what sense geographical processes and places can legitimately be described as emergent, how such places themselves produce emergent effects, and how we should conceive of

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

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

and study the 'emergent' space economy. It should be read as exploratory in nature, and selective in its coverage: our motive is to stimulate further discussion and debate around the potential contribution that an 'emergence perspective' might make to evolutionary economic geography, rather than lay claim to presenting a comprehensive or definitive statement. We begin by discussing the different types of emergence that have been identified by writers on this concept, and around which considerable debate exists.

2. The Concept of Emergence

As many commentators on emergence stress, the concept is used in diverse ways across diverse disciplines to denote diverse phenomena. This variety raises the question of what these phenomena have in common, and whether a general conceptual framework can be formulated that allows a treatment of emergence without explicit reference to a specific underlying mechanism. One way of thinking about emergence is to contrast it with the minimalist claim that "wholes are nothing but the sum of their parts". This claim commits minimalists to believing that the properties of a system as a whole are simply fixed by the properties (including the relational properties) of its constituent parts or components: the whole can simply be described in terms of, that is, is reducible to, its lower-level parts. By contrast, the basic idea of emergence is conveyed by the claim that "wholes are more than the sum of their parts". More specifically, emergence is a process in which lower-level components of a system interact so as to produce effects (properties, patterns, functions) at higher levels of the system, so that the latter are said to be 'supervenient' on the former but are not simply reducible to those individual components (see Table 1). As de Haan (2008) puts it, "some property or phenomenon is observed that somehow transcends the level of the objects that nevertheless produce it" (p. 293). According to Lawson (2003, p. 44) a stratum of reality can be said to be emergent, or as possessing emergent powers, if there is a sense in which it (i) has arisen out of a lower stratum, being formed by principles operative at the lower level; (ii) remains dependent on the lower stratum for its existence; but (iii) contains causal powers of its own which are irreducible to those operating at the lower level and (perhaps) capable of acting back on the lower level. It is this last attribute that is particularly

intriguing and potentially highly significant, but also most contentious and keenly debated.

Table 1: Emergence: Key Intersecting Concepts

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

Indeed, while many social theorists are keen advocates of the relevance of emergence to an understanding of the social world (such as Archer, 1995; Sawyer, 2005; Elder-Vass, 2010 and Lawson, 2010), others (such as Searle, 1992) are willing to accept only weak emergence, and deny the 'strong' form implied by Lawson's third criterion (iii). Yet others deny the idea of emergence altogether. For example, Giddens' (1984) structuration theory stands in stark contrast to emergence. Thus, according to Archer (1995, p.94), by its appeal to the inseparability or elisionism of the individual and society, structuration theory analyses the social world by "considerably flattening out the ontological depth of the social world by denying the existence of emergent properties which pertain to a 'higher stratum' when they do not obtain at a 'lower' one". It is not our intention to enter into this debate here, which in any case is well rehearsed in Sawyer (op cit). Rather, our working hypothesis in this paper is that the notion of emergence is indeed potentially relevant for explicating the evolution and development of the economic landscape, and thus worth exploring to ascertain the scope and importance of that relevance.

Adopting this working hypothesis does of course commit us, again as a working assumption, to an ontological emergentism. By this is meant the assumption that emergent properties or phenomena are real and distinct, and cannot be explicated purely in terms of, simply decomposed into, or reduced to, the properties of the constituent parts or components of the system in question (Lawson, 2010). This conception of emergence is often described as 'strong' emergence because it implies that new classes of processes, properties and influences come into existence at higher levels. It is contrasted with 'weak' emergence that does not entail the introduction or emergence of new processes or principles that causally influence lower-level components. Further, as Deacon (2006) stresses, throughout most uses of the emergence concept there is the implicit assumption that an effect is manifested at ascending levels of scale. Indeed, scale is of special importance to the problem of emergence because an increase in the numbers of low-level (or micro) components increases iterative interaction possibilities. And with every iterated interaction, relational properties are multiplied with respect to each other, so an increase in numbers of elements and chances for interactions increases the relative likelihood and importance of emergent properties and phenomena. Nor do scale effects work only upwards: many discussions and interpretations of emergence invoke the idea of 'downward causation', whereby an emergent higher-level property, pattern or element exerts causal powers over the lower level components or processes that produced it[3].

This latter aspect can be used to distinguish between different types, categories or orders of emergence. Deacon (2006) for example, defines three types of emergent phenomena that can be arranged into a hierarchy of increasing complexity, each growing out of and dependent on emergent processes at lower levels: what he terms first-order, second-order and third-order emergence (Table 2).[4] *First-order emergence* is the simplest form. Higher level properties and structures emerge as amplified forms from – are 'supervenient' on – the interactions and properties of lower-level components,

[3] While downward causation is admittedly ambiguous and often used broadly to refer to explanation and determination rather than direct causation (or 'bringing something about') (Hulwit, 2006), the term is retained here as a label for a series of causal, constraining, determining, and influencing effects produced by an emergent entity

[4] Deacon's typology of emergence is not the only one, but in our view it is one of clearest and most suggestive discussions of the concept (albeit in biological and physical systems), and in what follows we draw mainly from his work.

and there may be many different ways that different micro-details of structure and interaction can converge to produce the same higher order properties (the phenomenon of 'multiple realizability' – see Sawyer, 2005), but there are no top-down or downward causal effects that change the nature or properties of the lower level components themselves. In his discussion of physical systems, Deacon (op cit) cites liquid properties (laminar flow, surface tension, viscosity and so on) as examples of first-order emergent phenomena: the interaction relationships between molecules (of say oxygen and hydrogen) become amplified and summed to produce aggregate behaviours that emerge as liquid properties (of water in this instance) with ascent in scale. This is why a highly diverse class of molecular species are capable of exhibiting similar liquid behaviours in appropriate conditions. Liquid properties supervene on the lower-order properties of the constitutive molecules and their interaction effects, and are entirely determined by them. And yet the vast iterative dynamics of these interactions also has a variety cancelling effect that converges to similar results across a wide range of types of molecule and modes of interaction.

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

micro-level options and outcomes, which in physical systems often means that self-reinforcing 'lock-in' occurs to a particular system architecture of macro-level form and micro-level interactions. Second-order emergence is thus said to be characteristic of self-organising systems, and imparts a morphodynamic character to them. The classic example used to illustrate second-order emergence physical systems is snow-crystal formation: Interactions between water molecules create binding patterns that generate a crystal structure that in its turn constrains (exerts an emergent 'top-down' influence) on those molecular interactions. The conditions under which each snow crystal begins to develop are unique, so that no two crystals end up with the same geometry. But once crystal development has begun it becomes a form-propagating process. In this way a snow crystal is effectively a record of the initial conditions of its development. But it is also more than just a simple record of those initial conditions, because of the way in which prior stages of crystal growth progressively constrain subsequent stages: the crystal's distinct and unique morphology gets 'locked-in' (see Deacon, op cit).

Table 2: Three Orders of Emergence (after Deacon, 2006)

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

Third-order emergence extends second-order emergence in two important respects: selection processes, and 'memory' effects. Whereas second-order emergence is characterised by the emergence of self-organised macro-level morphology arising from the recursive amplifying interactions among the micro components and between the latter and macro-level forms and properties, in third order emergence 'memory' and selection effects impart an evolutionary character to the system. Selection implies that second-order systems receive information that 'instructs' them to form adaptive traits in the context of the system's (changing) environment (Goodenough and Deacon, 2003). Not all lower level components need be equally adaptive in response to such information, so the heterogeneity of responses of the micro-elements will determine how the macro-structure or system evolves. And the responses of those individual micro-components may depend on their role or position with the macro-structure. Some lower level components of the system may not survive at all, and any new ones that are added will also influence how the macro-level structure or system evolves over time. This means that both the supervenience of higher-level structures and properties on the interactions and behaviour of the micro-level components will change over time, as micro-components selectively adapt to changing external and environmental conditions ('information'), and that the nature of emergent downward causal influences back on to those micro-components will also change. Systems characterised by third order emergence need not, therefore, converge onto a stable form, but may continually change morphologically and functionally.

Further, the nature and direction of this continual change will be affected by memory effects within the system: the issue of 'memory', not seen in second-order emergent processes, adds a further source of evolutionary dynamic to systems characterised by third order emergence. Deacon defines 'memory' as a situation where

> specific historical moments - either of higher-order regularity or of unique micro-causal configurations – can exert a cumulative influence over the entire causal future of the system (op cit, p. 137).

In this sense, specific past higher-order states repeatedly shape the lower-order dynamics of a systems' micro-components that in turn lead to future emergent states. Further, this feature, Deacon goes on to argue, allows every prior morphological relationship itself to become a potentially amplifiable

initial condition to any later relationship. In combination, selection and memory make the evolution of a system unpredictable on the one hand, and yet on the other hand also historically organised, with an unfolding quasi-directionality.

In fact, Deacon's definition of memory and its role in third order emergence would seem to bear similarities to the notions of path dependence and hysteresis used in economics and social and political theory (for example, David, 1988, 205; Arthur, 1989; Setterfield, 1998, 2009; Garud and Karnøe, 2001, Magnusson and Ottosson, 2009). Standard path dependence assumes that a random or contingent initial event shapes the entire subsequent path of the system in question, and moreover that the path converges onto a stable (equilibrium) form or outcome, which is disturbed only when the system is subjected to an external disturbance or shock of some kind. Such a shock may shift the system to an alternative path: which path is selected may depend on the nature of the shock and other circumstances at the time. But the shock in effect becomes a new 'initial condition', akin to that discussed by Deacon. This is obviously similar to the idea of hysteresis, where a shock displaces a system to a new equilibrium outcome. But other types of path dependence are also compatible with – and indeed extend - Deacon's notion of 'memory'. For example, in 'selective path dependence', it is not the original initial event, and hence the entire cumulative sequence that matters, but only particular significant events – 'specific historical moments' of a certain kind (for example extreme events). Or again, 'memory', or path dependence, can be of a 'recent event' kind, where it is only recent deviations, perturbations or 'information' that matters in shaping the evolutionary dynamic of the system. In other words, the 'historical depth or reach' of memory (or path dependence) would seem to be of fundamental importance for third order emergence. As far as we know, this aspect of memory in third order emergence has yet to be explored.

3. First and Second Order Emergence in the Spatial Economy

Our intention in what follows is to ask whether this identification of three types of emergence in physical and biological systems has implications for

understanding emergence in economic geography. Can we distinguish analogous forms of emergence in economic landscapes?

As a starting point we need ask whether the typical spatial forms that economic geographers study – clusters, regional industrial complexes, cities, and so on – are in fact merely localised aggregations, that is simply the sum of their parts (firms, households, workers etc), and nothing more, or whether the process of spatial agglomeration (that is co-location) additionally gives rise to emergent effects. Aggregative properties are characterised by four conditions (see Sawyer, 2005). First, the system property is not a product of the way the system is organized: the component parts are inter-substitutable, that is can be re-arranged within the system without affecting the system's aggregate properties. Second, an aggregative property should remain qualitatively similar despite the addition or removal of a part of the system. Third, the function of the system remains invariant under processes of decomposition and re-aggregation of parts: there are no threshold effects. And fourth, there are no cooperative or inhibitory interactions among the parts: the relation between parts and whole is linear. Further, a critical realist reading of emergence insists that emergence is defined by interactions between entities that affect the powers or capabilities and susceptibilities of those entities. Aggregative effects, in contrast, merely affect the conditions under which those powers are exercised and mediated, so that they shape eventual outcomes, but not the capabilities of the entities involved (see Sayer, 2010).

On this basis, spatial agglomerations of firms - whether local clusters, industrial districts or cities, and regional economies more generally - would seem to be more than just simple aggregative phenomena. Firms, for example, are not identical, and hence not perfectly inter-substitutable, even within the same industry. Thus, the firm-composition of an industrial cluster, for example, will influence its organisation, and changes in its population of firms will have some impact on the nature of the cluster and its functioning: in this way a cluster's or industrial district's particular specialism, or its technological regime can change over time (see Martin and Sunley, 2011). Further, changes in the number of firms in a cluster or regional agglomeration may well give rise to threshold effects in terms of the success and performance of the other firms in the cluster or agglomeration, precisely because of the emergence (or disappearance) of system-wide properties or processes. Certain system-wide (cluster-wide or region-wide) growth-inducing properties, processes and

patterns – such as positive external localisation economies - may only emerge once the population of firms in the cluster or agglomeration reaches a certain size (threshold effects). And, of course firms interact: they may cooperate and collaborate, or they may be able to inhibit, exclude or constrain other firms by means of monopolistic or similar behaviour. Clusters, agglomerations, regional production systems, and cities, therefore, are more than simply aggregative phenomena: they are at least first order emergent systems of first order.

But the question is whether such spatial economic forms and structures are in fact more than simply first order emergent systems. It is difficult to think of many instances where the emergence of the spatial forms that typify the economic landscape, such as business clusters, specialised regional economies, cities, customer-supplier networks, so on, would not give rise to some sort of effects back 'down' from such spatial forms on to their constituent firms and workers. After all, the attraction of firms and workers to spatial agglomerations is precisely because those firms and workers perceive there to be advantageous effects from locating in such areas. Economic geographers (and indeed, human geographers in general) have long argued that there is more to space and place than the mere prior existence of fixed cadastral territories or 'containers' in which different events happen, different processes occur, and different spatial forms emerge and develop. Rather, a key claim by economic geographers is that space and place matter in a dual sense. The myriad decisions and activities of individual firms, workers, consumers and other economic agents, including their locational choices, *shape* the spatial organisation of the economy – the formation of cities, industrial clusters and districts, and broader patterns of regional development. Space is thus relational: it takes on meaning and form precisely because of what goes on across and within it; space is socially and economically produced: first order emergence. But more than this, geographers contend, the spatial forms and patterns produced by the actions and interactions of individual firms, workers and consumers, in turn exert causal influence on the behaviours and actions of those same agents. Economic agents produce emergent economic spaces, and the spaces they produce - cities, regions, clusters and the like - in turn feed back to influence the behaviours and properties of those agents of which they are composed:

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

In other words, if the economic landscape is an emergent feature, it also exerts downward causation (Massey's 'emergent powers') on the micro-economic components on which that landscape is supervenient. Much turns, then, on whether and to what extent cities, industrial districts, clusters, regional innovation systems, and the other such spatial morphological forms that are the focus of economic-geographic enquiry, are merely first order emergent features or whether they do indeed acquire and exert 'emergent powers', and what those powers are. And if the economic landscape is an emergent system with such downward causal powers, is it of second or third order?

As we have noted already, Krugman (1996) has provided one of the most lucid, if concise, discussions of spatial economic emergence and so we start with his exposition. Krugman begins with Philip Anderson's definition of complexity as the science of 'emergence': "That is, it is about how large scale interacting ensembles – where the units may be water molecules, neurons, magnetic dipoles, or consumers – exhibit collective behaviour that is very different from anything you might have expected from simply scaling up the behaviour of the individual units" (Krugman, 1996, page 3). On this basis he suggests that examples of emergence abound in economic theory. Thus, according to Krugman, when Adam Smith wrote of the way that markets lead their participants "as if by an invisible hand" to outcomes that nobody intended, what, asks Krugman, was he describing if nothing but an emergent property? Turning to economic geography and location theory, Krugman subsequently argues that the classic Von Thünen model of concentric land use patterns around an 'isolated town' can be interpreted as a model of an emergent process (op cit, pp.9-12). The concentric ring pattern is not intentionally produced by individual farmers and will emerge even if they are unaware of its existence. Yet he also argues that this model, while it incorporates a simple and weak form of emergence, is not self-organizing, as the location of the town is assumed a priori and is not created by the endogenous dynamics of the model. In self-organizing systems, spatial structure arises not from inherent pre-given differences among locations (such as soil fertility in the

Von Thünen case)[5] but from the internal logics of the system (transport costs, competition, costs of production, price formation, etc).

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

Krugman's models of self-organizing emergent urban economies bear a strong family resemblance to the core regional models of the New Economic Geography (NEG), of which he has been the leading proponent. These models are also based on the outcomes of a tension between centrifugal and centripetal forces as they are mediated by the level of transport costs. Once again these models show that individual firms' decisions can produce

[5] In NEG parlance such natural pre-given qualities of places are referred to as 'first nature' differences.

endogenous dynamics that lead to self-reinforcing regional agglomerations of various kinds and geographical scales (see, for example: Fujita, Krugman and Venables, 1999; Fujita and Thisse, 2002; Baldwin et al, 2003; Combes, Mayer and Thisse, 2008; Glaeser, 2010). Thus, although neither Krugman nor his co-workers and acolytes invoke complexity theory or notions of self-organisation or emergence in their NEG writings, we might also describe the NEG core model as a model of economic emergence.[6] But this, of course, raises the question what type of emergence is represented in these models, and do they help us to understand the significance of emergence in actual economic landscapes?

The dynamics in these models of spatial economic emergence correspond with some of the characteristics of second order emergence as perceived by Deacon (op cit). The models show a type of recurrent or recursive architecture in which there is an interaction between the firm and its host agglomeration. That is, micro-level particularities, in this case the location decisions of individual firms, are amplified by the decisions of other firms and thereby determine the macro-configurational property, namely the agglomeration of firms in one or more centres. Furthermore, a form of downward causation occurs in these models either through positive external economies effects (Marshallian-type external 'economies of localisation' associated with the positive effects of locating near similar firms, such as the attraction of specialised labour and suppliers). There is also a recognition that after some threshold of spatial agglomeration has been reached, certain negative diseconomies may emerge, such as rising costs and congestion effects, that act to disperse and decentralise activity away from an agglomeration. Thus a temporal dynamic appears as initial micro-decisions influence macro-structures which in turn act to amplify, or contrain, or amplify micro-level interactions and shape future choices. The recognition of such feedbacks on firms opens the door, albeit narrowly, to forms of downward causation. The recursive and self-reinforcing morphogenesis of spatial forms such as cities and clusters depends on the dynamic balance between these different types of downwardly causal emergent effects.

[6] In fact, it is somewhat curious that Krugman has never integrated his work on the economic landscape as a complex self-organising system (Krugman, 1995, 1996) into his work in NEG.

However, while these models demonstrate the importance of second-order type emergence to regional and urban economies, and indicate some of the underlying economic mechanisms, at the same time they capture only limited forms of second-order emergence. In the first place, the models show that the spacing of firms is important, but is this configuration merely aggregative rather than emergent? In one sense, in these models it is simply the aggregation and lumping of (hypothetical) firms together in particular (hypothetical) sites that gives rise to increasing returns effects. The forms of non-linearity and downward effect pictured by these models are also highly restricted largely because NEG theorists harbour a high degree of suspicion about non-pecuniary externalities and doubts about non-reductive, non-individualist forms of explanation – they are based on rather orthodox assumptions (profit maximising firms, perfect mobility of labour and capital, market clearing, iceberg transports costs, identical consumer tastes, and the like) (see Martin, 2011). In general, they deal only with pecuniary externalities that affect the costs of operation in a location. Further these pecuniary externalities are envisaged as exerting a one-off influence on a firm's location decision, and the models have little else to say about the character of the firms, which in effect are treated in a black-box fashion. Thus these formal models of spatial economic emergence do not incorporate other forms of local and regional spillovers, such as learning effects, or networks and collective institutions, which may have a profound influence on the development of a firm. There is little sense in these types of models that *relational* emergence may be fundamental to the capabilities of economic agents and that the locational configuration of those agents actually enables them to do things that would otherwise be impossible.

Fundamentally, then, while these NEG models can be argued to resemble Deacon's second order type of emergence, the range of possible downward causation effects associated with emergent spatial forms such clusters and agglomerations is a restricted one. Moreover, the models certainly do not capture the more complex dynamics of third order or evolutionary emergence. Hence, in these models there is no sense of selection and memory so that past development does not affect the development of local and regional economies. Admittedly, these models claim to show that 'history' is important in the sense that individual decisions can be amplified through self-reinforcing reactions, and this also allows for the possibility of 'locational hysteresis (where a

temporary shock can set off self –reinforcing movements of firms and workers to an alternative location – see Baldwin et al 2003). But in practice, the notion of 'history' in NEG models of the economic landscape is simply logical rather than real in nature: that is, it refers to the dependence of the equilibrium spatial outcomes (model solutions) on the model's 'initial conditions' (for a critique of the conceptions of both 'geography' and 'history' in NEG models see Martin, 1999; Garretsen and Martin, 2010; Martin, 2011). In short, NEG accounts of the formation of spatial-economic forms and structures are not evolutionary: they take no real account of the memory and selection effects that characterise third order emergence. Yet, within economic geography the increasing focus on the evolutionary nature of the economic landscape assigns considerable importance to 'memory' (in the form of path dependence) and selection processes in that evolution. In the next section, therefore, we consider the degree to which third order emergence may contribute to an understanding of the economic landscape as an evolutionary system.

4. Evolutionary Emergence and the Economic Landscape

If NEG models are able only to incorporate second order emergence, then we might expect evolutionary economics to provide a basis for conceptualising third order type of emergence in spatial economic systems. However, while evolutionary economists accept the importance of emergence (for example see Hodgson, 1997; Dopfer and Potts, 2004), thus far evolutionary economics has lacked a substantive theory of the phenonemon (Harper, forthcoming). Dopfer and Potts (2008), for example, illustrate this sense of unfulfilled promise. They offer a realist theory of economic evolution based on the role of cognitive, behavioural, technical and social rules that govern economic activity. Rules originate at a micro-level in human imagination and intention and are adopted by populations of 'carriers' (individuals and firms). The adoption and combinations of rules creates clusters of rules at a meso-level, while macro-level analysis pertains to the co-ordination and coherence of these meso-level rule-sets. Dopfer and Potts (2008) argue that firms, organisations and meso-level entities, such as industries and regions, have emergent powers precisely because of the ways in which they combine rules, but they say little about what these emergent powers mean or how downward causation operates. Indeed, for the most part their account is dominated by

upward causation: “Economic growth is what happens when a new idea that has been successfully trailed, adapted and embedded is able to provide the basis of an operational expansion of activities. Economic evolution is the ongoing supply of such generic opportunities” (ibid, p. 91). Their approach tracks rules through ascending scales: “Economic systems evolve as a new idea becomes a micro, meso, and then macro trajectory” (ibid, p. 93). Yet, while they note that some rules allow the creation of other rules, there is little in their account about how context and the form of relationships allow, bias or constrain the appearance of new rules. [7]

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

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

accounts to constrain lower-level systems by subjecting them to 'instructions' to show adaptive traits in order to survive. However, while third order emergence reinforces the value of an evolutionary perspective it also implies that the understanding of how evolution works in the economic landscape needs to be revised.

In the process of third order emergence, feedbacks between variables are not simply the products of accidental initial conditions but are also subject to processes of selection and memory. As Goodenough and Deacon write "The larger point, then, is that third-order systems, by being remembered/selected and not simply the episodic outcome of unspecified initial and boundary conditions, have the all-important property that they are subject to constructive influence". In this view emergent cycles produce traits in behaviour, and those traits that aid adaptation to the environment are selected, represented and remembered. In this way there is an essential interdependence between self-organizing and evolutionary processes. In Deacon's account the outcomes of self-organization can feed back on their underlying resources via selection pressures.[8]

To focus the discussion, consider the case of a business cluster, a strong candidate for the sort of third order emergence proposed by Deacon, and a spatial form of key interest to economic geographers (see Martin and Sunley, 2003; Breschi and Malerba, 2005; Asheim, Cooke and Martin, 2006). As defined by the originator of the notion, Michael Porter, clusters are "geographical concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also cooperate" (Porter, 1998, p. 197). Though not without problems in terms of their conceptualisation and empirical identification (see, for example, Martin and Sunley, 2003), with some notable exceptions (such as state–sponsored clusters and industrial districts: see Markusen, 1996), clusters can be viewed as self-organising systems arising from the uncoordinated agglomeration of

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

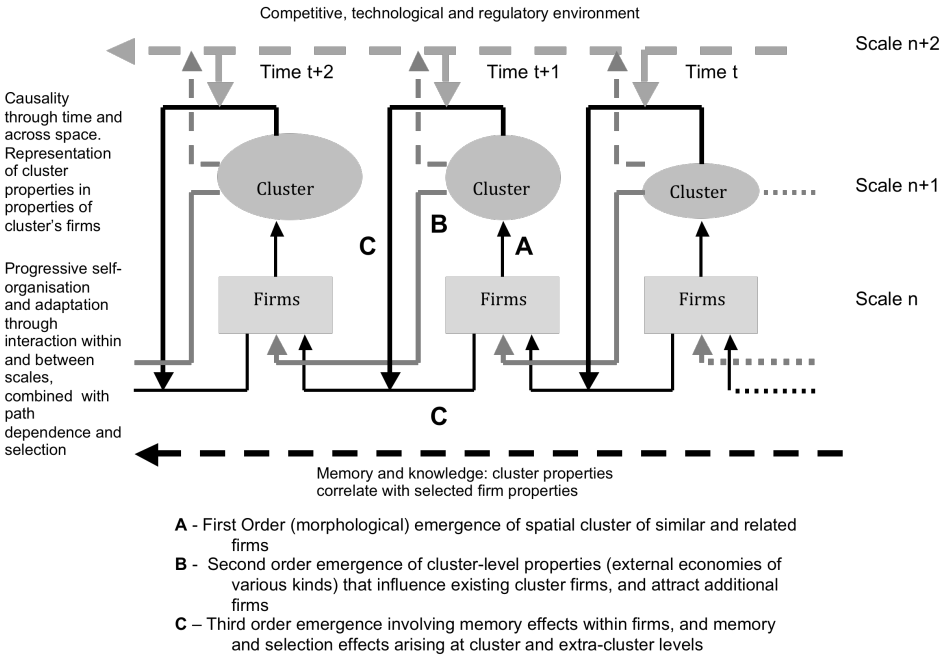
similar and related firms, workers and institutions in particular localities. Once a particular industrial/technological specialism begins to take root in a locality, and a process of clustering develops, this is believed to lead to, and be reinforced by, the emergence of localised externalities or spillovers of various kinds. These externalities - or 'localisation economies' as Marshall called them in the context of his closely related idea of the 'industrial district' - for example, a specialised labour market, knowledge networks, specialised support industries and services, dedicated institutions and trade and industry associations, business conventions, and patterns of trust, develop from the properties and proximity of firms in the cluster, but are 'macro-level' features of the cluster as a whole, and available to (have 'downward' causal influence on) the cluster's firms as sources of productivity gain and competitive advantage. And the more successful those firms become as a result, the more attractive the cluster becomes to yet other similar firms and workers:

> External economies are the spillovers that result from regional concentrations of industry, and explain the snowball effect of a virtuous circle of growth.... A central theme in economic geography, both new and traditional, is the way these external economies drive the evolution of regional economies. An industry or cluster of industries generates spillovers which reinforce that industry's local advantage, or in some cases spillovers to other industries which are thereby encouraged to locate in a particular region. A key point about externalities is that they give a large role to history (Krugman, 2005, p. 39).

A cluster is thus not just an emergent morphological spatial entity, but a relational system of firm interdependencies, both traded and 'untraded'. Properties of the firms, and the interactions between the firms, become represented in and give rise to cluster-level properties, especially externalities, which then exert a 'downward' causal influence on the operation and dynamics of the firms concerned: that is, cluster level properties emerge which then shape and become represented in firm properties (see Figure 1).

At least four different types of downward effect, outlined in the emergence literature, may be exemplified by processes in business clusters (see Table 3). The first of these might be termed 'boundary conditions' in which patterns of organization exert a selective influence and shape which causal powers of their constituents are activated (Hulswit, 2006). A firm's location within an agglomeration composed of dense contacts and markets can certainly open up

Figure 1: Stylised Schematic of the Emergent Evolution of a Local Business Cluster



(An adaption of Deacon's (2006) model of Third Order Emergence to the case of a cluster)

new opportunities and thereby allow firms to exploit and develop their capabilities. Many suppliers form and prosper through their integration in local networks organised by a lead or flagship firm. It is widely argued that co-location and regular face-to-face interactions can facilitate the building of trust between partners and that, in many knowledge-based industries, these remain important to both innovation and securing new business. In other circumstances, of course, these regulating effects can be negative and location in a cluster might well prevent a firm from activating some of its capabilities, possibly by encouraging a focus on local customers and suppliers and discouraging the search for new networks.

A second and more profound type of effect proposed by Bickhard and Campbell (2000) is where emergent consequences outside of a particular system act to influence its lower-level component processes and interactions. For example, it is well known that location in a successful business cluster can have a large branding and reputational benefit to its constituent firms (Glückler, 2007). In such cases location in a cluster helps particular firms to

convince and persuade customers, build external market relationships and thereby grow more rapidly. Thus downward influence does not just have effects within a particular cluster but as the cluster gains a reputation for leadership in a particular industry it may become a key gateway or portal to global markets (for example see, Sunley, Pinch and Reimer, 2011). A similar process has been seen in research and development, once a cluster gains a reputation for being at the research frontier its external reputation will attract further investment and opportunities for networks and collaboration. Once again, however, these downward effects are obviously contingent and the decline of a cluster's reputation might well hinder and weaken a firm's regard and performance.

Table 3: Types of Downward Causation and Some Spatial Economic Examples

Type of Downward Causation	Examples off Spatial Economic Effects (eg in a Cluster)
Effects of system organisation Boundaries and patterns of organization of a system shape which causal powers of their constituent components are activated (or deactivated)	Spatial agglomeration of firms opens up local market niches and supplier opportunities for firms concerned. Though generally positive, such local orientation may also restrict technological search and export reach of local firms
Effects of external system consequences Emergent consequences of system on its external environment influence properties and interactions of system components	Local cluster can shape wider industry of which it is a part, and acquire external reputation which influences the resources available to its firms, their performance and market position
Effects of system-level dynamics Properties and constraints emergent at system level become internalised by system components	Conventions and practices may emerge at the agglomeration or cluster level which then become internalised in the routines, capabilities and decisions of the constituent firms
Effects on generative processes Properties, processes and constraints emergent at system level alter selection pressures on, and hence sources of constructive variation in, lower level components	Form and degree of specialisation of local agglomeration or cluster, and nature of local local competition and collaboration, may shape the scope for and direction of innovation, spinoffs and start-ups

Third, there also types of downward causation whereby non-linear constraints emerge from higher level dynamics and become internal to the constituents of a system (Bickhard and Campbell, op.cit). In the case of clusters,

collaborative and collective learning, either through direct knowledge exchange or inter-firm labour mobility are widely recognized examples (see, Malmberg and Maskell, 1999; 2006). The diffusion of routines and conventions across neighbouring firms through copying and imitation represents another way in which firms' productivity and capability may be shaped by emergent effects. These knowledge effects may penetrate into firm strategies cultures via habits and routine behaviour. Indeed, it has been recognized that regional cultural contexts and shared practices even shape individual cognition and decisions so that situated decision-making reflects the context in which it occurs (Storper, 2009). An alternative example is the emergence of local inflation in wages, supply or transport costs due to the density and frequency of transactions in a particular cluster. Such a negative externality might well shape and influence firm strategies by forcing them to raise productivity and innovate in order to control or reduce these rising costs.

A final kind of downward effect involves constraints on the generative processes and sources of variation produced by lower levels. In this type of effect, the contexts produced by self organization may create niches that shape how selection operates. In the case of a business cluster, various types of local external economies may shape and bias the selection, or generation and viability of new products and firms within those contexts. Of course, the influence of externalities on innovation practices is a topic of keen debate and much remains unknown about how these influences operate. While some argue that Marshallian localisation economies are most conducive to specialised innovation, others look to Jacobs-type externalities and the proximity of diverse sectors as allowing recombinant innovation, and yet others point to hybrid models that emphasise knowledge spillovers across complementary sectors (see Boschma and Iammarino, 2009). Yet all these approaches share a focus on how downward effects condition and influence innovation. Selection includes both the development of knowledge networks that shape the construction of particular innovations, as well as the creation of market niches and heightened demand for particular products. Where markets are built through the construction of personal relationships and contacts, competitive market selection often depends on the form of those relationships, their density and their configuration. Downward effects may also be evident in entrepreneurial processes. We also know, for example, that some regional contexts ('milieux') are much more conducive than others to

the creation of new firms and start-ups though their greater availability of parent firms, supporting organisations, business angel networks and specialist financial firms. Thus the relational patterns that exist within a region may be more supportive of the amplifying feedbacks surrounding the start-up of a company.

As a consequence of such processes the industrial structure of a regional economy or cluster, and the external economies associated with that structure, *co-evolve*. The recursive nature of this process involves the two key features that Deacon suggests define third order emergent systems, namely memory, or path dependence, and selection. Memory, or path dependence, effects occur through several mechanisms and across scales (firm, cluster, and external environment). Firm properties shape cluster properties which in turn shape subsequent firm properties. At the same time, the firms themselves carry over routines, practices, products and methods from one period to the next, whilst also embodying learning effects and knowledge spillovers arising from interactions with other firms in the cluster. And to the extent that the cluster firms compete or collaborate with networks of similar firms in other clusters, or embody knowledge from such competing or collaborating firms located elsewhere (the cluster's 'environment'), the cluster influences that external 'environment', which in its turn feeds back to influence local cluster firm behaviour. Further, these processes will impact differently on different firms in the cluster (since firms will differ in their adaptive capacity and resilience) such that selection effects will occur, and the population of cluster firms will change as some cease to compete, decline and disappear while new ones are created. In many ways, then, clusters would seem to embody the processes and traits that Deacon marks out as distinguishing third order evolutionary emergence.

The concept of third order emergence implies that the recursive relationships within clusters, and similar regional and local agglomerations, between lower level entities (firms) and higher-level emergent phenomena (local externalities deriving from the presence and interactions between those firms) give rise to, and are in turn shaped by, path dependence. In fact, the relationship between emergence and path dependence is an issue that requires elaboration, not least because for evolutionary economic

geographers, path dependence is held to be a fundamental feature shaping the evolution of the economic landscape: the spatial economy is a system whose outcome evolves as a consequence of its own history (Boschma and Frenken, 2006; Martin and Sunley, 2006; Martin, 2010). Many of the basic mechanisms that make for path dependence in the economy – various forms of self-reinforcing increasing returns and external and network economies – have a quintessentially local dimension in their form and operation. In this way path dependence can be seen as a process or effect that is locally contingent and locally emergent. Path dependence and the spatial form of the economic landscape are mutually constitutive: the emergence of clusters, industrial districts, regional industrial complexes, cities, and the like, are both the outcome and the source of path dependence.

Path dependence, then, can itself be viewed as an emergent property of the economic landscape, whilst at the same time acting as a key mechanism by which the characteristic spatial forms of that landscape themselves emerge. Path dependence imparts 'memory' to the evolution of the space economy. The issue, however, is how 'strong' that memory is, and what the relative roles are of low-level components (firms) and higher-level emergent forms (for example clusters). Most discussions of path dependence - both in economic geography, and more generally across the social sciences - adopt Paul David's (1985; also 2005, 2007) canonical model of path dependence as 'lock-in of outcomes by remote historical events', the idea that small, historically contingent 'accidents' or micro-level 'chance events' can have long run effects on the future path of economic technologies, organizations and institutions, and hence on spatial economic structures. This view of path dependence actually leaves little scope for on-going change and adaptation, and instead emphasises continuity – 'more of the same' - and convergence to equilibrium (stasis) (Martin, 2010). It would also seem to be close to the way in which Deacon (op cit) discusses the role of memory in third order evolutionary emergence, namely that

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

> prior state of the whole, but also with respect to their own remembered past states (Deacon, 2006, pp. 137-137; emphasis added)

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

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

These twin processes can be observed in cities, clusters, industrial agglomerations and the like. Such spatial forms consist of constantly changing populations of firms and agents, so that some degree of incremental change and adaptation is almost always present. In the cluster example outlined briefly above, for example, changes in the population of firms that

make up the cluster - the appearance of new firms, the disappearance of others, and the product, market and technological re-orientation of still others - alter the composition of the cluster as a whole, and hence its higher level properties, such as externalities, and the nature of the 'downward causation' effects from the cluster back on the firms on which it is supervenient. This ongoing process involves memory, and is path dependent; but it need not involve any 'lock-in' to an equilibrium state or form (Martin, 2010). To be sure, there may be an asymmetry in the supervenience-downward causation relationship, in that it might require considerable change amongst the firms making up a cluster before higher-level emergent features – such as cluster externalities – change significantly. Or, on the other hand, those externalities may change so slowly that they may hinder change and adaptation amongst the firms making up the cluster, possibly leading to their loss of competitiveness and even decline. And there is now research emerging to suggest that agglomeration and localisation economies may exhibit 'life-cycles', and evolve through a phase of increasing returns effects and then eventually giving way to diminishing returns effects (Potter and Watts, 2010)

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

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

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

6. Conclusions

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

The concept of third order emergence is important as it implies that evolutionary economic geography requires a less reductionist understanding of how economic evolution operates. While there have been recent developments in evolutionary economic geography that pay more attention to the co-evolution of firms, institutions and their spatial contexts (see some of the contributions to Boschma and Martin, 2010, for example), evolutionary approaches have remained too infused by reductionism to adequately

incorporate the significance of emergence. Third order emergence suggests that self-organization and evolutionary selection constitute each other and thus it emphasises that we need a more interactive and multi-scale understanding of how economic evolution operates. At the same time, we have concluded that the biological origins of the notion of third-order emergence mean that it requires further elaboration within a socio-economic context in order to provide much insight into what has been called relational emergence. Emergence in economic evolution is far more relationship-driven than is suggested by many theories based solely on self-organization. Despite its limitations, however, the notion of third order emergence is a potentially valuable organizing concept in economic geography. It provides a framework for exploring how it is that the spatial forms of the economy- clusters, regions, firm networks and so on – are recursively related to economic action. It supplies the basis for a conceptualisation of the ways in which place and other spatial contexts are integral to economic change and evolution. Of course, the high level of abstraction of the various metaphorical notions of emergence means that they do not explain the social processes and interactions through which economic emergence occurs in different ways in different contexts. The strongest test of an 'emergence perspective' in studying the economic landscape will be whether the perspective itself proves to be generative and encourages research into the detailed processes and specific effects that produce these differences.

References

Ablowitz, R. (1939) The Theory of Emergence, *Philosophy of Science, 16,* pp. 1-16.

Alexander, S. (1920) *Space, Time and Deity*, New York: The Humanities Press

Archer, M. (1995) *Realist Social Theory: The Morphogenetic Approach*, Cambridge: Cambridge University Press.

Arthur, W.B., Ermoliev, Y.M. and Kaniovski, Y. (1994) Path Dependent Processes and the Emergence of Macrostructure, in Arthur, W.B. *Increasing Returns and Path Dependence in the Economy*, Ann Arbor: University of Michigan Press, pp. 33-48

Asheim, B., Cooke, P. and Martin, R.L. (Eds) *Clusters and Regional Development: Critical Reflections and Explorations*, London: Routledge.

Baldwin, R., Forslid, R., Martin, P., Ottaviano, G. and Robert-Nicoud, F. (2003) *Economic Geography and Public Policy*, Princeton, NJ: Princeton University Press.

Beinhocker, E.D. (2006) *The Origin of Wealth: Evolution, Complexity and the Radical Remaking of Economics*, London: Random House.

Bickhard, Mark H. (2000) 'Emergence' in P.B Andersen, C. Emmeche, N.O. Finnermann, and Christiansen, P.V. (Eds) *Downward Causation*, Aarhus: University of Aarhus Press, pp. 322-348.

Blitz, David (1992) *Emergent Evolution: Qualitative Novelty and the Levels of Reality*, Dordrecht: Kluwer Academic Publishers.

Boschma, R. and Frenken, K. (2006) Why is Economic Geography not an Evolutionary Science? *Journal of Economic Geography* 6, pp. 273–302.

Boschma, R. and Martin, R. (2007) Editorial: Constructing an Evolutionary Economic Geography, *Journal of Economic Geography 7*: 537-548.

Boschma, R. and Martin, R.L. (Eds) (2010) *Handbook of Evolutionary Economic Geography*, Chichester: Edward Elgar.

Boschma, R. and Iammarino, S. (2009) Related variety, trade linkages and regional growth in Italy, *Economic Geography 85*, 3, pp. 289-311.

Breschi, S. and Malerba, F. (Eds) (2005) *Clusters, Networks and Innovation*, Oxford: Oxford University Press.

Combes, P.-P., Mayer, T. and Thisse, J.-F. (2008) *Economic Geography: The Integration of Regions and Nations*, Princeton, NJ: Princeton University Press.

David, P. (1985) Clio and the Economics of QWERTY, *American Economic Review* 75, pp. 332–37.

David, P. (2005) Path Dependence in Economic Processes: Implications for Policy Analysis in Dynamical Systems Contexts, in Dopfer, K. (Ed) *The Evolutionary Foundations of Economics*, Cambridge, U.K.: Cambridge University Press, pp. 151–94.

David, P. (2007) Path Dependence and Historical Social Science: An Introductory Lecture. Paper presented at the Symposium on TwentyYears of Path Dependence and Qwerty-Effects, RussianUniversity–Higher School of Economics,Moscow,13 May 2005. SIEPR Policy Paper No. 04-022.

Deacon, T. (1997) *The Symbolic Species: The Co-evolution of Language and the Human Brain*. London, Penguin.

Deacon, T. (2003) The Hierarchic Logic of Emergence: Untangling the Interdependence of Evolution and Self-Organization', in B. Weber and D. Depew (Eds.) *Evolution and Learning: The Baldwin Effect Reconsidered* (Cambridge, MA: MIT Press), pp. 273–308.

Deacon, T. W. (2006) Emergence: The Hole at the Wheel's Hub, Chapter 5 in Clayton, P. and Davies, P. (Eds) *The Re-Emergence of Emergence*, Oxford: Oxford University Press.

De Hahn, J. (2007) How Emergence Arises, *Ecological Complexity, 3*, pp. 293-301.

Dopfer, K. and Potts, J. (2004) Evolutionary realism: a new ontology for economics, *Journal of Economic Methodology 11*: 195-212.

Clayton, P. and Davies, P. (Eds) (2006) *The Re-Emergence of Emergence*, Oxford: Oxford University Press.

Elder-Vass, D. (2010) *The Causal Power of Social Structures: Emergence, Structure and Agency*, Cambridge: Cambridge University Press.

Endler, J. A., and McLellan, T. (1988) The Process of Evolution: Towards a New Synthesis. *Annual Review of Ecological Systematics* 19, pp.395–421.

Fujita, M., Venables, A. and Krugman, P. (1999) *The Spatial Economy: Cities, Regions and International Trade*, Cambridge, MA: MIT Press.

Fujita, M. and Thisse, J. (2002) *Economics of Agglomeration: Cities, Industrial Location and Regional Growth*, Cambridge: Cambridge University Press.

Garretsen, H. and Martin, R.L. (2010) Rethinking (New) Economic Geography Models: Taking Geography and History More Seriously, *Spatial Economic Analysis, 5*, p. 127-160.

Giddens, A. (1984) *The Constitution of Society: Outline of the Theory of Structuration*, Berkeley: University of California Press.

Glückler, J. (2007) Geography of Reputation: the City as Locus of Business Opportunity, *Regional Studies 41, 4*, 949-961.

Goodenough, U. and Deacon, T. (2003) From Biology to Consciousness to Morality, *Zygon 38*: 801- 819.

Halley, J.D. and Winkler, D.A. (200?) Classification of Emergence and Its Relation to Self Organisation, Mimeo, CSIRO Molecular and Health Technologies Private Bag 10, Clayton South MDC 3169, Australia.

Heard, D. (2005) A New Problem for Ontological Emergence, *The Philosophical Quarterly*,

Holland, J. (1998) *Emergence: From Chaos to Order*, Oxford: Oxford University Press.

Hulswit, M. (2006) How Causal is Downward Causation? *Journal for General Philosophy of Science, 36*, pp. 261-287.

Humphreys, P. (1996) Aspects of Emergence, *Philosophical Topics*, *24*, pp. 53-70.

Kim, J. (2006) Emergence: Core Ideas and Issues, *Synthese*, *151*, pp. 347-354.

Krugman, P. (1996) *The Self-Organising Economy*, Oxford: Blackwell.

Krugman, P. (2005) Second Winds for Industrial Regions? In Coyle, D., Alexander, W. and Ashcroft, B. (Eds) *New Wealth for Old Regions*, Princeton, New Jersey: Princeton University Press.

Lawson, T. (2003) *Reorienting Economics*, London: Routledge.

Lawson, T. (2010) Ontology and the Study of Society: Emergence, Social Organisation and Social Relations, *Mimeo*, Faculty of Economics, University of Cambridge, July, 2010.

Lovejoy, A.O. (1926) The Meaning of Emergence and its Modes, *Proceedings of the Sixth International Congress of Philosophy*. London: Longmans, Green and Co., pp.20-33.

Malmberg, A. and Maskell, P. (1999) Localized Learning and Industrial Competitiveness, *Cambridge Journal of Economics 23*, 2, pp. 167-185.

Malmberg, A. and Maskell, P. (2006) Localized Learning Revisited, *Growth and Change 37*, 1, pp. 1-18.

Markusen, A. (1996) Sticky Places in Slippery Space: A Typology of Industrial Districts, *Economic Geography, 72*, pp. 293-313.

Martin, R.L. (1999) The New 'Geographical Turn' in Economics: Some Critical Reflection, *Cambridge Journal of Economics, 23*, pp. 65-91.

Martin, R.L. (2010) Roepke Lecture in Economic Geography - Rethinking Regional Path Dependence: Beyond Lock-in to Evolution, *Economic Geography, 86,* pp. 1-27.

Martin, R.L. (2011) The New Economic Geography: Credible Models of the Economic Landscape? In Lee, R., Leyshon, A., McDowell, L. and Sunley, P. (Eds) *The Sage Handbook of Economic Geography*, London: Sage, pp. 53-72.

Martin, R.L. and Sunley, P. (2003) Deconstructing Clusters: Chaotic Concept or Policy Panacea? *Journal of Economic Geography, 3*, pp. 5-36.

Martin, R.L. and Sunley, P. (2006) Path Dependence and Regional Economic evolution, *Journal of Economic Geography, 6*, pp. 395-438.

Martin, R.L. and Sunley, P.J. (2007) Complexity Thinking and Evolutionary Economic Geography, *Journal of Economic Geography, 7*, pp. 573-602.

Martin, R.L. and Sunley, P.J. (2011) Conceptualising Cluster Evolution: Beyond the Life Cycle Model? Paper submitted to *Regional Studies*.

Massey, D. (1992) Politics and Space/Time, *New Left Review, 196*, pp. 65-84.

Mazzocchi, F. (2008) Complexity in Biology, *European Molecular Biology Organisation Reports, 9, 1*, pp. 10-14.

Morgan, C.L. (1923) *Emergent Evolution*, London: Williams and Norgate.

O'Connor, T. (1994) Emergent Properties, *American Philosophical Quarterly, 31* pp. 91-104.

Porter, M.E. (1998) *On Competition*, New York: Free Press.

Potter, A.J. and Watts, H.D. (2010) Evolutionary Agglomeration Theory: Knowledge Transfers, Increasing Returns and the Industry Life-cycle, *Journal of Economic Geography 11*, pp. 417-455.

Potts, J. (2000) *The New Evolutionary Microeconomics*, Chichester: Edward Elgar.

Pepper, S. (1926) Emergence, *Journal of Philosophy, 23*, pp. 241-245.

Sawyer, R.K. (2001) Emergence in Sociology: Contemporary Philosophy of Mind and Some Implications for Sociological Theory, *American Journal of Sociology*, 107, pp. 551-585.

Sawyer, R.K. (2005) *Social Emergence: Societies as Complex Adaptive Systems*, Cambridge: Cambridge University Press.

Sayer, A. (2010) Reductionism in Social Science. In R.E.Lee (Ed) *Questioning Nineteenth Century Assumptions About Knowledge, II: Reductionism*, Albany: State University of New II: Reductionism, Albany: State University of New York Press, pp. 5-39.

Schelling, T. C. (1971) Dynamic Models of Segregation, *Journal of Mathematical Sociology, 1*, pp. 143-186.

Schelling, T. C. (1978) *Micromotives and Macrobehaviour*, New York: W.W. Norton.

Searle, J.R. (1992) *The Rediscovery of Mind*, Cambridge, Mass: MIT Press.

Setterfield, M. (2010) Hysteresis*, Working Paper 10-04*, Department of Economics, Trinity College, Hartford, Connecticut .

Sperry, R.W. (1986) Macro- versus Micro-determinism, *Philosophy of Science, 53*, pp.

Stephan, A. (1992) Emergence - A Systematic View On Its Historical Aspects, in Beckermann, A., Flohr, H., and Kim, J. (Eds.) *Emergence or Reduction?* Berlin: Walter de Gruyter, pp.25-47.

Stephan, A. (2002) Emergentism, Irreducibility and Downward Causation, *Grazer Philophische Studien, 65*, pp. 77-93.

Storper, M. (2009) Roepke Lecture in Economic Geography - Regional Context and Global Trade, *Economic Geography*, 85, pp. 1-21.

Sunley, P. Pinch, S. and Reimer, S. (2011) Design Capital: Practice and Situated Learning in London Design Agencies, *Transactions Institute of British Geographers 36,3*, pp. 377-392.

Sugden, R. (1989) Spontaneous Order, *Journal of Economic Perspectives, 3*, pp. 89-97.

Weber, B.H. and Deacon, T.W. (2000) Thermodynamic Cycles, Developmental Systems, and Emergence, *Cybernetics and Human Knowing 7*, pp. 21-43.

Welshon, R. (2002) Emergence, Supervenience and Realization, *Philosophical Studies, 108*, pp. 39-51.