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Competitive selection, self-organisation and Joseph A. Schumpeter

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Abstract. Post-Schumpeterians have tended to use biological analogies to understand economic evolution, in contrast to Schumpeter himself. In this paper it is argued that the biological analogies used tend to be outdated and that Schumpeter espoused an intuitive understanding of the evolutionary economic process that is closely related to modern conceptions of self-organisation, suitably adapted for application in socioeconomic systems. Using a self-organisation approach, competition can be understood without recourse to biological analogy, in terms of general systemic principles that operate in the presence of variety. Viewing economic evolution in terms of complex adaptation in self-organising systems yields nonequilibrium and nonlinear perspectives that parallel Schumpeter's own intuitions, reinvigorating them as the basis of evolutionary economic thinking in the new Millennium.

Key words: Joseph A. Schumpeter – Self-organisation – Competition – Selection – Evolutionary economics – Biological analogy – Nonequilibrium process – Nonlinear discontinuity

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1 Introduction

It is well known that Joseph Schumpeter did not believe that biological analogies were of much use in understanding economic evolution. Yet, following the lead of Nelson and Winter (1982), many post-Schumpeterian evolutionary economists have tended to rely upon the biological analogy of natural selection, either of a Darwinian or Lamarkian type. In this paper, this contradictory aspect of post-Schumpeterian evolutionary economics will be examined and Schumpeter's evolutionary thinking will then be re-assessed within an alternative self-organisational perspective provided in Foster (1997). It is argued that such a perspective clarifies and revitalises Schumpeter's insights, ensuring that they will continue to provide the main inspiration for evolutionary economics in the new Millennium.

Already, some post-Schumpeterians have begun to disengage themselves from biological analogies. For example, Metcalfe (1998) carefully considers Nelson and Winter's (1982) suggestion that the approach to natural selection offered by the biologist, Ronald A. Fisher, can provide a formal basis for dealing with evolutionary processes in economic systems. Metcalfe (1998) agrees with them but then argues that the statistical mechanics employed by Fisher are, in fact, quite general in their application to any kind of evolving system. Thus, what can be viewed as a 'principle of competitive selection' in the presence of variety does not involve a biological analogy at all. Rather, it is a general principle that operates in both the economic and biological domains in different ways. For example, Metcalfe stresses the greater importance of the storage and dissemination of knowledge in the economic case. Having abandoned biological analogy in favour of what is, in essence, a general systems approach, he argues that there is a correspondence between his competitive selection model of economic evolution, and the intuitions of Joseph Schumpeter.

Metcalfe (1998) builds upon the neglected insights of Steindl (1952) and Downie (1958) and makes a highly significant contribution not only to evolutionary economics, but also to economics in general. His formal and clear redefinition of the concept of equilibrium and his vivid depiction of competition as a process that eliminates variety offers one of the most coherent challenges to mainstream competitive thinking in recent years (see Foster, 1998). However, in this paper, it is argued that, although he has provided an essential building block, he does not offer a complete theory of economic evolution – what is lacking is Schumpeter's emphasis upon novelty and the generation of new variety. It is suggested here that processes of competitive selection must be set within in a more general self-organisation approach to economic evolution, as discussed in Foster (1997) and Foster and Wild (1998, 1999), before it can be integrated with Schumpeter's fundamental insights concerning economic evolution.

It is not the intention here to re-iterate in any detail what is meant by 'economic' self-organisation but, instead, to make two main points. First, it is argued that evolutionary biology, the source of selectionist analogies in evolutionary economics, is itself embracing self-organisation as an important part of the evolutionary process. Thus, those engaging in analogous thinking must consider the implications of this for their own evolutionary economic theorising. Second, it is argued that Schumpeter's vision of economic evolution offered intuitions and insights, which are highly compatible with a specifically 'economic' self-organisation approach. In particular, his juxtaposition of equilibrium and nonequilibrium depictions of processes, which has puzzled some economists for decades, is found to be consistent with a modern self-organisational perspective on the behaviour of evolving systems. Thus, it is concluded that Schumpeter offered a much better analytical foundation for understanding economic evolution than biological analogies concerning natural selection.

In Section 2, contemporary thinking in evolutionary biology will be briefly reviewed to evaluate the relevance and usefulness of biological analogies favoured by many evolutionary economists. In Section 3, Schumpeter's writings are examined to compare and contrast his vision of economic evolution with that of contemporary evolutionary biologists. Parallels are drawn between his non-biological representation of economic evolution and recent attempts to understand such evolution using a self-organisation approach. Section 4 contains some concluding remarks concerning the integration of the principle of competitive selection within a self-organisation approach to economic evolution.

2 Contemporary thinking in evolutionary economics

It is a daunting task for an economist to unravel the debates in evolutionary biology and the extent to which they should is questionable. However, economic and biological ideas have been inextricably linked for at least two centuries and it is clear that an understanding of contemporary currents in biological thinking can enlighten us as to what evolutionary economics might come to mean in the future. A good place to start is the work of Ronald A. Fisher, who revitalised a flagging Darwinian research program in the early twentieth century. Building upon Mendel's genetic insights, Fisher (1930) argued that Darwin's conclusions could be deduced from statistical mechanics by choosing the gene, rather than the individual, as the unit of selection. In so doing, the analogy used was Boltzmann's statistical mechanics representation of thermodynamic processes. Given time, any gene variety would be resolved to the most probable state of gene homogeneity. Thus, he saw fitness as maximised in the same way that entropy is maximised in Boltzmann's thermodynamic model. Crucially, Fisher redefined equilibrium from a Newtonian balance of forces to a Boltzmannian state where all structural change ceases. By focussing upon the statistical outcome of genetic interactions, the human analogies used by Darwin became unnecessary. In particular, Malthus' 'balance of moral forces' in the face of universal scarcity and associated survival struggles between individuals were exorcised from Darwinism. In their stead was a consistent treatment of two opposing universal tendencies, evolution and entropy, drawing upon the same type of statistical mechanics and the same, non-Newtonian conception of equilibrium.

This new 'Hardy-Weinberg' equilibrium was offered to biologists at the same time as the physical analogy of a Newtonian balance of competing forces equilibrium was just beginning to hold sway in economics. So, just as economics shifted towards deterministic theorising about stable Newtonian equilibrium outcomes, evolutionary biology became a matter of statistical mechanics. Variety, yielded by random mutation, is resolved by natural selection in a relative and probabilistic manner: 'appropriate' genetic mutations grow faster in numbers than 'inappropriate' ones, leading to the ascendancy of the former. Natural selection, envisaged as a product of small changes in a vast number of genes, ceased to be seen as a product of conditions of scarcity but rather something going on at all times. Genes do not compete in any direct sense but rather form new localised combinations that grow at differential rates. The relative growth of genomes through the relative reproductive success of individuals, rather than the Malthusian struggle for survival, became the heart of evolutionary biology.

So, while Joseph Schumpeter studiously avoided analogies with dangerous Darwinian ideas, Darwinism was re-inventing itself. However, evolutionary biology did not become a branch of statistical mechanics as, to a large degree, thermodynamics had done, nor did it become part of genetics. To the contrary, Darwinists were reluctant to abandon their traditional type of theorising and soon discovered that they had to retain the Newtonian conception of equilibrium to continue to engage reductionist forms of deduction, now at the level of the gene, rather than the individual organism. Despite the fact that Fisher's statistical theory is concerned with averages and probable macrostates, deductions concerning microstates were favoured and human behaviour analogies remained popular.

By the 1970s, Dawkins (1976) offered the most extreme example in his 'selfish' gene conception and, in parallel, game theorists, such as Maynard Smith (1983), modelled individual behaviour at the level of the gene as more rationally 'human' than the humans that they inhabit and constitute. Of course, no one believed that genes actually exhibited sophisticated behaviour – the "watchmaker" is always blind – the outcome of Fisher's statistical process was viewed 'as if' strategic, optimising behaviour had occurred. Of course, 'as if' assumptions are analogies. Two are involved: first, random statistical behaviour yields an outcome as if a human being had been engaged in solving an optimisation problem and, second, a thermodynamical type of equilibrium state is treated as if it is a Newtonian equilibrium, i.e., a balance of forces.

For an economist, the invocation of such 'as if' assumptions has a familiar ring and, by the 1980s, we began to observe strong parallels between the analytics used by neoclassical economists and neo-Darwinian evolutionary biologists. Both dealt with equilibrium outcomes rather than processes; both used a characterisation of equilibrium that is not of the thermodynamic type; both applied game theoretics to examine the existence and stability of equilibrium states. The neoclassical economist saw optimisation models as justified by the presumed existence of competitive selection processes, following Alchian (1950) and Friedman (1953), rather than anything akin to the genetic evidence available in biology. By the end of the 1980s, the Nash equilibrium and the associated 'evolutionary stable strategy' had become shared conceptualisations in both neoclassical economics and neo-Darwinian biology. Neo-Darwinians had shown great reluctance to abandon human analogies and, ultimately, they developed a body of theory using analogies, not related to actual human behaviour but to human *idealisations* concerning optimisation and ultra-rationality.

To what extent does neo-Darwinism of this type conform to Fisher's depiction of natural selection? The answer is 'not much' because evolutionary game theorists refer to analytical states of equilibrium whereas Fisher's equilibrium is a steady state with historical meaning, just as thermodynamic equilibrium is a definite outcome of a historical process. Neo-Darwinians, with some notable exceptions (see Depew and Weber, 1995), were, unlike Fisher, uninterested in thermodynamic processes or statistical mechanics. Fisher had been intent upon providing an approach that he regarded as true to Darwin's fundamental insights, but his Mendellian focus upon genes was, initially, rejected by many Darwinists. Acceptance that competitive struggle between individual organisms in conditions of scarcity is not the sole source of evolutionary change and that gene combinations create the variety upon which natural selection works, threatened to move evolutionary biology away from botanists and zoologists to geneticists in a different scientific tradition.

The notion that the outcome of a Fisherian genetic selection process is analogous to an equilibrium solution of an optimisation problem did not fit well with the genetic evidence. Dobzansky (1951) argued that organisms store large amounts of variation and, thus, it is difficult to argue that natural selection is responsible for maintaining it. Thus, accumulations of genetic combinations occur that are not the outcome of natural selection, breaking the tenuous link from natural selection to variation. Roughly a decade later, the revolution in molecular genetics, initiated by Crick and Watson, struck another body blow to neo-Darwinism, since DNA variations were found to arise from mutation and recombination. Another decade on, Jacob and Monod (1961) demonstrated that much of the order that emerges in the genome is the result of the self-organising properties of large genetic arrays. By the 1990s, the genetic evidence against neo-Darwinian explanations had cumulated to such an extent that strong objections by respected biologists became common (see, for example, Swenson, 1991; Fontana et al., 1994).

Depew and Weber (1995) argue that the emergence of serious objections to exclusively natural selection views of evolution through the 1980s, in effect, allowed developmentalist thinking to make a comeback in evolutionary biology. It bore little relation to earlier developmentalist traditions, since it was based upon the self-organisation approach to the emergence of organised complexity in systems. This approach, in turn, had its roots in non-equilibrium thermodynamical thinking and, thus, is consistent, in an ontological sense, with the original Fisherian approach – both apply similar statistical mechanics to processes of structural change. However, the self-organisational approach to biological evolution was not new (see, for example, Prigogine and Waime, 1946) but generally ignored in the neo-Darwinian surge to capture and defend the theoretical high ground in evolutionary biology. When Brooks and Wiley (1986) built upon Prigogine's self-organisation approach to provide a different vision of biological self-organisation, dealing with information, as well as energy stocks and flows, neo-Darwinian opposition was strong, as it had always been against all forms of 'developmentalism'.

However, by the early 1990s, neo-Darwinists became more accustomed to the idea that some kind of self-organisation operates in biological evolution, in addition to the selective force of natural selection. Thus, when Salthe (1993) and Kauffmann (1993), in their different ways, made strong and controversial cases that evolution has to be thought of in terms of both self-organisation and natural selection, they were no longer dismissed out of hand. Salthe (1993) argued that the traditional distinction between development and evolution becomes blurred once we set both in the context of self-organisation. Kauffmann (1993) is less radical, seeing natural selection as still pivotal, maintaining complex, self-organised genetic systems within a range between freedom and fixity, making it possible for evolution to take place. However, in so doing, he demotes competitive selection to the status of a boundary phenomenon "that is constantly pushing emergent, self-organising systems towards the edge of chaos" (Kauffman, 1993). By the mid-1990s, self-organisation had become an accepted part of the ongoing debates concerning evolutionary biology, with neo-Darwinians exploring ways in which it could be incorporated into their theoretical representations of natural selection. Depew and Weber (1995) review the various approaches now being explored to combine self-organisation and natural selection in evolutionary biology.

For two centuries, the scientific authority of Newtonian thinking about systems has come from its analogous association with the observable functioning of physical systems. In the same way, the scientific credibility of the self-organisation approach, like the competitive selection approach of Fisher, comes from the fact that it is built up from observable thermodynamic principles. In turn, thermodynamics came from inquiries into the properties of machines engineered using Newtonian scientific principles. Thus, Fisher sought to strengthen Darwinism by basing it upon a thermodynamical analogy concerning change and equilibrium in closed systems. Over a decade later, the self-organisation approach was born when thermodynamicists began to deal with *open* systems maintaining themselves far from thermodynamic equilibrium through the ingestion of free energy. Biologists have come to understand that self-organisation is more than just an energetic process in the biological domain, it involves the acquisition and processing of information that yields the novelty and variety upon which competitive selection operates.

Increasingly, the process of self-organisation in biology is being viewed through the lens of nonlinear dynamics which, in one sense, confirms Salthe's claim that development and evolution are overlapping *historical* processes but, in another sense, suggests that they are *analytically* separable as distinct phases of self-organisation:

Functionality in general (and hence development) derives from the property of equifinality, or many-to-one mapping, possessed by all nonlinear oscillators, while adaptability in general (and hence evolution) arises from the dynamical property of one-to-many mapping, or bifurcation. Functionality and adaptability are the two faces of all living things, and nonlinear dynamics captures this dual property of organisms in a simple and natural way... Thus, both functionality and adaptability can be encompassed by one and the same mathematical model. One could not ask for a more elegant unification of the two complementary facets of the evolutionary process. (Barham, 1995, pp. 290–291)

Thus, a formal, mathematical representation of the growth and oscillatory characteristics, associated with the process self-organisation, has begun to spread into evolutionary biology, merging with, and reinforcing, an established non-linear mathematical tradition in population ecology. By relaxing the concept of an equilibrium from a point to a curve or a region, mathematics ceases to be used to deduce point equilibrium outcomes but, instead, it is used to represent the non-linear dynamics of processes. There is an on-going debate in evolutionary biology concerning the adequacy of mathematics to represent evolutionary processes that will not be discussed here, except to say that similar questions will be discussed below in the context of economic evolution.

An alternative approach to biological self-organisation that has come to prominence is to see species as keeping themselves away from the point of Fisherian equilibrium by engaging in the cultural transmission of beneficial practices, acquired through individual organisms interacting with their environment. Restrictions on energetic and material intake, of the type that are viewed as leading to genetic selection, can be neutralised. Thus, cultural groupings can slow the resolution of genetic variety by introducing and consolidating behavioural novelty – the kind of biological self-organisation that Brooks and Wiley (1986) speculated upon a decade earlier. Such cultural groupings remain 'far from Fisherian equilibrium' through the acquisition of new information and the exploitation of attendant new energy sources, leading to genetic inertia and non-linear phases of genetic selection between distinctive groups, if and when exploitable information runs out. It follows that the expansion of organised complexity of culture in a highly developed species, such as our own, diminishes the impact of natural selection on its genetic make-up and increases its ability to pressure other species at a lower level of cultural development. Again, it is inappropriate here to pursue this new theme in evolutionary biology. However, Heyes and Galef (1996) provide a good starting point, Alexander (1987) made the contribution that got the ball rolling and Novak and Sigmund (1998) provide a very recent example of the kind of analytic support now being offered, using conventional simulations of strategic behaviour.

Enough has now been said here to establish that many biologists have come to accept that self-organisation is an important aspect of biological evolution and the debate is now concerned with ways of best representing such processes, both theoretically and empirically. Turning our attention back to economics, it is clear that Darwinian and Lamarkian natural selection analogies, so often favoured by neo-Schumpeterian evolutionary economists, are founded upon ideas that are fast becoming obsolete. Bearing in mind the emergence of the view amongst many biologists that cultural self-organisation is important, there is little doubt that economic evolution should also contain powerful self-organisational tendencies.

Depew and Weber (1995) conclude their book with a strong warning to all social scientists that ignore contemporary currents in evolutionary biology and persist in relying only upon natural selection analogies:

These reflections suggest that it should be at least a mild constraint on any evolutionary theory that claims to explain human phenomena that it should throw light on, rather than eliminate or reduce away, the interactional, relational, intentional, and symbolic features that interpretative social scientists have already discovered about social reality. Perhaps it is not too much to say that what we need is an evolutionary theory worthy of the best social theory, not a social theory trimmed to fit a rapidly receding, overly simplistic evolutionary theory. (Depew and Weber, 1995, p. 495)

What is striking about this quote is that one could imagine that it came from the writings of Joseph Schumpeter half a century ago. Could it also be the case that, in some intuitive way, he had come to understand the self-organisational character of evolutionary processes, in an economic setting, even before processes of self-organisation had become recognised in physics, chemistry and biology?

3 Schumpeter revisited

Did Schumpeter espouse Darwinian biological analogy concerning natural selection? Hodgson (1993) argues that he did not and, further, that his use of general equilibrium ideas, combined with the absence of an explicit biological analogy concerning natural selection, implies that he was not really dealing with economic evolution but, rather, economic development. In effect, Hodgson (1993) suggests that Schumpeter dealt only with the functional/developmental process, which Barham (1995) alludes to, in his discussions of biological evolution. However, it will be argued below that it is incorrect to characterise Schumpeter's representation of economic evolution as an equilibrating developmental process. Hodgson (1993) misunderstands Schumpeter's use of equilibrium/disequilibrium terminology and confuses it with later post-Schumpeterian and neo-Austrian characterisations of economic evolution. Consider, for example, Kirzner's (1973) discussion of the entrepreneur:

For Schumpeter the entrepreneur is the disruptive, disequilibrating force that dislodges the market from the somnolence of equilibrium; for us the entrepreneur is the equilibrating force whose activity responds to the existing tensions and provides those corrections for which the unexploited opportunities have been crying out. (Kirzner, 1973, p. 127)

Schumpeter, like other innovative economic thinkers in his time, such as F. von Hayek and J.M. Keynes, felt obliged to start his analysis in familiar economic theory, to show the radical nature of his insights. General equilibrium is, therefore, only a pedagogic starting point, not an analytical end point, in his depiction of economic evolution. Furthermore, Hodgson (1993) conveys the impression that Schumpeter dealt mainly with the role of technological innovation in the business cycle and, thus, had a narrower view of economic evolution than American institutionalists, such as Veblen (1898). In point of fact Schumpeter stressed that economic development is due to *organisational*, not simply technical, change or, in his words, "new combinations":

Development in our sense is... carrying out of new combinations, (Schumpeter, 1934, p. 66)

This type of development was viewed as endogenous to the economic system and, thus, could not be described by general disequilibrium:

By "development" therefore, we shall understand only such changes in economic life as are not forced upon it from without but arise by its own initiative from within. (Schumpeter, 1934, p. 63)
He was also very careful not to confuse development with conventional notions of economic growth:

... development consists primarily in employing existing resources in a different ways, in doing new things with them, irrespective of whether those resources increase or not. (Schumpeter, 1934, p. 68)

It is clear that the developmental processes that he discusses are concerned with organisational change at several levels and these are orchestrated by entrepreneurship, which is a behavioural attribute that only has meaning in organisational contexts:

Everyone is an entrepreneur only when he actually "carries our new combinations" and loses that character as soon as he has built up his business, when he settles down to running it as other people run their businesses. (Schumpeter, 1934, p. 78)

The entrepreneurial desire to discover new and profitable organisational combinations provides what we can now label as a self-organisational impetus within the economic system, creating organised complexity. "Combination" implies, not competition, but the deliberate formation and re-formation of cooperating groups engaged in production. The result is expanding variety in products and processes. Thus, although, Hodgson (1993) is correct in questioning the widespread belief that Schumpeter used a biological analogy concerning natural selection, he misses Schumpeter's unique contribution to evolutionary economics: a preoccupation with organisational change and an associated abandonment of the conventional Newtonian conception of the equilibrium/disequilibrium dichotomy.

Just as the Newtonian equilibrium analogy was taking over in economics, Schumpeter, like Fisher in biology, rejected it as an analytical device for dealing with evolutionary processes. However, Mendel and Boltzmann did not inspire Schumpeter. Instead, his self-organisational intuitions were derived from his extensive and detailed study of economic history. Furthermore, his representation of the process of evolution in the economic system was more complex and adaptive than that of Fisher. As we have seen, half a century had to elapse before biologists began to accept that the kind of complex adaptation, proposed by Schumpeter in economic settings, has a role to play in biological evolution. However, given the strength of Hodgson's (1993) attack upon the logical consistency of Schumpeter's analysis, it is necessary to return to the debate concerning Schumpeter and his use of biological analogy, to see just how misunderstood his writings have been in this regard.

Kelm (1997) versus Hodgson (1997) represents a recent instalment in this debate and it provides a useful vehicle for establishing Schumpeter's self-organisational credentials. Both miss the point that Schumpeter's discussion of concepts of equilibrium outcomes and non-equilibrium processes are fundamental in his discussion of economic evolution. Where Hodgson (1993) sees confusion, there, instead, lies remarkable self-organisational insight concerning economic evolution. Contrary to the neo-Walrasian interpretation of Hodgson (1993) echoed in Hodgson (1997), for Schumpeter, the key feature of an evolutionary economic process is, undoubtedly, the *absence* of equilibrium. He saw both economic development and economic evolution as historical processes and, as such, *nonequilibrium* in nature:

... we will not postulate the existence of states of equilibrium where none exist, but only where the system is moving towards one. When, for instance, existing states are in the act of being disturbed, say, by.... a mania of railroad building, there is very little sense in speaking of an ideal equilibrium coexisting with all that disequilibrium. It seems much more natural to say that while such a factor acts there *is no equilibrium at all*. (Schumpeter, 1939, p. 70) [Italics added]

Hodgson (1997) is generally correct in dismissing Kelm's attempt to interpret Schumpeter in Darwinian terms. However, because he does not fully appreciate the radical nature of Schumpeter's rejection of the Newtonian equilibrium construct, he does not spot a fundamental mistake, committed early in Kelm's discussion:

Since Darwinian theory is arguably the most powerful scientific theory of endogenous change, it would not be too surprising of Schumpeter's theory of economic evolution had more elements in common with it.... (Kelm, 1997, p. 107)

Despite Darwin's extensive discussion of the adapted qualities of the flora and fauna that he observed and how they might have come about because of natural selection, Darwinian theory is *not* concerned with endogenous change. It is concerned with equilibrium *outcomes* of unspecified competitive selection processes that are akin to disequilibrium dynamics, given some exogenous environmental shock that disturbs some ecological equilibrium (see Maynard Smith, 1970; Ruse, 1982). Kelm (1997) then goes on the confuse *dis*equilibrium and *non*equilibrium:

But even if such an equilibrating tendency can be assumed to exist, it is in reality constantly upset by disequilibrating forces, some which *originate from within the economic system*. (Kelm, 1997, p. 105)[Italics added]

Disequilibrium implies equilibrium and therefore, disequilibrating forces must come from without – should one come from within, then there can be no equilibrium – a nonequilibrium state must prevail. Schumpeter understood this and that is why a Darwinan analogy was not useful for his purpose.

In offering an alternative representation with features that we can now label 'self-organisational', Schumpeter had to be careful with his terminology. He chose to refer to an evolutionary process as in a disequilibrium state when discussing it from the perspective of the initial pedagogic starting point of Walrasian static equilibrium. When discussing the evolutionary process in its own right he discussed it as a nonequilibrium process. From the perspective of the analytical general equilibrium starting point, the entrepreneur constitutes an exogenous shock but from the perspective of the nonequilibrium evolutionary process, entrepreneurship is endogenous.

Schumpeter turned methodological convention, derived from physics, on its head: in the domain of economics, nonequilibrium processes of evolutionary change are the norm. Around the nonlinear historical paths, generated by such processes, there are oscillations. These are precipitated by exogenous shocks that are dissipated by homoeostatic mechanisms, resulting in equilibrating tendencies in circular flows. Schumpeter argued that economists could usefully understand these short-term equilibrating tendencies using Marshallian and Walrasian analytical tools. Thus, static economic logic can be brought to bear at any point in historical time, but is wholly unable to assist in gaining an understanding of evolutionary developments:

... "static" analysis is not only unable to predict the consequences of discontinuous changes in the traditional ways of doing things; it can neither explain the occurrence of such productive revolutions nor the phenomena, which accompany them. (Schumpeter, 1934, p. 62)

Thus, Schumpeter brought endogeneity to the centre of evolutionary analysis, not by mimicking Darwin, as Kelm (1997) suggests, but by departing, fundamentally, from Darwin's Newtonian analogy. Schumpeter stressed that the Newtonian conceptualisation of equilibrium could only be used in an analytical sense to understand systemic interconnections and the operation of homeostasis in conditions where growth is approximately linear. Thus, stationary states to which historical growth processes often tend are not equilibria in this analytical sense, but rather, states where linear equilibrium thinking begins to lose its usefulness in understanding the short-term behaviour of a system:

... we will ... recognise existence of equilibria *only at discrete points on the time scale at which the system approaches states which would, if reached, fulfil equilibrium conditions*. And since the system in practice never reaches such a state, we shall consider, instead of equilibrium points, ranges in which the system as a whole is more nearly in equilibrium than it is outside of them. (Schumpeter, 1939, p. 71)

Like Alfred Marshall before him, he saw the mechanical concept of equilibrium as a rough approximation to be used with great caution in connecting the principles of economic logic with historical facts (see Foster, 1993). Indeed, Schumpeter's view of evolutionary processes as non-linear and discontinuous *necessitates* that historical stationary states, attained after phases of economic development, are structurally unstable and, thus, lack stable equilibrating tendencies. In identifying economic evolution as a nonequilibrium process, Schumpeter summarised his conceptualisation in the following terms:

. . . hence, our position may be characterised by three corresponding pairs of opposites. First, by the opposition of two real processes: the circular flow or the tendency towards equilibrium on the one hand, a change in the channels of economic routine or a spontaneous change in the economic data arising from within the system on the other. Secondly, by the opposition of two theoretical *apparatuses*; statics and dynamics. Thirdly, by the opposition of two types of conduct, which, following reality, we can picture as two types of individuals; mere managers and entrepreneurs. (Schumpeter, 1934, p. 82)

Two connecting threads run through his three pairs of opposites. First, *circular flow – statics – managers*, deals with the repair, maintenance and incremental improvement of economic organisational structures and their products – this is the marginalist and gradualist world that preoccupied Alfred Marshall. Second, *spontaneous change – dynamics – entrepreneurs* deals with nonequilibrium processes that yield increases in organisational complexity, where "dynamics" refer to evolutionary, not simply 'developmental' processes:

. . . that kind of change arising from within the system *which displaces its equilibrium point that the new one cannot be reached form the old one by infinitesimal steps*. Add successively as many mail coaches as you please, you will never get a railway thereby. (Schumpeter, 1934, p. 64)

Entrepreneurship contributes both to the developmental process of organisational innovation and to discontinuous change when historical stationary is approached or attained.

Thus, we have a correspondence between Schumpeter's conception of evolution and that contained in the self-organisation approach. However, in dealing with economic evolution, Schumpeter clearly did not subscribe to Barham's (1995) neat and tidy nonlinear dynamic distinction between functional development and adaptive evolution. For Schumpeter, the processes of development and evolution overlap so much that they are almost interchangeable terms. Thus, if he thought, intuitively, in self-organisational terms, it is unlikely that he would have concurred with nonlinear discrete dynamic representations of the growth profiles of self-organising systems, since they do not dispense with analytical equilibrium but, rather, generalise it into points, curves and regions.

Attempting to capture nonequilibrium processes in terms of weakened concepts of equilibrium preserves the determinism of mathematics but removes its analytical power. A complex equilibrium region is of little or no help to the economist attempting to bring to bear the power of economic logic upon unfolding historical events. Predictive power is lost and the myth that logical equilibrium and historical stationary states can be connected is perpetuated. Through simulation and calibration, a nonlinear dynamic model can be made to follow a growth trajectory that looks realistic, but the mathematical mechanism employed bears no relation to the self-organisational processes executed by irreversible and dissipative structures. Employing a deterministic nonlinear dynamic mathematical model deductively is to use, in effect, a *mathematical analogy*, to attempt to understand economic evolution.

Schumpeter was clearly opposed, as Richard Goodwin often recounted, to the use of discrete, nonlinear dynamic logic to capture the growth dimension of economic evolution. Furthermore, he did not use cumulative causation, path dependence or 'lock-in' arguments to provide a rationale for dynamic mathematical representations of evolutionary processes. Despite this, some post-Schumpeterians, such as Richard Day in his many distinguished contributions, have been attracted to mathematical analogy. This has been due, in part, to the repeated empirical observation of non-linear logistic diffusion curves in the presence of innovation. Thus, the use of discrete versions of this curve has been attractive to deduce bifurcation points that mimic observed nonlinear discontinuities. Schumpeter did recognise that there exist tendencies in historical data that can be captured in mathematical form and given an empirical dimension through econometric estimation but his commitment to a nonequilibrium view of the associated evolutionary process precluded the deductive use of such discovered mathematical structure.

In Foster and Wild (1998, 1999) it is argued that an approach which is truer to Schumpeter's vision is to view logistic diffusion curves, not as deductive devices but as abstractions of historical tendencies present when economic self-organisation is occurring. The presence of a logistic growth trajectory can be confirmed or falsified using suitably transformed historical growth data, provided that short term equilibrating tendencies are allowed for by employing conventional economic logic to suggest variables for inclusion in an augmented logistic diffusion model. The likelihood of structural discontinuity is then addressed by examining the properties of the unexplained residuals as a historical stationary state is approached. Thus, Schumpeter's view that equilibrium thinking is only useful in acceptable ranges of historical experience can be given operational meaning.

Of course, econometric estimation of logistic diffusion curves is not novel and has been employed widely in studies of innovation since the seminal study of Griliches (1957). However, studies of innovation do not always appear to have been undertaken in line with Schumpeter's non-equilibrium depiction of organisational change. First, as has been pointed out, his stress on organisational change has tended to be reduced to a narrower preoccupation with technical change. Second, we see many innovation diffusion studies which, either explicitly or implicitly, associate historical stationarity at the top of a logistic curve with a state of analytical equilibrium. Development is, thus, depicted as disequilibrium, not as an emergent process with an unknown outcome. It is remarkable that such studies are often labelled as 'neo-Schumpeterian', despite the clear contradiction with Schumpeter's 'self-organisational' thinking.

4 Concluding remarks

In this paper, recent developments in evolutionary biology have been briefly reviewed and it has been concluded that the self-organisation approach is in the process of being integrated with natural selection to define a 'new' evolutionary biology. In evolutionary economics there are only limited signs of such a parallel development: old-fashioned biological analogies are still widely favoured and very little attention is given to self-organisation or the 'systems thinking' from which it is derived. It is worth noting, in this regard, that biological analogies of competitive selection have now come to be challenged strongly in the field of management science where 'ecosystem thinking' has stimulated an emerging self-organisation perspective upon business strategy (see Brandenberger and Nalebuff, 1995; Moore, 1996; Hagel and Armstrong, 1997). It is also concluded that Joseph Schumpeter's insights concerning economic evolution are highly compatible with recent attempts to develop a specifically economic variant of self-organisation. Correspondingly, much confusion is identified both amongst those who see Schumpeter as a closet Darwinian and also amongst those who seek to try to formalise economic evolution in terms of discrete dynamic nonlinear mathematics. We can expand upon these two conclusions.

First, many evolutionary economists do not appear to appreciate that the competitive biological analogies which they apply have become heavily circumscribed in evolutionary biology due to a growing acceptance that self-organisation plays a key role in evolution. The self-organisation approach has been shown to be more compatible with the findings of geneticists than the reductionist and mechanical approach of neo-Darwinists, with their reliance upon 'storytelling' by human analogy. Furthermore, the self-organisation approach and the Fisherian perspective upon competitive selection are compatible in an ontological sense, given their common roots in thinking concerning thermodynamical systems. As Metcalfe (1998) stresses, the statistical mechanics that Fisher borrowed from thermodynamics does not constitute an analogy but, rather, represents a process of resolution that must operate in the presence of variety in any kind of dissipative system. Similarly, self-organisation is not an analogy either but, rather, an enduring property of dissipative systems which manifests itself in different ways in different contexts (see Foster, 1997).

Second, it is argued that the debate as to whether Joseph Schumpeter espoused biological analogy is sterile because it is clear that he, like Alfred Marshall before him (see Foster, 1993), had an intuitive understanding of what self-organisation constitutes in the economic domain. Schumpeter, was, however, more expansive in his evolutionary economic thinking, making explicit the nonlinear character of what we would now see as a self-organisational process in the economy. Schumpeter did not accept Marshall's view that the economic system was always capable of evolving through incremental adaptation. In Schumpeter's schema, Marshall's view relates to the managerial drive to engineer efficiency-enhancing new combinations, rather than the entrepreneurial drive to discover novel combinations. Furthermore, Schumpeter's more expansive depiction of the circular flow led him to prefer a more general analytical conception of equilibrium in Walrasian terms to understand the complex interconnections involved at any point in time. It is argued that Schumpeter offered an intuitive understanding of "economic self-organisation" (see Foster, 1997) that differs in important respects from what is now understood as biological self-organisation. In particular, development and evolution are not viewed as distinct processes in the economic domain.

The idea that competitive selection and self-organisation should both feature in a neo-Schumpeterian model is not new. It was suggested in the late 1980s by, among others, Silverberg, Dosi and Orsenigo (1988). These authors combined a Fisherian model of competitive selection with a mixture of adoption, learning and imitation. Although the latter mixture is inspired by the analogy of physio-chemical self-organisation, in the respective traditions of Ilya Prigogine and Hermann Haken, organisational development is held constant in their simulations. Thus, in the end, they do not employ an economic self-organisation approach, in the sense of Schumpeter, but, rather, a more complex form of competitive selection. In choosing to represent innovation in logistic diffusion curves emerging from learning, adoption and imitation, they followed a well-tried tradition in studies of innovation. Wisely, they did not attempt to use the analogy of physio-chemical self-organisation in any direct sense. However, in so doing, they tend to understate the importance of self-organisation in economic evolution.

Just as Metcalfe (1998) has pointed out that competitive selection is a general principle with different characteristics in the domains of economics and biology, so it is true with self-organisation. Self-organisation is not a physio-chemical analogy but a general principle in systems that process energy, matter and information. Economic self-organisation is not the same as biological self-organisation, despite the fact that they share common properties. Thus, a unified neo-Schumpeterian model must deal with *economic* self-organisation and *economic* competitive selection. Such a unified approach has the potential to solve the problem that Fisherian modellers of competitive selection face in the economic domain: if variety is always changing, often because firms access new niches as they innovate, and the unit of selection changes as more organisation parallels increasing complexity, how can it be applied in real world settings? Typically, the fear of competition is itself a stimulus to innovation, thus the tendency towards a stationary state affects the stationary state itself and we have a non-equilibrium process.

What we have to accept is that, in economic systems, variety is never fixed, as Schumpeter stressed, repeatedly. Variety at the individual level leads to further new variety as individuals form into cooperative organisations. Thus, we have a process of economic self-organisation and the cumulative formation of organised complexity. For Schumpeter, those with entrepreneurial skills are instrumental in generating such variety by bringing together new techniques and/or new organisational arrangements. They, in turn, draw upon the mass of variety in knowledge and productive skills that pre-exists. The methodological difficulty that arises with Metcalfe's Fisherian model is that it is only analytically tractable if we view new variety as being exogenous, constantly revising the equilibrium outcome. If we follow Schumpeter and think of variety as being endogenously created, as a response to problems and opportunities in the system in question, then we cannot sustain an analytical equilibrium set-up. A non-equilibrium process cannot have an evolutionary equilibrium outcome that can be *deduced*.

However, the 'absence of change' definition of equilibrium used in Metcalfe (1998) is not analytical, but involves attainable historical stationary states. Difficulty arises only if we choose to proceed 'as if' such an equilibrium is analytical, in the neo-Darwinian manner. Otherwise, the Metcalfe model continues to have explanatory content – differential growth will always change market share, even though the units of selection never stay still – it is predictive content that is missing. However, if, for whatever reason, variety generation becomes insignificant, then the model will have both explanatory and predictive content, not in the sense of a tendency towards a stable *analytical* stationary state but towards a *historical* stationary state. As we learn from Schumpeter, the temporary stemming of the flow of new variety in such circumstances is precisely the reason why such stationary states are punctuated by structural discontinuities. Given the historical nature of such discontinuities, it is not to the dynamic mathematics of bifurcation that we should turn, but, instead, to a post-Schumpeterian analysis of the historical processes involved. Mueller (1997) provides a pioneering contribution in this regard.

The Schumpeterian notion that there is a continual, spontaneous generation of novelty in the socioeconomic system breaks the Darwinian causal link between selection and variety generation. When this link is cut, the competitive selection model becomes secondary in economic evolution – the primary engine of evolution is variety generation. Even in cases where organisational failure is high, such as the restaurant business (see Hannan and Freeman, 1989), novelty creation is decisive. Consumers select those restaurants with the best organisation, products and services provided by the most creative and most entrepreneurial in the business. However, the market process does not generate new variety, only opportunities to test out new novelty. It is the combination of creative skill and entrepreneurial desire to take such opportunities, often against very unfavourable odds, which creates a self-organised and vastly complex population of restaurants. Restaurants do not usually compete with each other directly simply because their products and services are heterogeneous. What they attempt to do is establish repeat trading arrangements, or even a contract, with targeted consumers. What we think of a competition in this sector is, in fact, novelty entering at a high rate. Should novelty stop entering, then the Metcalfe model tells us that competition would be eliminated in favour of the strongest and/or most efficient. Economic evolution, at least temporarily, would cease.

Before we can use a competitive selection model predictively, we need to be able to establish that conditions exist where variety is relatively constant and that other factors influencing the expansion and survival of techniques and the firms in which they are used are relatively unimportant. First of all, the competitive selection model will predict nothing when the elements of the population dealt with are entering a niche that is still open. When the niche is open, individuals will cooperate to their mutual advantage and, in so doing, may develop novel organisational links and, thus, continually alter the unit of selection. Secondly, it is when a niche limit is approached, that variety is most likely to tend towards the type of homogeneity predicted by a competitive selection model. However, even in these conditions, a process of selective competition and attendant homogenisation need not occur, simply because awareness of the possibility of competitive elimination, in itself, is a spur towards the generation of new variety and structural adaptation. It is here that we have a key feedback loop – the internalisation of selection and adaptation – that is unimportant in the biological case but one which Schumpeter came to believe was of central importance in the case of the evolution of large economic organisations.

The Metcalfe (1998) model is a considerable achievement because it offers an explanation of a crucial aspect of economic evolution and relies upon an alternative definition of equilibrium to the 'balance of forces' one preferred by most economists. However, in the natural sciences, the Boltzmann/Fisher representation of statistical mechanics has been superseded. Long ago, thermodynamics moved on from its classical to its non-equilibrium phase, to understand the self-organisational qualities of chemical and physical structural change, and biology has, more recently, begun to open up its Fisherian genetic fundamentals to provide its own distinctive conceptualisation of biological self-organisation. Thus, we should look upon the Metcalfe (1998) model as only a beginning in the quest to discover a general characterisation of economic self-organisation within which creative, cooperative and competitive processes can be analysed. To begin this quest, we need look no further than the remarkable insights of Joseph Schumpeter.

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