Financial Crisis: Market Evolution & Risk Perception

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Abstract

Financial markets are the basis of every capitalist economy as it is the platform for fair pricing of assets. Financial market evolution can be depicted by replicating Biological evolution and ecology in natural systems. When joined with the perception of financial risk a clear linkage can be shown that a sudden financial shock in one market can instantaneous ripple through markets worldwide. An example of the 2007 US sub-prime housing market crisis is used as an example.

Keywords

Financial markets, capitalist economy, biological evolution.

Introduction

The intent to write this paper is to understand the primary underlying concepts in biological evolution, ecology and complexity in biological systems and how they could be replicated in view of the development of financial markets. Further to review the concepts relating to behavioural finance and the perception of risk that explain why people sell financial assets when markets are falling or purchase assets in inflated markets creating financial bubbles. Together these two concepts of financial market evolution and financial risk perception can explain how financial shocks in one market can be easily reverberated across the world instantaneously. This paper will take the 2007 US sub-prime housing market collapse as an example.

This paper is distributed in the following sections: the next section reviews biological evolution, ecology and complexity relating it to financial market evolution, then section three discusses the concepts surrounding the perception of risk and finally, linking these two prior concepts to explain how the drop in asset prices in one market can be reverberated across markets across the world.

Biological Evolution, Ecology and Complexity

Market Evolution – Biological Evolution, Ecology and Complexity

Biological systems as the basis of life form on earth, therefore there could be a possibility that social and economic systems developed by humans may follow the same underlying concepts, rules and structures as the more complex biological systems. As, humans are biological systems themselves it is inherent that our thinking automatically encompasses these patterns of decision making that maybe implicit in biological processes. Therefore, this paper will review in this section, concepts surrounding progress in natural systems in view of biological evolution, ecology and complexity.

The basis of biological evolution and ecology primarily emphasises that new structures retain specific forms as they evolve as the growth patterns are restricted

by certain criteria of development. These patterns provide specific advantages therefore evolutionary progress takes place in this manner. Smith (1986) explains that a population of entities exists because they possess a hereditary mechanism that will evolve them through adaptations for survival. In biology, the two views that explain the hereditary mechanism are Evolution and Ecology. Evolution sees life as a continuation of ecological processes, while ecology is a snapshot of life at any particular time. Reviewing these biological views this paper discusses the evolutionary view in the section below followed by the ecological view.

Evolutionary View – Darwin's Survival of the fittest

Smith (1986) partly portrays life as a neo-Darwinist idea, where Darwin (1859) explains life as a flow towards improving biological species through competition of the survival of the fittest.

Darwin (1859) specifically mentions that organisms adapt to the environment around them in order to excel and survive through the process of evolution. Where, the stronger specifies or organisms survive, while the weaker perish. In nature, organisms survive by using the properties of multiplication, variation and heredity and states that these three properties are critical for an organism to survive in any natural environment (Darwin 1859). Smith (1986, p.6) believes that there is also a necessary connection between the factors of reproduction and adaptation in an environment that help an organism survive.

Darwin (1859) claimed that all living things on Earth are descended with modification from one or a small number of simple original forms. He further claims that the major cause of evolutionary change was natural selection, i.e. those modifications that help the evolving entities to survive and reproduce will be maintained and those that don't help will automatically perish. Darwin (1859) was willing to accept that evolutionary changes may also be brought about by other causes (such as the effects of use and disuse), the neo-Darwinist position sees natural selection as the only relevant mechanism by which evolution leads to adaptation, thus resulting in the survival of the fittest. This position does not rule out other causes of evolutionary change, but it does contend that any cause other than natural selection will result in essentially random changes.

An open ended neo-Darwinist definition of life would confirm any living entity with the properties of multiplication, variation and heredity. However, this causes a number of complications to this neo-Darwinist thinking that may not contradict the neo-Darwinist position but would at least suggest other factors to be taken into account. These factors could possibly include self-organisation and development, reproduction and symbiogenesis that are briefly described below.

Self-Organisation and Development

Although some people might accept the extreme neo-Darwinist definition of 'Survival of the Fittest', few would claim that it can give a full explanation of life on Earth. As, life is embedded in the physical world therefore the rules of physics and chemistry as well must surely impose important constraints on the biological evolutionary process.

In recent years there have been a growing number of attempts to integrate theories of self-organisation with the evolutionary theory. Kauffman (1993) argues that the laws of physics generate general principles of self-organisation that must be considered when studying the evolution of life. He says that the building blocks of life at a variety of levels from cells to organisms are precisely the robust, self-organised and emergent properties of the way the world develops around us. If selection merely moulds further the stable properties of its building blocks, the emergent order exhibited by such systems should persist in organisms (Kauffman 1993).

Other researchers argued that the developmental processes of organisms also impose significant constraints upon organismal design (for e.g. Wolpert (1993), Goodwin (1994), Raff (1997)), remembering that the nature of these constraints is subtly different to the general principles of self-organisation proposed by Kauffman and others. Developmental constraints are somewhat arbitrary with respect to underlying physical laws, but they are nevertheless real constraints for organisms employing any kind of developmental process. Waddington (1957, p.7) believes that the hereditary

differences, which arise in animals are not quite random like the differences between two heaps of bricks. They result from changes in orderly systems of development and each new variety has an order of its own, maybe less, but sometimes more complex than that of the original form from which it was developed.

Wolpert (1993) argues that the self-organisational and feedback mechanisms operating during the development of an embryo to an adult organism radically restrict the space of morphologies that evolution is free to explore. Developmental mechanisms, together with their genetic control, put a severe constraint on the evolution of animal form. It is not selective pressures that have kept the basic pattern of the vertebrate arm the same, but the fact that altering the basic pattern is almost impossible. Therefore, not all imaginable animals are possible. Any theory of evolution must incorporate an appreciation of developmental mechanisms.

There are many arguments over the relative importance of the spontaneous order inherent in the physical world of the constraints imposed by developmental processes and of natural selection in determining morphology (e.g. Smith (1986, p.43)). But, all these factors clearly have some part to play in the process. These considerations indicate that we cannot understand life purely through studying the genes, but we must also think about their interactions with the physical medium in which they are embedded. Belew and Mitchell (1996, p.14) discuss that common metaphors for the genes (e.g., programs, blueprints, etc.) as the information-carrying component in evolution rests on an inappropriate pre-formation view of information, as if information exists before it's utilised.

Another important point about evolution taking place in a medium with some inherent self-organisational properties is that although the possible forms achievable by evolution may be restricted, the instructions for making those forms that are achievable can be compactly described on the organism's genome. In other words, the genome does not have to encode information about every aspect of the adult organism's design because some features will just fall into place for free as the developmental process unfolds, due to the self-organisational properties of the constituent matter.

Reproducing

Common conceptions of life are rooted firmly in our experience of organisms being grouped into species with biological reproduction within a species and crosses between species being either infertile or impossible. With the highly dissected form of genetic information that results from the existence of different species, the possibility emerges for the specialisation of life forms into plants, animals and countless subdivisions. Without species, evolution would be a continuous divergence evolutionary novelty appearing in the genome of one individual would be passed on to its descendants, but would never spread to other lineages.

However, the existence of species and reproduction is not a universal feature of life. Margulis and Sagan (1986, p.15) argue the fact that we are descendants of that minority of organisms that are biologically reproducing that has led us to an unbalanced and unrealistic view of biological reproduction. Indeed, the existence of biological reproduction in nature is a great puzzle from a neo-Darwinian point of view. As, these reproducing organisms only pass on half of their genes to their off-springs that would appear to be at an evolutionary disadvantage to those that reproduce asexually. The question of how biological reproduction evolved and how it has been maintained in the face of apparent selection pressure constitutes major research topics of modern evolutionary biology (Smith (1986) and Margulis & Sagan (1986)). The reason for mentioning this subject here is that our common notions of life through our experience of biological life. That may include some aspects, which are not universal laws of biology. But are rather contingent features of the particular way in which life has evolved around us.

Symbiogenesis

Another complication to the neo-Darwinist picture is the fact that many species enter into close ecological relationships with other species. The general term for this is symbiosis. Unfortunately this term is used in various different ways in the biological literature. However, three distinct types of inter-species relationship are seen:

1. *Parasitism*: where one organism benefits from the relationship to the detriment of the other organism(s) involved;
2. *Commensalism*: where one organism benefits with no significant detriment or benefit to the other organism(s) and
3. *Mutualism*: where both (all) species benefit from the relationship and the intimacy of such symbiotic relationships vary considerably.

In 'ectosymbionts' the associations between organisms are purely external. Where as in 'endosymbionts' one of the organisms is actually incorporated internally into the other (the 'host'). In the extreme, it is possible that the relationship between host and endosymbiont becomes so strong that the previously independent organisms are totally dependent on each other for their survival and reproduction, and effectively become a single organism. This process that is the evolutionary origin of new morphologies and physiologies by symbiosis is called `symbiogenesis', a term coined by Merezhkovsky and subsequently developed by Kozo-Poliansky (1979). It is now widely accepted that the process of symbiogenesis played a key role in the transition from prokaryotic cells to eukaryotic cells (e.g. Margulis (1981), de Duve (1996) and Smith & Szathmáry (1995)). This has led a growing number of people to question whether symbiosis also played a key role in other major events during the evolutionary history of life (Smith 1991).

The significance of symbiogenesis with respect to neo-Darwinism is that Darwin's arguments concerning descent with modification seem to imply that evolutionary novelty comes about vertically, by mutations in the genes passed on from the parents to the offspring. In contrast, symbiogenesis is a mechanism for horizontal gene transfer, where the genetic material from essentially unrelated organisms can be brought together in a single descendant. Whether this process is considered to be consistent with neo-Darwinism is a matter of debate. If one thinks about Darwinian evolution occurring at the fundamental level of the genes, it can certainly be argued that it is consistent (e.g. Dawkins (1976), Smith (1991)). For example, Smith states that whether symbiosis constitutes a challenge to neo-Darwinism depends of course on what one understands by neo-Darwinism.

It can be interpreted to mean that mutation (change in the genetic material) is not (except occasionally and by accident) adaptive to its causative agent. Therefore, as organisms are adapted to their ways of life that adaptation must have arisen by natural selection acting on originally nonadaptive genetic variation. However, the ways in which genetic material from different ancestors is united in a single descendant has profound effects (Smith 1991, p.26). Even if we accept that symbiogenesis is consistent with neo-Darwinism, we should recognise that this particular mechanism for producing evolutionary novelty has apparently played a key role at certain stages in the history of life on Earth.

Supple Adaptation

Bedau (1996; 1998) has recently proposed an extreme evolutionary definition of life. Nearly all other definitions, whether evolutionary or ecological, see life primarily as a property of individuals (be they organisms, cells, or genes). In contrast, Bedau claims that a system capable of open-ended evolution (or supple adaptation) in its entirety, should be considered as the primary form of life. A system exhibits supple adaptation by the "ongoing and indefinitely creative production of significantly new kinds of adaptive responses to significantly new kinds of adaptive challenges and opportunities" (Bedau 1998, p.127).

Bedau (1998) continues to say that a supplely adapting system is an evolving population of organisms or a whole evolving ecosystem of many populations or in the final analysis, a whole evolving biosphere with many interacting ecosystems" (Bedau 1998, p.131). In this view, particular components within the supplely adapting system, such as individual organisms, qualify as secondary forms of life by virtue of their specific relationship with the system. Exactly what relationships are required between a component and the system for the component to qualify as being alive is an open question. In suggesting this definition, Bedau emphasises that natural selection is not sufficient for supple adaptation and it produces supple adaptation only when it is continually creative (Bedau 1998, p.127).

At first glance, Bedau's suggestion might appear similar to Lovelock's (1979) 'Gaia' hypothesis that the whole Earth is equivalent to a single living organism. However, the similarity is only superficial as Lovelock sees the Earth as a homeostatic, self-regulating entity or in other words, an entity that has the properties we commonly associate with more standard biological organisms. Bedau, on the other hand, is certainly not claiming that the biosphere has these properties. He states that the world must have a certain set of properties that enable it to act as a supplely adapting system if it is to be able to support the evolution of living organisms.

Bedau (1998) himself acknowledges that many obstacles must be overcome before a satisfactory definition can be produced in these terms. But, claims that the approach has promise for providing good explanations for a number of fundamental puzzles about life. The primary interest of his proposal in the present context is that it defines secondary forms of life as being the product of the right kind of evolutionary process (i.e. one capable of supple adaptation), rather than of evolutionary processes in general.

The intriguing implication is that many of the specific phenomena related to biological life that are not usually associated with purely evolutionary definitions (e.g. self-maintenance, food webs, etc.) might actually be necessary features of any system capable of supple adaptation. In this way, such features might ultimately be incorporated into an evolutionary framework of the type suggested by Bedau. Of course, this is just a theory, like any other, but it is worth serious consideration. In the following section we return to more traditional Individual-based approaches, but those that have concentrated on ecological rather than evolutionary considerations.

Ecological View

Distinct from the evolutionary approach to defining life, a separate and older tradition has sought to define life in more direct ecological terms. This approach does not seek to answer the question of what an organism is in terms of the history of its predecessors, but rather in terms of its characteristic organisation. Some have even argued that it makes no sense to define life in terms of evolution, as evolution is purely a mechanism for change. Varela (1979, p.33) states that reproduction requires a unity to be reproduced, this is why reproduction is operationally secondary to the establishment of the unity and it can't enter as a defining feature of the organisation of living systems.

Similarly, in the distinction between evolutionary and ecological hierarchies of nature, Salthe (1985, p. 235) questions whether organisms have a place in the evolutionary hierarchy. Where, much of the population genetics deals directly with gene frequencies and does not bother with genotypes. In looking at an individual organism, it is remarkable that there is very little that stays constant over its lifetime. Energy is continuously expended as it goes about its activities and this lost energy is replaced by the regular ingestion of food or by the direct harnessing of sunlight. Even the very molecules from which an organism is made are generally in a state of flux. In contrast to most other objects in the world, organisms also have a remarkable capacity for self-maintenance and repair in the face of environmental perturbations.

The image of organisms as self-maintaining structures that are open to both energy and matter has led many to consider them as dissipative systems (e.g. Haskell (1940) and O'Neill et al. (1986)). Earth's atmosphere is an example of a physical dissipative structure. They all require a continuous input of energy to maintain their structure and dissipate this energy as a result. However, organisms differ from physical dissipative structures in their ability to exert control on the flux of energy and matter through them. Thus, organisms are self-producing and self-maintaining structures.

Kauffman (1995, p.274) states the 18th century view of Immanuel Kant, where an organism is seen as distributed parts that exist for and by means of the whole, while the whole existed for and by means of the parts. Maturana and Varela (1980) and Varela (1979) have attempted to formalise this notion of self-production and self-maintenance in their definition of 'autopoietic systems'. The formal definition of autopoiesis is:

Varela (1979, p.13) states that "An autopoietic system is organised (defined as a unity) as a network of processes of production (transformation and destruction) of components that produces the components that:

1. Through their interactions and transformations continuously regenerate and realise the network of processes (relations) that produced them and
2. Constitute it (the machine) as a concrete unity in the space in which they exist by specifying the topological domain of its realisation as such a network."

In other words, an autopoietic organisation is one that actively produces and maintains its own structure. Maturana and Varela (1980) also suggest an informal definition: "an autopoietic machine is a homeostatic or rather a relations-static system that has its own organisation (defining network of relations) as the fundamental invariant".

Kauffman (1995) claims that the intellectual lineage starting from August Weismann's view of the "germ line" has led to the loss of the earlier image of cells and organisms as self-creating wholes. Varela (1979, p.34) agrees saying that the great developments of molecular biology have led to an overemphasis on isolated components and a disregard to pertaining what makes the living system whole, an autonomous unity that is alive regardless of whether it reproduces or not.

Hybrid Definitions

Attempts to fuse the ecological and evolutionary pictures in an illuminating and precise manner are complicated by the intricate, non-linear interactions involved. One of the major problems in developing a coherent picture of living systems is the description of the two-way interactions between processes occurring at vastly different time scales. Waddington (1957, p .9) says perhaps the main respect in which the biological picture is more complex than the physical one is the way in which time is involved in it. To provide anything like an adequate picture of a living thing, one has to consider it as affected by at least three different types of temporal change, all going on simultaneously and continuously. These three time-elements in the biological picture differ in scale. On the largest scale is evolution, on the medium scale is life history and finally the shortest time-scale is rapid turnover of energy or chemical change.

In the sixty years since Waddington wrote this, little progress has been made in developing models, which satisfactorily capture the interactions of processes happening at these different time scales. Recent attempts to achieve such a synthesis has been discussed by Holland (1995). Further efforts from the theoretical biology community at modelling the interface between ecology and evolution are discussed in Travis and Mueller (1989), (Stanley 1989) and (Feldman 1989). In the above section some objections were raised to defining life in terms of evolution, as evolution is just a mechanism for change. Margulis and Sagan (1986) accept this, but claim that both autopoiesis and reproduction are distinguishing processes of living matter.

They argue that while autopoiesis defines the organisation of an individual living entity, we still need to retain the idea that organisms reproduce in order to appreciate the larger picture of life: "Autopoiesis occurs to maintain an organism during its own life, but by itself autopoiesis does not guarantee that an organism will show genetic continuity or that the characteristics of any given organism will persist faithfully through time. The process that ensures genetic continuity is reproduction. But autopoiesis remains the primary process. On the one hand, without it the organism would not survive to reach the stage at which reproduction becomes feasible. On the other hand, autopoiesis does not depend on reproduction, at least within a single generation. An infertile but healthy person with muscle, circulatory, excretory, and other organ systems in excellent running order is autopoietic even though he is unable to reproduce. In an evolutionary sense, however, such an individual has forfeited genetic continuity; he is already dead." (Margulis and Sagan 1986, p.13).

Any approach that redefines life using terms such as reproduction and autopoiesis has the great advantage that such terms can be precisely defined. Nils Barricelli, possibly the first person to implement and experiment with an artificial evolutionary system (Barricelli 1957; 1962; 1963) clearly

realised the problems with using words such as 'life'. In his work, Barricelli gave a precise definition of what he called a 'symbioorganism' (the work was based upon the concept of symbiogenesis, discussed earlier). Rather than asking whether the organisations that evolved in his system were alive, he turned the question backwards:

"As a matter of fact (the question of whether the evolved organisations are alive) has no meaning as long as there is no agreement on a definition of a 'living being'. However, if the reciprocal question 'whether the objects we are used to calling living beings are a particular class of symbioorganisms' has a meaning? This is the question we have been trying to answer in this paper" (Barricelli 1963, p.99).

Origin of Life

In the previous section, the distinction was made between definitions of life, which emphasise the evolutionary perspective and those that emphasise the metabolic or ecological perspective. A similar distinction exists in models put forward to explain the origin of life on Earth. The two approaches can be called the replicator-first approach and the metabolism-first approach. The replicator-first approach assumes that the original seed for life was the existence of some sort of material that could exist in a large or infinite variety of forms, could reproduce more or less faithfully without the assistance of complicated machinery, and had some mechanism whereby specific other reactions or processes could become associated with specific forms of the material. This view was first explicitly expounded by Muller (1966). Candidates for the original self-replicating material of this type include RNA (for references see, for example, Nuño et al. (1995) and Lazcano (1995)), and clay minerals (Cairns-Smith (1971;1985). The presence of a simple self-reproducer of this nature is enough to begin a process of evolution.

The idea is that some forms of the material may be such that they have processes associated with them (e.g. they may act as a catalyst for some reaction) that act to stabilise the material. Such forms will be favoured by natural selection (precisely because they are more stable), and evolution proceeds by selecting reproducers that catalyse more and more reactions that are beneficial to the stability of the replicator. At some point the reactions will effectively give the replicator complete control over the composition of its local environment, at which stage the network of reactions will probably fluff our criteria for being a living organisation. Many prominent evolutionary biologists and chemists favour this approach (e.g. Smith & Szathmáry (1995), Dawkins (1976) and Cairns-Smith 1985).

In contrast, the metabolism-first approach assumes that self-maintaining organisations were the seed of life. These models assume that the world is such that self-maintaining (collectively auto catalytic) organisations of chemical reactions occur spontaneously with reasonable probability. Being self-maintaining, they persist for reasonable durations. Another consequence of being self-maintaining is that they produce all of the components from which they are composed, so it is easy to imagine scenarios by which some organisations of this type might reproduce (e.g. by splitting in two).

Such self-reproducing organisations will become more abundant, and will replace non-reproducers if there is competition for resources. With self-reproduction comes the possibility of evolution, so any variations of these self-reproducing and self-maintaining organisations that make them more stable will be selected from. By this process, the idea is that a genetic representation emerged by natural selection (in the right conditions) to give the organisation a high degree of stability. With a genetic representation comes an unlimited range of hereditary variation, enabling the organisations to participate in prolonged evolutionary processes (see Smith & Szathmáry (1995, p.67-72)). This approach to the origin of life is favoured by Maturana and Varela (1980), Varela (1979, Ch. 5), Dyson (1985) and Kauffman (1986).

Pattern of Life

At this stage it is worth stepping back from the debate over definitions of life from the point of view of individual organisms, and considering the way in which life has evolved on Earth on a larger scale. We are interested in the fundamental question of which features of evolution we might expect to be

universal and which features are due to mere contingencies in the particular history of life on our planet.

Evolutionary Progress

We might ask whether there is any underlying direction in evolution, such as a tendency for organisms to become more complicated. Although this might at first sight appear to be obvious, the concepts of evolutionary progress and of the evolutionary increase in complexity are in fact the subject of great debate. (Note that an increase in complexity would be just one possible example of evolutionary progress; in other words, the concept of evolutionary progress is broader than that of complexity increase and could be used in relation to many other measures.) Countless putative examples of evolutionary progress exist in the literature, such as an increase in the maximum sizes of organisms (Bonner 1988), an increased resistance of taxonomic groups to extinction (Raup and Sepkoski 1982) and net progress in the expansion of life (e.g. increase in the number of species, the number of individuals and in biomass and energy form) (Ayala 1988). McShea (1996, p.477) criticises the evolutionary progress literature for concentrating on theorising rather than empirical inquiry, but he also warns that "marshaling cases does not document a pervasive trend either. The many increases could well be offset by an equal (or greater) number of decreases". Referring to the question of whether there has been an increase in the complexity of multicellular animals (metazoans) over the Phanerozoic Era.

Almost as numerous as the number of examples of claimed evolutionary progress are the number of measures that have been used to track this progress. These measures are often intended to indicate the complexity of an organism, and include the length of coding DNA in an organism's genome (Cavalier-Smith 1985), the number of different cell types in an organism and the number of species in a community (Bonner 1988).

Among the mechanisms, which have been proposed to drive evolutionary progress, a common theme is the selective pressure and ecological niche opportunities that arise from other species in the ecosystem. Co-evolution and symbiosis are general principles here and have been applied to explain evolutionary progress in a number of specific ways. Examples include Van Valen's (1973) Red Queen hypothesis, in which it is postulated that even in a constant physical environment there will be indefinite evolutionary change as each species evolves to meet changes in others in the ecosystem. A similar scenario was suggested by Waddington (1969, p.115-6). On a larger scale, consideration of population sizes and spatial heterogeneity are also common factors in explanations of differentiation between populations, such as allopatric models of speciation, and Wright's "shifting balance" theory. Although many different mechanisms have been proposed to explain apparent evolutionary progress, McShea (1991) noticed that most are based upon a small number of underlying principles. These include some kind of ratcheting process, where a progressive step, once it occurs, is not easily lost (perhaps because the new development has become very tightly integrated with the rest of the system) and is thereby able to act as a stable base for further progression. Another common principle is the repetition-and-differentiation-of-parts theme (as noted by Darwin (McShea 1991, p.308) and Smith (1986, p.45-47), among others).

However, many would claim that there is no consistent progress in evolution. Thompson (1917) remarked "that things not only alter but improve is an article of faith and the boldest of evolutionary conceptions. I for one imagine that a pterodactyl flew no less well than does an albatross, and that Old Red Sandstone fishes swam as well and easily as the fishes of our own seas". Williams (1966, p. 42-43) doubted that there was any consistent notion of complexity, which can be said to have increased from the Paleozoic to the present day and Gould (1989) agrees with these sentiments.

Darwin's theory does not in itself predict evolutionary progress is emphasised by Smith (1988), "our theory of evolution does not predict an increase in anything. At first sight, Fisher's (1930) 'fundamental theorem of natural selection' might seem to predict an increase in mean fitness, but it would be a mistake to think that there is any quantity that necessarily increases" (Smith 1988, p.220). Whether Darwin himself believed in the idea of evolutionary progress is itself a matter of debate (see Nitecki (1988)). This is not surprising when some people quote passages such as: "as natural selection

works solely by and for the good of each being, all corporeal and mental endowments will tend to progress towards perfection" (Darwin 1859, Ch. 14) and others quote: “After long reaction, I cannot avoid the conviction that no innate tendency to progressive development exists" (Darwin 1872). At the root of much of this controversy lies the fact that the notion of progress is poorly defined, it can be used in a variety of different ways and above all, it is a value-laden notion. In an analysis of the concept, Ayala (1988, p.78) notes that progress “contains two elements: one descriptive, that directional change has occurred; the other axiological (evaluative), that the change represents betterment or improvement". It is the latter aspect of the concept that is the source of much of the disagreement.

Many argue that we, as human beings, are not impartial observers, and that our value-judgements are easily influenced (even subconsciously) by cultural, political and religious considerations (e.g. Ayala (1988), Hull (1988), Ruse (1988), Nitecki (1988), Gould (1988) and McShea (1991)). In simple terms, Gould says “progress is a noxious, culturally embedded, untestable, nonoperational, intractable idea that must be replaced if we wish to understand the patterns of history" (Gould 1988, p.319). The use of the term complexity is also problematic. McShea (1991, p.320) says “Complexity is more specific, more concrete and therefore more tractable, but on account of its historical and still commonplace association with progress, it carries the axiological taint".

Driven and Passive Trends

McShea (1994; 1998) also considers the possible causes that have been proposed to explain evolutionary trends and highlights a broad distinction between driven and passive accounts. A driven trend occurs when a directed, pervasive force exists in a system causing a particular measure to move in one direction rather than another. However, McShea (1998) points out that trends can occur in measures even in the absence of such driving forces (i.e. passive trends). These may occur when some sort of boundary exists in the system representing a minimum (or maximum) below (above) which the measure is unable to move. The distinguishing feature of such boundaries compared to the biasing forces that cause driven trends, is that they only operate on a small subset of the state space.

As a simple (if somewhat implausible) example, imagine a multicellular organism (consisting of a very small number of cells) which is free to evolve both in the direction of more cells and in the direction of fewer cells, with no selection pressure favouring evolution one way or the other. Both larger and smaller organisms arise by chance as evolution proceeds, so the diversity of observed sizes increases over time. Now, imagine that there is no particular upper limit on the size of the organisms, which may evolve (at least, until they consist of millions of cells). However, there must be a lower boundary on organism size each organism must comprise at least one cell. In this situation, the mean observed organism size will increase, due to the existence of a boundary but in the absence of any directed force. McShea (1996, p.486) suggests various ways by which these two causes maybe distinguished and most explanations that have been proposed for complexity state trends implicitly invoke biases and thus are driven. In contrast, little has been said about possible causes of boundaries, a subject which is ripe for deeper theoretical investigation. In our work on artificial evolutionary systems it is therefore important to remember that some of the patterns of life observed in the biological world may not be due to pervasive directed forces, but rather due to the existence of boundaries.

Major Evolutionary Transitions

Much of the debate over evolutionary progress, based upon evidence from the fossil record, is concerned with the pattern of evolution during the Phanerozoic Era (i.e. from the first occurrence of abundant fossils of multicellular organisms to the present day). However, multicellular organisms evolved from unicellular organisms, and those, in turn, must have evolved from simpler origins (Smith & Szathmáry 1995). The one measure of progress upon which there seems to be some agreement is that of life having passed through a succession of major hierarchical transitions. In the book The Evolution of Individuality, Buss (1987, p.183) states that, “Life, beginning as self-replicating

molecules, did not persist in this initial state. Rather, it subsequently elaborated `vehicles' in which the original heritable units became increasingly distanced from direct interaction with the external environment".

One succession that has been proposed begins with self-replicating molecules as the first stage of the evolution of life. These molecules later grouped together into larger collections of self-replicators, which became enclosed within a membrane. From these protocells, prokaryotic cells evolved, and collections of prokaryotes subsequently became associated with each other to form eukaryotes. From simple unicellular eukaryotes, multicellular organisms evolved, and single multicellular organisms then grouped together in various social patterns. Such a progression has been proposed by Smith and Szathmáry (1995). There is still some concern over the consistency of the criteria used to define each of the transitions (e.g. McShea (1996)), but the majority involve an increase in hierarchical object complexity at least.

Further, Buss' (1987, p.186) states that "Darwin's strong urging, the notion of evolution by natural selection and the notion of progress have been divorced from the outset. However, in the limited sense that life evolves hierarchically and progress is inherent in the evolutionary process". If we restrict ourselves to considering only those transitions, which do involve an increase in hierarchical object complexity, we see that each entails the absorption of a number of previously free-living individuals into a new, hierarchically higher, unit of selection. When a transition of this nature occurs, two major factors are involved. The first is a synergism between the interests of the individuals at the lower level and the new individual at the higher level. This synergism "will act to create novel organisations allowing exploitation of the external environment in ways that the lower unit alone could not accomplish" (Buss 1987, p.185). However, the individuals at the lower level might evolve in ways that disrupt the higher level organisation. Thus, the second factor is a conflict between the two levels of selection. "The rate and magnitude of such conflicts must be limited, or the higher unit will perish. If variants arise in the lower unit whose effect is to limit the occurrence or magnitude of subsequent variation, then the higher unit will eventually become resistant to further perturbation" (Buss 1987, p.185).

Once a transition has occurred, then, the new unit of selection must become stabilised if it is not to break down into its component subparts again. Smith and Szathmáry (1995) also suggest that the genetic relatedness of individuals in the lower level may also play an important role in conferring immediate selective advantage at the time of transition. If the new organisation does become stabilised, then it, in turn, is able to participate in the same sort of process, leading to yet higher organisational levels. Bronowski's term "stratified stability" captures this picture of progression well (Bronowski 1973).

Buss (1987, p. viii) summarises that the organisation of any unit will come to reflect those synergisms between selection at the higher and the lower levels which permit the new unit to exploit new environments and those mechanisms which act to limit subsequent conflicts between two units. From this point of view, a new perspective on the pattern of evolution emerges. It is a picture of major hierarchical transitions, with long periods in between during which it is debatable whether any consistent notion of progress applies. Buss (1987, p. 188) claims that "the major features of evolution were shaped during periods of transition between units of selection". In the period after a transition, an adaptive radiation of forms is possible to fill the novel evolutionary niches afforded by the new kind of organisation. In the context of organic evolution, Salthe (1985, p. 253) suggests that this expansion continues until a saturation point of number of kinds is reached, "when the emphasis of the process shifts toward co-evolutionary elaborations of pairs, guilds, and even more complex symbioses". The saturation point can be released if, for example, a subset of the organisms become geographically isolated and able to participate in a new adaptive radiation, but none of these processes will necessarily lead to any general evolutionary progress. This view of evolution is also consonant with Schwemmler's (1989) notion of a constant oscillation between divergent and convergent phases and to some extent, with Gould's (1989) picture of diversification and decimation.

Contingency in Evolution

Proponents of the general picture of evolution discussed in the previous section tend to emphasise the role of contingency (historical accidents) in determining the course of evolution. In The Evolution of Individuality, Buss (1987, p.187) says that the fact that life is that it hierarchically redirects attention to the effect of history on biological phenomena. The major features of genomic organisation of cell architecture and of organismal ontogeny arose as the products of history-dependent variation at the time of the transition from one unit of selection to another. Units which persist today do so because variants which restrained further interaction between two units of selection arose and fixed the organisation of the unit in question at a given state.

Similarly, Smith (1986, p. 45) says that his own view is of a series of historical accidents, subject to engineering constraints on the one hand, and to the conservatism of development on the other. The engineering constraints arise when there may be only a small number of ways of solving a particular engineering problem faced by a species. By conservatism of development, Smith (1986, p. 46) is referring to the fact that it seems to be a general feature of evolution that new functions are performed by organs which arise, not de novo, but as modifications of pre-existing organs.

Finally, Gould's (1989) view on the subject is that invariant laws of nature impact the general forms and functions of organisms. They set the channels in which organic design must evolve. These physical channels do not specify arthropods, annelids, mollusks, and vertebrates, but, at most, bilaterally symmetrical organisms based upon repeated parts. When we set our focus upon the level of detail that regulates most common questions about the history of life, contingency dominates and the predictability of general form recedes to an irrelevant background. Gould (1989, p. 289-290) says that Darwin recognised this central distinction between laws in the background and contingency in the details".

This paper will now analyse how biological evolution and ecology can explain the evolution of financial markets.

Evolution of Financial Markets

Market Structure Development: Robust and Interconnected

Biological findings in the previous section identified some critical factors for continuation of life on this planet that were: Survival of the Fittest, Heredity, Self-organisation, Reproduction, Symbiogenesis and Complexity. As, biological life has evolved into intelligent life forms over time (i.e. humans) and with the development of their brains have developed the ability to value objects using perception. Therefore, as each human perceives each material or other object with a different viewpoint assigning it different value. Resultantly, we have many buyers and sellers in different markets with varied price offers. Now, realising that human perception is a result of biological development, it makes sense to replication lessons from biological evolution and ecology in view of the evolution of financial markets.

Darwin’s (1859) concept of Survival of the Fittest can be seen more often through the concept of competition between different entities, for example between stock exchanges as they try to increase the number of listings or increase trading volumes. Competition has increased over time forcing stock and derivatives exchanges to merge, for example the New York Stock Exchange (NYSE), EuroNext and the London International Financial Futures Exchange (LIFFE) or Chicago Mercantile Exchange (CME) and Chicago Board of Trade (CBOT). Survival of the Fittest is probably the most visual factor in evolution as only the stronger individuals survive. Therefore, in order to fight competition these exchanges have been forced to merge to be able to compete with their rivals. Resulting from these mergers are the heredity of organisation cultures and other organisational factors that are transferred over to the new merged exchanges. Once these entities have merged their cultures mixed with each other and evolve into sometimes a different culture altogether with a history of the previous entities. Some mergers are successful, however mergers in general are very hard to get right due to many

reasons. However, the Self-organisation factor in this change after a merge is simply the constraint that cultures from each of the merged firms will constrict the future culture that will develop in the merged entity. Here, the concept of merger or acquisition of another exchange could in biological terms be labelled as Reproduction.

In many cases, markets will develop Symbiotic relationships where one market will work with another, for example every market is possibly connected to nearly every other market on the macro level being part of an economy. These days with corporations working globally and the advances in technology it is hard to believe that markets aren't connected internationally. With this comes the difficulty of Complexity, as numerous markets are interlinked with each other. Thus, changes in a market could possibly impact markets and institutions that are Symbiotically connected to this market. Such Symbiotic relationship connects numerous financial markets at varying levels across the globe in today's world as extreme large flow of investment funds moves from country to country in demand for higher returns on investment.

Financial Risk Perception and Pricing of Assets

Prospect Theory in Financial Markets

If financial markets have symbiotic relationships, a fall in a single market should impact the other interlinking markets. This was seen through the end of 2007 and through early 2008 as stock markets around the world moved in close conjunction with the Dow Jones Industrial Average (BBC 2008).

Stock markets are formed with the association of market makers (i.e. humans) who are interested in buying and selling stocks in a free market. These people (market makers) provide a price at which they will buy or sell a stock and this price is based on what they perceive the price of that stock should be. Also, they would want to keep in mind not what their perception of this stock is, but also the perception of the other market makers. It is probably hard to guess the perceptive value millions of market markers who trade in a particular stock (in some smaller stock markets the number of people trading certain stocks maybe much less). In other words, the liquidity of a stock is based on the number of people who are trading that stock. Therefore, stocks in smaller market may have less liquidity compared to blue chip stocks in bigger markets like the New York Stock Exchange.

Previously, Harry Markowitz (1952) has provided the Mean-Variance Hypothesis that explains the relationship between an asset and the market portfolio. In behavioural finance, you could see this as the perception of risk associated to that specific asset against the perception of risk associated with all the assets comprising the market. In this case, it could be seen for example as the psychological value perception of the IBM stock will have against the psychological value perception of the Dow Jones Industrial Average. It is quintessential to realise that every person dealing in these stocks will be thinking differently and will be in different circumstances (for example, one had extra money to invest or the other hand someone may need money urgently to pay their debts). William Sharpe (1964) and Stephen Ross (1976) have provided the Capital Asset Pricing Model and the Arbitrage Pricing Models respectively to price stocks. These models offer a mathematical explanation of stock pricing. However, perception of valuing a stock or an asset in general is a psychological exercise. Therefore, Prospect Theory (Kahneman and Tversky 1979) provides an explanation of the economic decisions that humans would make under the conditions of risk or uncertainty. It simply states that humans don't value losses and gains the same way. Instead, they need more than double in gains compared to the loss they may sustain when they make a bet. So, not only gains and losses are unproportionally over weighted, but they also underweight outcomes that have risk compared to certain outcomes. Therefore, people try to gamble when losses (become loss averse/risk taking) hoping they will be able to reduce them somehow and try to hold on to gains (become risk averse). Resultantly, when bad news hits a stock market traders will react immediately to sell that stocks thinking that further bad news may become available relating to this stock and its price may fall further.

Related to behavioural finance there is another field of study called Game Theory that is reasonably well connected to the valuation of assets. Game theory provides an understanding on how different

players in a game would react to the other players based on the information that is available (even in circumstances when limited information is available). Game theory has two prevalent models called the Non co-operative game theory provided by John Nash (1951) and John Von Neumann and Oskar Morgenstern (1944). Both these theories have been significantly used in industrial organisation and political economics. The also have an impact on the competition in markets. The Non co-operative game theory provided by Nash (1951) explains how participants in a game would try to improve their outcomes against their opponents, while improving the outcomes for everyone in the game as well. This theory simply shows that everyone in the game is directly linked with the other players in a game. Here, if we took a single stock market to resemble a game with numerous players being the participants within this game. Then, every action that each player would take to maximise their outcome, resultantly they will impact the actions of all other players in the game. Further, each player will take an action based on what they perceive the other player's (in this case the market because there are too many players/traders forming a market) actions. In addition, Prospect theory explains that human risk psychology biases people to prefer gains against losses and certain gains over probable gains. As a result, we could provide a simple equation to explain this thinking:

Perceived Value of an Asset by an Individual = their perception of the market's perception of this asset's value at a time in the future (t= N) **x** their own perception of the future value of this asset at a time in the future (t=N)

Perception is a subjective value and can be hard to quantify. However, from the point of view of valuing a stock, the following questions can be asked –

1. based on the information available right now how much does the futures market expect the stock to be at a time in the future, and
2. what do you think the value of that stock would be at the same time in the future.

The perceived value of the stock is a combination of the market's perceived value and your perceived value. Obviously, as new information will become available the stock price will change and it is not possible to pre-empt the future. Though, the future stock price will eventuate from the current price, therefore according to Chaos Theory (Lorenz 1996) if we know today's stock price and the information that will become available tomorrow then we could calculate tomorrow's stock price accurately. When we include prospect theory with chaos theory and non co-operative game theory we realise that calculating the future stock price is rather difficult. However, we now do realise that not only are markets (via symbiogensis) and traders (via non co-operative game theory and chaos theory) within these markets connected to each other. But, we also realise from prospect theory that people react differently to gains and losses.

Financial crisis impacts across markets: Sub prime crisis

According to prospect theory and cognitive neuroscience, people are risk averse in general. So, the impact of bad news in co-ordination with prospect theory, we would presume makes stocks drop. This happens as people look to protect their gains. However, people are also risk taking in reducing losses, which makes them sell stock if they believe the stock prices are falling. In this case, they would take the risk to reduce their loss assuming the prices wouldn't go back up soon. Further, the risk/return profile of a risk averse person would be less than 1 because they will try to take lesser risk and require a higher return. Therefore, high risk assets (e.g. Junk Bonds) will have less demand, while low risk assets will have higher demand (e.g. 90 day US treasury bills). As a result, the high risk assets will be overpriced and vice versa. Similarly, in the Sub prime crisis investors have moved further away from the high risk assets due to the increase in risk in the market. As, housing asset prices have fallen over the past 3-4 years across the US. High risk assets have become more expensive, as less liquidity is available.

The US sub prime crisis is an asset bubble that has formed due to the underpricing of higher risk assets. Investors on these high risk assets eventually started defaulting as the US interest rates increased. Over the past few years, the securitised assets sold by repackaging sub prime debt provided investors a risk perception that these high risk assets were low risk. Rating companies like Standard

and Poor's and Fitch IBCA supported this concept by providing AAA and AA+ ratings. These assets were probably incorrectly priced due to lack of information and understanding of the overlying complex securitised products used to resell these underlying mortgage loans. As, stock prices have fallen in the US, these have had impacts on other exchanges worldwide. This has happened as US is the biggest economy in the world and a recession in the use would affect the sales of companies listed on other international exchanges. Therefore, this interlinkage between companies and exchange globally causes impacts from on country to be transferred across boundaries. Eventually, majority of the international indices listed on exchanges around the globe have moved in tandem with losses and gains on the US exchanges. This interlinkage also occurs due to the lack of liquidity available on the credit markets internationally. Resultantly, credit markets are having a strong impact on stock market movements globally.

Conclusions

Prospect theory and market evolution have caused stock markets to be interlinked with each other globally. Therefore, the change in the US market through the Sub prime crisis is impacting stock markets globally. This paper has discussed biological evolution and analysed if similar evolution and ecology could be present in the evolution of markets. Also, how does this evolution interlink stock and other financial markets? A brief discussion is provided on the implications of the sub prime crisis in the US and its impact on global stock and credit markets. Additionally, that global financial markets are tightly interlinked also as companies work across global boundaries these days. So, we should consider the global impact of financial crisis in today's markets.

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