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Darwinism, probability and complexity:
market- based organizational transformation and change explained through the theories of evolution

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Abstract

The study of transformation and change is one of the most important areas of social science research. This paper synthesizes and critically reviews the emerging traditions in the study of change dynamics. Three mainstream theories of evolution are introduced to explain change: the Darwinian concept of survival of the fittest, the Probability model and the Complexity approach. The literature review provides a basis for development of research questions that search for a more comprehensive understanding of organizational change. The paper concludes by arguing for the development of a complementary research tradition, which combines an evolutionary and organizational analysis of transformation and change.

Introduction

In this paper, we look at a broad-ranging view of the dynamics of change and transformation in organizations, and how they can be interpreted in terms of evolutionary theory. Our discussion reflects a relatively new area of study, which links together a disparate number of sources, as diverse as economics, biology, mathematics, sociology and philosophy. Our objective is to move beyond the conventional paradigms of change analysis, to introduce novel perspectives of how organizations change, and to stimulate others to work on these issues.

Evolutionary theory's more famous component is without doubt Darwin's concept of natural selection and its offshoot: 'survival of the fittest'. We start our discussion by dispelling some of the myths on Darwinism and its relevance to the much wider field of evolutionary theory.

We propose to link the body of knowledge on organizational change and transformation to the three mainstream theories of Evolution: the Darwinian concepts, the Probability model and the Complexity approach. Each mainstream is discussed in detail with respect to its relevance to organizations.

When dealing with the subject of organizational change, it is important to understand that speed of change does not reflect the magnitude of change. The speed of change represents only one variable in organizational change, and that one variable may not be significant for transformation. On one side of the spectrum, we look at evolutionary or incremental change, which refers to a slow, systematic course of action. Darwinism subscribes to this idea of a slow build up of change. At the other end, we look at revolutionary change, which usually refers to the suddenness of the change. In terms of evolutionary theory, this is brought about through strong mutations from the norm occurring at rapid intervals, often referred to as punctuated equilibrium. The dynamics can be explained through the Probability model and the Complexity approach.

Whether revolutionary and evolutionary changes lead to transformation depends on the time continuum of observation. Palaeontologist are more likely to witness major transformation because of the millions of years they observe. In our study of organizations, the magnitude of change or transformation is measured in terms of depth and impact on culture. Our period of observation is limited to a few decades, and long-term longitudinal studies are few and far between. This points us to two major considerations. First, the adoption of evolutionary theory to organizational change has to be

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modified because of the disparity between observing millennia and observing decades. Evolutionary theory in organizational studies is a tool for generating perspective, but not a measuring instrument of change. Secondly, the internal processes of change within an organization become vital variables in our observations. For this reason, we look at what impedes and what generates change, and we briefly discuss the effects of paradigms, inertia and mimetics.

Evolution: Dispelling the Myths

Much of the application of evolutionary theory in social science shows a bias towards the more orthodox neo-Darwinian view of 'survival of the fittest'. A fuller understanding of what constitutes evolution is required to develop a comprehensive theory of evolution that is applicable to the study of change and transformation in organizations.

The concept of 'survival of the fittest' was developed by Spencer, and is wrongly attributed to Darwin. Darwin's theory referred to a gradual steady rate of change in species, which brought about evolution. The concept of evolution of the human species from primates caused considerable controversy, at a time when the notion of human supremacy was prevalent. Spencer moulded the concept of evolution to the prevailing paradigms, and suggested that it was the fittest and the higher societies that survived the process. Spencer's theories of social evolution were used to support the success of European nations as advanced civilizations. During the late 1800s, many anthropologists promoted their own models of social and biological evolution. Their writings portrayed people of European descent as biologically and culturally superior. With the increase in knowledge in genetics and species, such theories are today viewed as a fallacy. Evolution does not have directionality towards higher species. The strongest proof is the persistence of bacteria as the most common and dominant form of life on Earth.

The most common application of survival dynamics is found in economics, where survival theories are used to analyse how firms thrive and compete in industries. Typical studies such as those of Nelson and Winter (1982) apply the evolutionary idea to economic change. Here, the framework and methodology of the research is thorough, but applies only one part of the scientific knowledge of evolutionary theories.

The theory of 'survival of the fittest' is insufficient to deal with change and transformation in organizations. First, it promotes the idea of gradual change and excludes radical, quick change that can occur through genetic mutation. Secondly, it assumes survival of superior species, rather than the most fit at the time for the surrounding environment. The survival model cannot be used to analyse firms' transformation processes such as reengineering, or to explain the dynamics of knowledge management and its proliferation.

The field of evolutionary economics recognizes these shortcomings, and also includes principles of genetics and speciation. The variation–selection–retention model (Metcalfe et al. 2000) is used to give a fuller picture of how organizations create new strategies, how they select viable ones, and how they retain the successful strategies as industry standards.

The two other mainstream theories besides neo-Darwinism are Probability and Complexity theories. We argue that neo- Darwinism, Probability and Complexity can be viewed as complementary dynamics.

Probability theories refer to change that occurs through chance rather than through planning. The body of knowledge on evolution addresses other change dynamics, such as: the dependence on preceding events; the unpredictability of outcomes; the clustering of change events in nature; and the role of isolated groups as the common sources of change. The concept of punctuated equilibrium is the most widespread application of probability theory in the social sciences. Through punctuated equilibrium, long periods of small incremental change are interrupted by brief periods of

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discontinuous, radical change. Eldredge and Gould (1972) introduced the concept in the field of evolutionary biology, and Tushman and Romanellli (1985) developed and tested a model for industry.

Lichtenstein (1995) examined punctuated equilibrium theory from evolutionary biology and by developing its analogies to organizational transformation. He views punctuated equilibrium as insufficient to guide research on transformation and recommends the use of self-organization concepts from complexity theory. Lichtenstein's research is important because it recognized that several forms of evolution exist. Lichtenstein's treatment of the analytical model is, however, limited to punctuated equilibrium, which forms part of Probability Theory, and self-organization, which is part of Complexity Theory. Lichtenstein argues that, while evolutionary theory has been analogized in the organization sciences (Campbell 1969; Gersick 1988; Hannan and Freeman 1977; McKelvey 1982), it is not been treated from its original ecological perspective.

The importance of such an outline from a natural science perspective cannot be overstated: unless we fully understand the basic tenets of evolutionary theory, we are not in a position to make literal analogies or empirical tests of any models of that theory. The larger issue, of course, is whether making the analogy from evolution to organizations is wise at all: just because both deal with change doesn't necessarily mean one is a good model for the other. (Lichtenstein 1995, 291)

Recognizing the location of evolutionary dynamics in the ecological literature would give a fuller picture of change and transformation in organizations. This can be achieved by applying a more comprehensive view of the three areas of evolution.

Complexity theory sheds light on the processes of co-operation, adaptation and outcomes as factors that create change and transformation. With the increase in attention that is given to complex systems, a fresh perspective is emerging to explain findings about organizational phenomena. Complexity research is not at the point of describing an underlying theory of organization (Horgan 1995). However, it can provide a powerful descriptive tool for understanding the world around us (Lissack 1996).

The use of complexity theory metaphors can change the way managers think about the problems they face. Instead of competing in a game or a war, they are trying to find their way on an ever changing, ever turbulent landscape. Such a conception of their organizations' basic task can, in turn, change the day-to-day decisions made by management. (Lissack 1996)

Social Sciences and Evolution

In this section, we look at how social researchers in the twentieth century have shown interest in applying evolutionary analysis to various disciplines. Organizational evolution builds on research in the social sciences (McKelvey 1982) and organizational ecologists (Carroll 1984; Hannan and Freeman 1989; Levinthal 1991; Singh 1990).

The theories of evolution are being applied to different disciplines such as sociology, psychology, political science, anthropology, economics and organizational behaviour. The end result is a cross-fertilization of ideas, which moves out of the paradigms of the respective fields and makes use of the latest thinking from a wider spectrum of knowledge.

In Crisis in Sociology: The Need for Darwin, Lopreato and Crippen (1999) show concern about the lack of intellectual rigour in sociology and build a persuasive argument for applying methodologies from the natural sciences. They adopt the viewpoint that conclusions must be based on factual observation, hypothesis and intellectual analysis.

In psychology, the evolutionary concept sheds light on human behaviour by understanding our evolutionary past. Evolutionary psychology is based on the assumptions that our ancestors have adapted to environments, which has resulted in modifications to the mind and body, and that the

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modern mind was built to solve the problems that our ancestors faced. The modern mind has not yet adapted to the post-industrial world of today, which gives rise to psychological disturbances (Barkow et al. 1992).

Oaksford and Chater (1998), however, provide another perspective on evolutionary psychology. They note that, while evolutionary psychology provides a viable alternative explanation for bias observed in standard models of rationality (Kahneman and Tversky 1996), other explanations can be just as valid. They show how an experimental Bayesian probabilistic approach can provide a detailed explanation of experimental data on Wason's selection task (Wason 1966), which is often viewed as an illustration of human irrationality. (For a review on the subject, see Stenning and Lambalgen 2001.)

In the legal field, Masters and Gruter (1992) introduce biological foundations and draw upon discoveries from the biologically based behavioural sciences. The approach is helpful for a more informed understanding of legal phenomena, particularly those dealing with complex social and political relationships.

Political science borrows from the complexity branch of evolutionary theory, to explain major outcomes from minor events in wars. Beckerman (1999) explains how Belisarius, leader of the Byzantine army, used non-linearity against the Persian army. He spread out his scouts to ride up and down the region between his forces and the advancing Persian army. The effect was to make Belisarius's forces appear larger than they really were. His forces were one-tenth the size of the their adversary. The Persians forfeited the battle. In this case, a very small input caused a disproportional large output.

In anthropology, the evolution of complex societies is one of the deepest puzzles. Great debates, with roots in the political thought of Plato, Aristotle and Confucius, have raged over whether the evolution of such societies is voluntaristic or coercive, whether their operations are to be understood in terms of conflicts, and whether the right unit of analysis is the individual or the social institution. Richerson and Boyd (1999) maintain that, with the tools of evolutionary analysis, it is possible to construct hypotheses that mix the various elements of classical positions.

In economics, the trend has taken diverse directions (Anderson et al. 1988; Hodgson 1993; Nelson 1995; Nelson and Winter 1982; Witt 1993). A few thinkers even aspire to ground the first principles of biology on economics (Ghiselin 1992; Tullock 1994).

The literature on the growth of knowledge applies an evolutionary viewpoint, which builds upon and goes beyond the work of Campbell (1969). In his book What Engineers Know and How They Know It, Vincenti (1990) discusses an interesting account of how evolutionary ideas can be used to understand the growth of knowledge. Focusing on his own field of aeronautical engineering, Vincenti examines five case studies of designoriented problems and their consequences, and then presents a model to help explain the growth of engineering knowledge. He contributes to the emerging view of engineering knowledge as an epistemological species different from applied sciences.

Evolutionary theory is finding its way into organizational sciences. Its interdisciplinary framework facilitates an inquiry into the issues surrounding organizational change (Aldrich 1999). An evolutionary approach provides a generic framework for understanding change. The approach is applicable to multiple levels of analysis and focuses on the processes of variation, selection, retention and the struggle for resources.

An evolutionary framework tolerates issues of indeterminacy which arise in longitudinal studies. Indeterminacy refers to the issue of whether events in organizations are determined through prior planning and managerial intent. Quinn (1980) questions the conventional split between the policy formulation and implementation and views these processes as interactive and unclear. Carroll and Harrison (1994) show that path-dependent processes in computer simulations could often generate outcomes other than those implied by historical efficiency.

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An evolutionary perspective treats the future as unknown and unpredictable. March (1994) points out that the process of variation, selection and retention is not historically efficient. Many accounts of organizational change ignore this sense of indeterminacy (Smith 1993). An evolutionary approach avoids imposing meaning on historical events from knowledge of outcomes. It does this by looking at the dynamics of change and development without the underlying assumptions of cause and effect.

The use of the paradigm of organization evolution presents a fundamentally new way of understanding transformation and proceeds into the realms of investigating change activated by exogenous and endogenous agents.

Evolution Theory and Organizations

In this section, we look at change and transformation in organizations, and how they can be interpreted in terms of evolutionary theory. A conceptual framework can be built from an understanding of the four processes of selection, the units of selection and the selection environment, discussed below.

Campbell (1969) attributes system evolution to four processes: variation, selection, retention and the struggle for scarce resources. Metcalfe et al. (2000) draw analogies to the above processes to describe economic transformation, which they divide into three elements:

Micro-diversity of agent behaviours, e.g. innovation, diversity of technologies, products, services organizations *Selection processes* that transform that diversity into patterns of economic change, e.g. company entry and exit, growth competition and survival *Development processes* that generate and regenerate that behavioural variation, e.g. imitation, benchmarking, globalization, franchising, interaction.

The evolutionary processes are listed below with definitions and examples relevant to organizations (Aldrich 1999):

Variation is the change from current routines and competencies. Change in organisations may be intentional or blind. Intentional variation occurs when people actively attempt to generate alternatives and seek solutions to problems. Examples in organisations: problem search, the founding of companies by entrepreneurs from outside the industry. Blind variation occurs independently of environmental or selection pressures. Examples: marketing mistakes, misunderstandings, surprises and idle curiosity.

Selection is the differential elimination of certain types of variation. External selection occurs through exogenous forces that affect the company's routines and competencies. Examples are market pressures, competitive pressures and conformity to institutionalised norms. Internal selection occurs through forces within the organisation such as: pressures toward stability and homogeneity, and the persistence of past selection criteria that are no longer relevant in a new environment.

Retention explains how selected variations are preserved, duplicated or reproduced. Organisations may create specialisation and standardisation of roles that limit discretion. Between different organisations there could be the institutionalisation of practices in cultural beliefs and values.

Struggle refers to the contest to obtain scare resources because their supply is limited, for example: the struggle for capital.

Units of Selection and Selection Environment

The dynamics of selection are determined by the units of selection, and the selection environment.

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Units of selection, such as company processes or routines can be selected for their elimination and replacement by other units. They could also be selected for a change of ranking in importance within the organization. They will be retained in the organization, but their value and their level of implementation would change.

The selection environments, such as companies, industries, markets and economies, determine which units of selection become more important and which ones survive. Organizations can be seen to thrive or go out of business because they are suitable for their selection environment. The evolutionary perspective evaluates how an organization fits its environment, rather than explaining corporate achievement or collapse in terms of strategic intent. The selection environment itself, such as a company, can become a unit of selection at another level. For example, Company A is the selection environment of a set of competing processing x, y and z. The company selects which processes to retain and which to discard. However, within an industry, Company A becomes a unit of selection, as its environment determines the extent of its success. In natural ecology, the selection environment plays an important role. In organizational studies, its effect is diminished by the fact that organizations would try to influence and manipulate that environment and effect the rules of selection. We see such actions in the building of alliances, collusion in pricing, collective buying and selling, and industrial lobbies.

Units of selection therefore fall into two categories:

(1) Activities and structures on which evolution operates, such as routines, competencies and jobs. Research in this area focuses on survival of initiative (Burgelman and Mittman 1994), managerial action (Miner 1990, 1995), and changing distribution of routines and consequences (Tushman and Murmann 1998)

(2) Bounded entities that carry activities and structures, such as groups, organizations, populations and communities. The area is mainly the domain of population ecologists, who maintain that transformation in organizational structure occurs when some organizations survive over others.

The survival of entities at all levels depends heavily on the reproduction and retention processes at the organizational level. The significance of organizations as carriers of routines and competencies and as bounded entities may explain why most evolutionary analyses are still carried out at the organizational level (Baum and Singh 1994).

Applying Organizational Evolution to Transformation

Aldrich (1999) shows how the variation– selection–retention model can be applied to the study of transformation.

Variation: In Aldrich's evolutionary model of transformation, the greater the frequency of variations the greater the opportunities for transformation. The level of variation may be reduced by endogenous selection norms favouring inertia. Otherwise, it may be helped along by institutional experimentation, incentives to innovate, authorization of unfocused variation, and creative acting out of organizational practices.

Selection: Changes in selection criteria open avenues for new practices. Internal selection criteria, which are not linked to environmental fitness, may be realigned. External discontinuities may trigger changes in selection pressures, such as changes in competitive conditions, government regulations or technological breakthroughs.

Retention: Transformations are completed when the knowledge required for reproducing the new form is embodied in a community of practice. Retention is operated by individuals and groups, structures, policies and programmes or networks.

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Aldrich looks at the above model as the basic dynamics within organizations that brings about change and transformation. He defines transformation as a major change in an organization involving a break with existing routines and a shift to new kinds of competencies that challenge organiz ational knowledge. He views this as happening along three dimensions of the organizations: Goals, Boundaries and Activities (Figure 1).

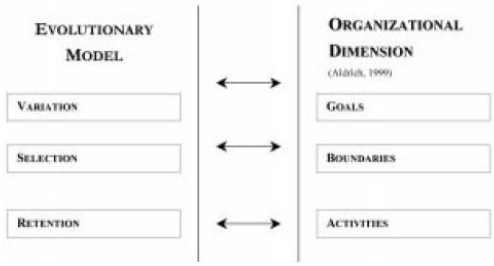

Figure 1. Applying the evolutionary model to organizational dimensions.

Goals: Organizations that are driven by goals engage in collective action towards a target. Transformation would occur when major changes in the goals are effected. An example would be the conversion of Health Maintenance Organizations (HMOs) in the US from non-profit to profit status.

Boundaries: Organizations experience expansion or contraction of their boundaries. Expansion occurs through acquisition, mergers or going into new market segments. Contraction occurs through downsizing, divestitures or a reduction in the market base being targeted. Contraction and expansion can be exogenous or endogenous to the organization. Aldrich describes ITT as a prime example of transformation of boundaries. ITT had spent billions acquiring more than 150 companies during the 1960s in order, according to the firm's president, to escape the status of a ''one product company''. Its acquisition policy set the firm to tenth on the Fortune 500 list. A decade after its acquisition spree, ITT was mired in poor performance and bureaucratic inertia. Its stock, which formerly traded in the $70 range, sunk to the $30 range. In response to this judgement of the financial markets, ITT embarked on a bold departure in ''reengineering'' itself. It divested some one hundred subsidiary businesses during the 1980s. In 1995, when the number of formerly acquired operations divested by the firm exceeded 200, ITT divided itself into three independently traded firms.

Activities: According to Aldrich (1999) activity systems in organizations are the means by which members accomplish work, which can include processing raw materials, information or people. Transformation occurs when changes in the activities have a major effect on organizational knowledge. The University of Michigan set up the M-Pathways Project in 1995 to focus on how the University does its administrative work in order to improve processes, simplify policies, and eliminate policies and procedures that do not add value.

Merging the evolutionary model of variation/ selection/retention to the organizational dimension of goals/boundaries/activities poses important research questions about change and transformation:

How is new behaviour generated? How is the non-viable behaviour eliminated? How are the viable behaviours retained as an industry standard? How are the company's goals, boundaries and activities being effected by the dynamics of variation, selection and retention?

The evolutionary approach is an encompassing perspective that is adaptable enough to serve as a model within which other approaches are recognized and accepted. Evolutionary models do not specify the engines driving variation, selection and retention and thus they depend upon ideas from other approaches for their power. The study of organizational change through evolution can be described as being between a Mode 1 and Mode 2 type of knowledge production.

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"Mode 1 problems are set and solved in a context governed by the largely academic interests of a specific community. By contrast, Mode 2 knowledge is carried out in a context of application. Mode 1 is disciplinary while Mode 2 is transdisciplinary. Mode 1 is characterized by homogeneity, Mode 2 by heterogeneity. Organizationally, Mode 1 is hierarchical and tends to preserve its form, while Mode 2 is more heterarchical and transient." (Gibbons *et al*. 1994, 3)

The research of change from an evolutionary perspective still requires a broader understanding of evolutionary dynamics from a natural science perspective. The following section looks at the development of the theory of evolution, its three mainstreams of Natural Selection, Probability and Complexity, and the various types of change dynamics within each.

Developments in Evolution Theories

To develop a theory of organization evolution effectively, it is necessary to have an understanding of the biological theory of evolution. A fuller understanding of the richness of evolutionary theory would help to rise beyond the concepts of Darwinian survival and selection. The Darwinian perspective is but one of several perspectives of evolution. Hull (1988) reports that evolutionary theory is fraught with fine distinctions. The evolutionary debate is influenced by the mental models and the political value judgements of its protagonists.

The following section outlines the history of evolutionary thought and describes the mainstream theories of Natural Selection, Probability and Complexity.

The notion of species changing into other species was contemplated in ancient Greece. It went into eclipse until the eighteenth century, when it resurfaced in the minds of advanced thinkers such as Pierre de Maupertuis, Erasmus Darwin and the Chevalier de Lamarck. Lamarck proposed that improvements acquired during an organism's lifetime were inherited. Charles Darwin, spurred into print in 1859 by the independent discovery by Alfred Russell Wallace of his principle of natural selection, established the theory of evolution. Gregor Mendel introduces the theory of particular inheritance in 1865, which provided the basis of the science of genetics. Modern molecular biology and genetics enhanced Darwin's theory.

With the introduction of genetics, Lamarckism is refuted. The characteristics of an organism, termed the phenotype, are not inherited and cannot be transmitted genetically to subsequent generations. An example of a phenotypic characteristic is a suntan: it is produced as a response to the environment, but only the ability to tan is transmitted in the genotype. The genotype is the material inherited by an individual from its parents, which has the potential to be transmitted to future generations.

Natural selection, the mechanism that Darwin and Wallace suggested, amounts to the non-random survival of randomly varying hereditary characteristics. Darwin and Wallace seem to have been the first to realise its full potential as a positive force guiding the evolution of all life.

The orthodox Darwinian viewpoint rests on two principles: that organisms become the fittest by chance and that the weak are weeded out. Darwin was developing his ideas at a time when man was viewed as the focal point of creation and indisputably the most superior. The notion of survival by chance was a challenge to the prevailing social paradigm, because it implied that humans had little influence over their genetic makeup and that their existence was a chance event. Spencer came in to modify the theory, introducing the concept of 'survival of the fittest', which conformed, with the belief in human supremacy.

When genetics was discovered half a century ago, doubts began to form about the process of gradual change through natural selection. Darwin himself was aware of the flaw in his theory. Fossil records showed one predominant set of species at different layers, as if one species simply replaced the other. He went around the obstacle by referring to the imperfections of fossil formations, calling them ''a few fragments of a few chapters preserved from the whole book of life''.

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Through genetics, natural selection then became a process that altered the frequency of genes in a population and this defined evolution. Current ideas on evolution are usually referred to as the Modern Synthesis, which is described by Futuyma (1986). The concept would be incomprehensible to Darwin, since he was unaware of genes and genetic drift. The modern theory of the mechanism of evolution differs from Darwinism in three important respects: It recognizes several mechanisms of evolution in addition to natural selection. One of these, random genetic drift, may be as important as natural selection. It recognizes that characteristics are inherited as discrete entities called genes. Variation within a population is due to the presence of multiple alleles of a gene. It postulates that speciation is usually due to the gradual accumulation of small genetic changes. Speciation is the evolutionary formation of new biological species. This is equivalent to saying that macroevolution is an accumulation of microevolutions.

In other words, Modern Synthesis is a theory about how evolution works at the level of genes, organisms and populations, whereas Darwinism was concerned mainly with organisms, speciation and individuals. The lack of understanding of the difference between Modern Synthesis and Darwinism is widespread in the popular press.

Mainstream Theories of Evolution

Our review of the main evolutionary processes maps the mechanisms of evolutionary change. It goes a step deeper into the principles of variation, selection and retention as the media for transformation analysis and shows the possible dynamics within each, classified in parallel within the mainstream theories of evolution. Depew and Weber (1995) recognize three cores: Natural Selection, Probability and Complexity. The three mainstreams are overlapping. Each theory goes a step beyond the previous one, but remains complementary to it. The structure that is created by the three approaches produces a workable framework for the analysis of change and transformation. It also adds to the variation–selection– retention model, as it provides a set of explanations of how they emerge at a deeper level of analysis. In the next section, the mainstreams are described in turn, and a list of potential dynamics for each theory is developed and explained (Figure 2).

Natural Selection	Probability	Complexity
1. The fittest, or the most adapted to the environment are selected	1. Historic Contingency & Stochastic Drift	1. Self-Organizing
2. Gradual steady rate of change, visible over a long period of time	2. Punctuated Equilibrium	2. Continuous Adaptation
3. Variation occurs by chance, not intent	3. Sources of change	3. Sensitivity to Initial Conditions
	4. Dual Nature of Evolution	4. Non-Linear 5. Increasing Returns 6. Emergence of Novelty

Figure 2. Mainstream theories of evolution and their dynamics of change.

Natural Selection Theory

The salient points of Natural Selection theory which are applicable to research on change are the concepts of survival of the fittest and gradual steady rate of change, described below.

Survival of the fittest. Natural selection theory provides a reductionist view of survival. The approach reflects a process where the players are helpless against their fate and the weakest will be left by the wayside. This was the most important and revolutionary part of Darwin's theory in his time. Most applications of evolutionary theory show a bias towards this orthodox neo-Darwinian view of evolution as 'survival of the fittest'. For natural selection to occur, two requirements are essential: (1)

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there must be heritable variation for some trait; (2) there must be differential survival and reproduction associated with the possession of that trait.

Selection theory has appeal in explaining the dynamics of competition in open market structures. It provides a framework for market competition (Alchian 1950; Merrell 1984; Moore 1993) without critically disrupting the prevailing paradigm of what constitutes an organization (Price 1995), since the selection occurs at the population level. Rothschild (1992) looks at the economic process as a selective competition between technologies.

Lloyd (1990) introduces a further concept in viewing commercial competition as a selection process between competing strategic memes. A meme is defined as a self replicating element of culture, passed on by imitation. Memes are ideas, behaviours or skills passed on from person to person by imitation. Ideologies, fashion, catch-phrases are examples of memes. The term was coined by Richard Dawkins in *The Selfish Gene* (1976). Dawkins moves the power of determining the future away from the species and onto their internal genes. The selfish gene refers to a gene that will sacrifice its host in order to preserve itself. For example, a bee will die after stinging an intruder in order to protect the hive. Dawkins paved the way for the concept of memes or self-reproducing ideas, which, he claims use humans exclusively for their propagation. If we are puppets, he says, at least we can try to understand our strings. Dawkins has come under strong criticism from several fronts, including biologists and religious circles. For Gould, physical constraints, developmental interactions, chance, cascades of species extinction and punctuated equilibria mean that the overall shape of life on earth is not explicable in selfish-gene adaptationist terms. Religious circles reacted to Dawkins' attack on creationism in the *Blind Watchmaker*. Dawkins' key hypothesis, in this regard, is that there is the universe, and the species within it came about by chance and that there is no purpose to the cosmos and our existence.

Memes effect our thought processes just as genes determine the nature of our bodies. Blackmore (1998) investigates whether the link between genes and memes can lead to important discoveries about the nature of the inner self.

Blackmore tackles the issue of our inner selves, concerning emotions, memories, beliefs and decisions through memetics. She considers the inner self as merely an illusion created by the memes for the sake of replication. Memes compete to establish themselves into our brains and minds. Blackmore uses memetics to explain how our telephones, televisions and computers could have been designed for the replication of memes. Memetics can account for our need to communicate and think. It can explain why ideologies are such powerful forces of competition and why they cause so many struggles in human lives.

Organizational selection is a process of displacement of older less well-adapted technologies or strategic memes by newer forms. Examples are found in the emergence of new industries and markets facilitated by the development of technology. Firms, which are capable of securing their position in such new industries, are observed to keep a hold on critical capability and build a web of dependent and interdependent players.

Variation through chance versus intent. When genetics was incorporated into Darwin's theory, it became accepted that the generation of new variations is a chance process. Change in a species does not come about because it is intended. It arises by random processes governed by the laws of genetics.

The biological world views variation in species as occurring by chance and not through intent to adapt to the environment, or through the direction of the species to a higher form. However, it is generally recognized that change in organizations is generally Lamarckian in that strategic intent is present. Lamarckian concepts may also be used to explain how culture involves the spreading of behavioural norms through tradition and education. Lamarck is reflected in the work of Lysenko (1898–1976), who dismissed the advances that had been made in classical genetics and held that the variability of organisms was determined by environmental changes.

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There is considerable debate regarding change through intention in organization. The debate is stimulated by the mainstream versus revisionist views of corporate strategy. Bowman and Helfat (2001) and McNamara and Vaaler (2001) provide a comprehensive analysis of the debate. Mainstream research assumes that factors associated with strategic management have a significant effect on the performance of its business units (Chandler 1962). Revisionists suggest that factors at corporate level have little or no effect on business-unit performance. The effect of strategic intent is less significant than factors at the business-unit and industry levels. Revisionists' views are developed from empirical work which measures the relative impact of corporate-level factors (McGahan and Porter 1997; Rumelt 1991; Schmalensee 1985). For example, Koza and Lewin (1999) examine an accounting service network created with the strategic intent of delivering incremental income in exchange for referrals across borders. The findings show that the projects had unpredicted positive returns, which were generated by the interactions within the network.

McNamara and Vaaler (2001) show that corporate strategy history from the 1970s and early 1980s supports the revisionists, but corporate strategy dynamics in the 1990s clearly support the mainstream view. The evolution of increasing effects of strategy coincided with a period were there was more focus on corporate performance. McNamara and Vaaler's research may not end the debate between revisionist and mainstream supporters, but may reconcile factors based on the time-period of observation from which the views emerged. Their analysis does not include investigation into the root causes of the effect of corporate strategy.

There is scope for further research on this area, particularly on why there are fluctuations in strategic effects. Evolutionary theory may provide a basis for the framework to analyse strategic intent from a multilevel contextual perspective.

Gradual steady rate of change. Change is gradual and slow, taking place over a long time. Supporters of the Modern Synthesis of the theory of evolution have focused on small changes in genes over a number of generations. It was thought, until recently, that the gradual changes from generation to generation that can be accurately tracked with the Hardy– Weinberg equilibrium equation indicated that past species regularly evolved gradually into other species over millions of years (Figure 3).

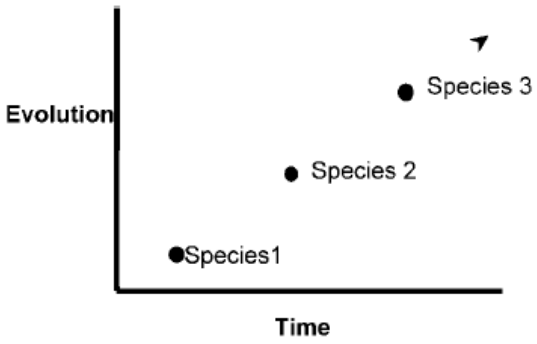

Figure 3. Gradual evolution.

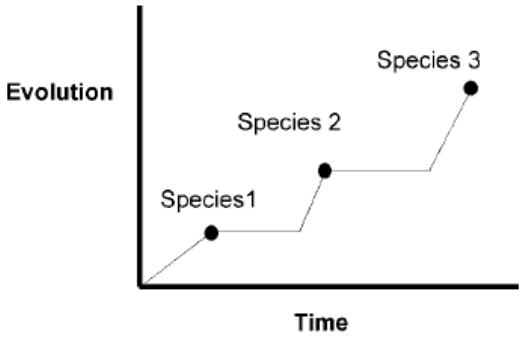

Figure 4. Punctuated evolution.

Fossil records were believed to support this theory. The concept of gradual change is reflected in research on corporate survival, which covers extended periods of corporate history. For example, Malerba and Orsenigo (1999) look at patterns of technological entry and exit across sectors and over the time period from 1978 to 1991.

The concept of gradual change is contested by a view of episodes of rapid change and long periods of stasis, known as punctuated equilibrium, to which we now turn.

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Probability Theory

Probability theory found its way into evolution research through the introduction of genetics. The next sections look at the issues and dynamics that fall under this mainstream of evolutionary thinking.

Punctuated equilibrium. Punctuated equilibrium (Eldredge and Gould 1972) describes a view of evolution where there are extended phases of consistency intermittently disrupted by short surges of new life forms. The pattern resembles Schumpeterian models, which have dominated the field of innovation diffusion and economic change (Figure 4).

Schumpeter (1939) conceptualizes long waves as disturbances in the equilibrium of an economic system, the exhaustion of these disturbances, and an eventual return to equilibrium. Schumpeter's work links to the phenomena of Kondratiev long waves in the economy (Freeman 1994). In terms of the overall industry, knowledge acquisition proceeds as a succession of learning curves, each building upon one another. Organizations demonstrate traits of punctuated equilibrium in the development of strategy, capability, processes and the production of novel concepts through research and development (Gersynk 1991; Price and Evans 1993). Punctuated equilibrium frameworks of transformation have become important theoretical models for research in change in organizations. Tushman and Romanelli (19985) tested the model formally. Their conclusions for the US minicomputer industry were: (1) a large majority of organizational transformations were accomplished via rapid and discontinuous change over most or all domains of organizational activity, (2) small changes in strategies, structures and power distributions did not accumulate to produce fundamental transformations; and (3) major environmental changes and chief executive officer succession influenced transformations.

Supporters of punctuated equilibrium theory contend that organizational activity is usually stable. Environmental conditions and the managerial decisions made during the time of founding the organizations will determine the initial pattern of activity (Boeker 1988; Eisenhardt and Schoonhoven 1990). Later on, the organizations develop an understanding to support continuation of the established patterns as a result of inertia within the organization (Hannan and Freeman 1984) and as a result of institutionalization (Meyer and Rowan 1977).

This aspect is reviewed in Tushman and Romanelli (1985). Radical, sporadic change of an organization's activities is necessary to break loose from inertia. The primary conjecture that can be derived from the punctuated equilibrium model is that the pattern of fundamental transformation is one of drastic, brief and all-encompassing change. Of course, the notion of the continual dynamic between continuity and change in social systems is hardly a novel one. One key question is the extent to which the process of punctuated equilibrium in organizational development is to be seen either as itself a result of specific strategic choices at the industry level, as in the generational label widely used in the computer industry, or as an internal mobilization strategy used by senior management in a particular organization to build collective support for change.

The concept of punctuated equilibrium is used by Wollin (1996), who incorporates a multilevel analysis to explain change in organization and industry systems. According to Wollin the multilevel, punctuated equilibrium model provides a useful viewpoint for understanding complex systems, such as organizations. It uses analogies from thermodynamics, mainly based on self-organizing mechanisms and deterministic chaos. *Historic contingency and stochastic drift.* Probability theory refers to change that occurs through historic contingency and stochastic drift (Eldredge and Gould 1972). Historic contingency is an event that may or may not occur, which will in turn determine the probability of the occurrence of future events. Stochastic drift is any random process, which evolves over time. For example, the evolution of the dollar exchange rate is a particular stochastic process often described as a 'random walk'. Eldredge and Gould see evolution following such a path. History and evolution cannot be clearly predicted, because they depend on time and chance, on mutation and innovation, on resources and environmental factors, on previous events. However, they do not depend on a plan or an inherent, common drive towards a higher state of being. Studies on organizational

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evolution subscribe to a diverse set of views. At one end are theories that show a process of organizational development that tends towards a more efficient or effective organization (Nelson 1994). Other theories assume a process that creates organizations that are historically efficient. Carroll and Harrison (1994) show that path dependent processes in computer simulations could often generate outcomes other than those implied by historical efficiency. In contrast, Barnett and Sorenson (1999) emphasize the importance of social constraints, where each organization's fitness depends on its co-evolutionary relationships with other organizations. They argue that these social constraints, under certain conditions, lead organizations to adapt badly to their environment. Variation, selection and retention in organizations are linked in continuous feedback loops and cycles, but March (1994) points out that the process is not historically efficient. For example, a manager may be reluctant to invest funds in improvements that are likely to benefit his successor. The decisions that are generated, selected and implemented may be driven by motives other than those that benefit a company in the long term. We therefore recognize that the very processes of selection with organizations may be driven by incentives and criteria which relate poorly if at all to longer-term considerations of organizational viability.

Sources of change. Incorporated in the punctuated equilibrium model is the concept that change emerges from small groups isolated from the main population (Eldredge and Gould 1972). A large population stifles the chance that a mutation in a species will be passed on to the next generation. Genetic studies show that small mutations are removed from large populations, hence implying that surviving mutations cannot come from mainstream groups (Maynard-Smith 1997; Mayr 1982). Hence evolution is more likely to occur if a small population is cut off from its parent population. The source of change in punctuated equilibrium theory sheds light on the mechanics of entrepreneurship and how it works. It also explains why some organizations are unable to sustain excellence in the long term (Price 1995). Incremental change is fastest in small groups within a company and will take time to diffuse through the whole organization. Price (1995) reviews research which shows that innovation and learning happens most easily in isolated populations (Beer *et al*. 1990; Pascale 1991; Schaffer and Thompson 1992; Tushman and Romanelli 1985). The Canon's photocopier drive came from an overseas subsidiary and not from the planners in Japan (Hamel and Prahalad 1989). Price (1995) looks at organizational paradigms as the limiting factor on innovation. He recommends that, in order for organizations to foster innovation, they should intentionally isolate small groups to allow new ideas to develop. Then they have to bring the ideas back to the main organization and allow them to diffuse through the organization. The concept of moving away from the core population to generate creativity is analogous to the concept of resource partitioning in markets. In ecology, resource partitioning occurs when different species have to share resources in the same area, but at different levels. For example, birds would feed from the trees, and mammals would feed from resources on the ground in the same woodland. The concept is modified when applied to markets, where it deals with the population dynamics of competing generalist and specialist organizations. ''Increasing concentration enhances the life chances of specialist organisations'' (Carroll and Hannan 1995). The importance of resource partitioning is that it contrasts with perspective from industrial economics. The latter sees high concentration as a barrier to entry for small organizations, while resource partitioning sees concentration as an opportunity for specialist firms to move away from the core market and to create new niches.

Dual nature of evolution. Evolutionary dynamics as explained by Eldredge and Gould (1972) refer to two modes of evolution occurring in parallel. On one hand, the replication of genes in a large population discourages the continuation of mutation. Larger populations act as a stabilizing dynamic for established genes. On the other hand, sudden change, or punctuated equilibrium, is possible through mutation from isolated smaller populations. The smaller populations become a source of change, counterbalancing the inertia of larger populations. The concept is summarized in Figure 5.

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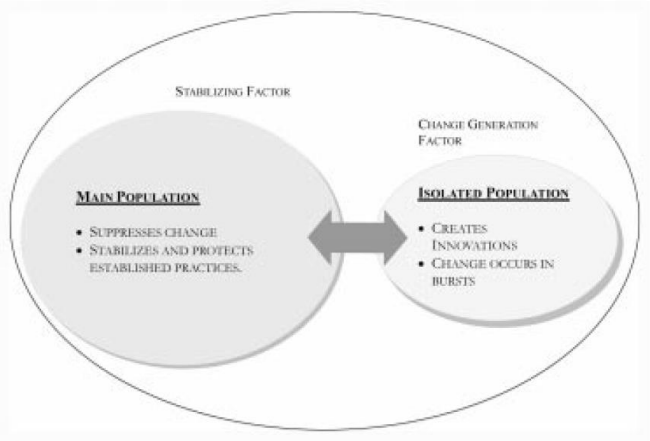

Figure 5. Dual nature of evolution.

If genetic processes impede step changes in evolutionary stable strategies, what is their equivalent in organizations? Inertia is a cause of an organization's effort to change and improve. Inertia has attracted the attention of several researchers who have examined this matter in order to identify it and to analyse how it operates within organizations.

Hannan and Freeman (1984) popularized the term 'inertia' in organizational literature treating the issue from a population ecology perspective. They defined 'structural inertia' as a primary component of an organization's inability to adapt successfully due to internal structural arrangements and environmental constraints. Inertia is not always a symptom of failure (Delacroix 1991; Kelly and Amburgey 1991), but it is certainly present in organizations and limits initiatives towards change.

Inertia is investigated further in Huff and Huff (1995). It constitutes one of the four factors that effect strategic change in the SIOP model. The model is primarily based on Stress arising from organizational limitations, Inertia in resource and commitment to the current strategy, Opportunity and Position in the industry. The model is designed to predict the timing of major change in strategy and the magnitude and direction of change.

Price (1995) looks at inertia, mental models and the unwritten rules in organizations. He uses mimetics to explain the phenomenon. The concept is built upon Dawkins' idea that the primary objective is the preservation of the gene, and not necessarily the organism. Companies are viewed as self-organizing entities that evolve through learning. An organism is created through genetics, while an organization is a product of the meme or mental model (Blackmore 1998). It acts like a gene to preserve itself by guiding the organization around a set of unspoken and unwritten rules and assumptions. Change in organizations follows the path of punctuated equilibrium, where innovations in products and processes occur in groups isolated from prevailing mental norms or memes.

Complexity Theory

Coveney and Highfield (1995) define complexity as a ''new way of thinking about the behaviour of interacting units, be they atoms, ants in an ant colony, flocks of birds, an ecosystem, corporations in an economy, or players in a stock market''.

For the purpose of our discussion, it is vital to delineate the difference between complicated systems and complex systems. A complicated systems, such as a thesaurus, is rich in detail. A complex system, such as a multinational organization, is rich in structure.

Managers are used to dealing with problems that are complicated and require attention to detail. Getting the task done is the primary objective, whether they are running a department, an IT system or

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a multinational company. Problems are broken down into constituent parts. Experts are engaged to solve each part within a management hierarchy.

This method fails when it is applied to problems that are complex, such as managing the growth of a fast-moving technology company. The rules keep shifting with changes in corporate and economic environments, and the organization keeps reorganizing itself to handle such shifts. An action on one part of the problem affects the behaviour of another part. Complexity theory partly explains the process of how organized systems spontaneously emerge out of chaotic systems. Complex systems are not merely complicated, static objects, but spontaneous, self-organizing, systems (Ditto and Pecora 1993, 78–79; Waldrop 1992, 11–12). The value of complexity theory to organizational researchers is its ability to account for the structure, coherence and self-organizing processes of an organizational system.

Recent developments in complexity and chaos theories provide a new explanation of the patterns of organizational change. The development cannot be attributed to a defined author as the field borrows from several others such as thermodynamics, chemistry and mathematics (Eigen and Schuster 1979; Mandelbrot 1983; Prigogine and Stengers 1984). Since the introduction of Complex Adaptive Systems, the biological metaphor has began to loom in management theory. The complexity paradigm views organizations as systems that evolve through a process of selection (Lloyd 1990; Price 1995). The development of Complex Adaptive Systems offers an explanation of evolution that downplays selection in Darwinian terms (Capra 1996; Kaufman 1995).

Complexity theory does not need to have a complex explanation. The principle of Occam's Razor1 applies in dealing with complexity for the study of organizational change. The following sections crystallize the key characteristics of complexity and their relevance to organizations.

Self-organizing systems. An example of a selforganizing system is a flock of birds flying in formation. The formation is formed by the subconscious rules followed by each bird, such as maintaining a fixed distance from its neighbour. Reynolds (1987) captures the essence of flocking behaviour in a computer simulation. The boids, or birds, are given three simple rules: to maintain a minimum distance from other objects in the vicinity, to match their velocity to that of neighbours and to move towards the perceived centre of the group.

The implication for organizations is considerable. A complex adaptive system starts with simple rules and goals for the individual, which create an organized complex formation. The end result is a configuration that seems to have its own life, which is capable of moving in harmony without a leader or external control. The process is bottom up, starting with a few simple rules for individuals, which create a flowing complex system.

The dynamics of supply and demand in an economy operate in the same way. Pricing strategy and purchasing decisions are adjusted in a self-organizing manner. The effect is termed 'emergent' self-organization. It explains the behaviour of traders in the stock market who decide the value of a flotation and determine future share value. The emergent behaviour is visible in thousands of transaction on the stock market which show the same characteristics, in the absence of an imposed rule for everyone to act that way (Battram 1999), reminiscent of Adam's Smith invisible hand.2

The rules are not strict and are better described as tendencies. The element of choice remains a prerogative of the individual. Self-organization is basically a process of evolution where the effect of the environment is minimal. The 'tendencies' take place primarily in and through the system itself. Self-organization can be understood on the basis of the same variation and natural selection processes as other, environmentally driven processes of evolution. A random variation process of generating rules and tendencies usually activates self-organization. The process creates an organized formation referred to by von Foerster and Zopf (1962) as the ''order from noise'' principle and the ''order through fluctuations'' mechanism by Prigogine and Stengers (1984).

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Kaufman (1995) captures the essence of self-organization: ''Contrary to our deepest intuitions, massively disordered systems can spontaneously 'crystallize' a very high degree of order.''

Hayek also developed the concept of spontaneous order to explain the advancement of civilizations (Rehr 1992). Language, customs, traditions have evolved without being planned or designed. Consequently, progress in society was not based on a plan or a definable intention. Building on Adam Smith's invisible hand, Hayek showed that planning does not always lead to order. The lack of a guiding hand need not degenerate into chaos. Hayek looks at the market as a prime example of this mechanism. Players in the market are driven by rules and behave within a framework of order, but the complex system that arises is difficult to understand fully.

Price (1995) sees the very process of evolution shifting the rules of organizational competition. Cohen and Stewart (1994) explain the process through the concept of 'simplexity' and 'complicity'. 'Simplexity' is the tendency of a single, simple system to generate highly complex behaviour. This leads to 'complicity', which is when two or more systems interact in a mutual feedback that changes them both, leading to behaviour that is not present in either system on its own. This is also a characteristic of emergence through co-evolution, which is the interdependence between a system, or an organization and its environment.

Lewin and Volberda (1999) look at strategic and organization adaptations as co-evolving with fluctuations in the environment, population and organizational forms. Examples of such fluctuations would be competitive dynamics, technological and institutional changes. New organizations can mutate and emerge from the existing population of organizations.

Continuous adaptation. Continuous adaptation can be seen in the stock market, where investors collect and analyse information and react to it. This is a spiralling feedback loop of modifying behaviour to the situation of other components in the environment. The resultant behaviour will modify the environment and vice versa. The analogy in ecosystems is that fast lions lead to faster gazelles, which would lead to even faster lions. The faster gazelles will survive to pass on their genes, and only faster lions would be able to prey on them and survive.

Battram (1999) looks at complex adaptive systems as continually adjusting their structure in reaction to feedback from their environment. Examples are found in the evolution of species, the changing neurone connections in the human brain, companies rearranging departments, and nations repositioning military and economic partnerships. The key dynamic of the adaptation process is the rearrangement and reconstruction of the building blocks within a system.

As in the case of the feedback loop between lion and gazelle analogy, there is a powerful interrelationship between entities in a system. The concept is termed co-evolution. It is concerned with the adaptation of the needs of all the members in a system, including environmental characteristics.

Capra (1983) asserts: ''Detailed studies of ecosystems over the past decades have shown quite clearly that most relationships between living organisms are essentially co-operative ones, characterized by coexistence and interdependence and symbiotic in various degrees.''

In *The Death of Competition*, Moore (1996) urges businesses to adopt an ecosystem model. He describes how Intel developed a coevolving network of businesses to become a major supplier of microchips.

The feedback loop in co-evolution is toward more complexity. There is also the possibility of a decline in diversity, as can be seen with the extinction of several species and the proliferation of mankind. It is not, however, correct to view the direction of evolution towards higher and fitter species. The fitness component is more related to adaptation to the environment than it is related to

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superior performance. As Gould (1996) reminds us, the species that has outlived all is not mankind but the lowly bacteria. Its ability to survive in extreme and diverse environments is unsurpassed.

When environments are competitive and aggressive from the start-up phase, cooperation emerges between the parties for the benefit of all (Axelrod 1997). This type of evolution of co-operation is seen in the mobile telecommunication industry, where companies have to co-operate to set standards and widen their networks by allowing access to each other's systems. Axelrod's work is influenced by the 'prisoner's dilemma'. The riddle is popular with economists and strategists and is cited widely in the literature. The prisoner's dilemma gets its name from a hypothetical situation where two criminals are arrested. The police have insufficient information and try to turn each prisoner into an informant by telling each one that the other has confessed. The 'dilemma' faced by the prisoners here is that, whatever the other does, each is better off confessing than remaining silent. But the outcome obtained when both confess is worse for each than the outcome they would have obtained had both remained silent. A common view is that the puzzle illustrates a conflict between individual and group rationality.

The absence of a leader or an 'invisible hand' in complex systems means we need a more comprehensive understanding of the interrelationships and interdependencies in networks and hierarchies (Battram 1999). Networks need hierarchies and hierarchies would require networks. The requirement for network stems from the benefits derived from co-operation. Herbert Simon asserts the necessity of compartmentalizing work within a system as a means of preventing all the work being lost if a system is disrupted. He looks at a complex system as "one made up of a large number of parts that interact in a non simple way. In such systems the whole is more than the sum of the parts, not in an ultimate, metaphysical sense but in the important pragmatic sense that, given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole" (Simon 1962, p 467).

Isomorphism is another feature of continuous adaptation. Isomorphism is a limiting process that makes companies in a market resemble other companies that confront the same set of commercial conditions. There are two types of isomorphism: competitive and institutional. Organizations struggle for customers and resources, as well as for political power and institutional legitimacy for social as well as economic fitness (DiMaggio and Powell 1983). Another perspective on this aspect of organizational evolution is to be found in the notion of strategic groups within and industry. (For a review of the substantial work in this field, see McGee 2001.)

As McGee and Thomas (1986, 150) note: ''A firm within a (strategic) group makes strategic decisions that cannot be readily imitated by firms outside the group without substantial costs, substantial elapsed time, or uncertainty about the outcome of those decisions.''

Sensitivity to initial conditions. Sensitivity to initial conditions is seen in chaotic systems such as the weather. The 'butterfly effect' symbolizes this process: ''a butterfly flapping its wings over the Amazon leads to a hurricane on the other side of the world'' (Lorenz 1993). Initial conditions are important to organizations and other complex systems. In the case of the boids described in the self-organizing section, the direction of the flight is randomly determined by the results of the first few interactions. ''Catch the wrong train and you will end up somewhere else completely'' (Battram 1999).

The theory of complexity shows how two systems starting out in similar, but not necessarily identical environments, will develop entirely different scenarios. This happens because of the adaptation effects within the system and non-linear dynamics. The units within the system co-operate and adapt to each other creating different organized scenarios. Long-term predictions are thus impossible.

The stock market is a prime example of this effect. The reaction of investors to critical events such as war has explosive effects on share prices. This implies hyper-movements at certain critical points. Technical analysts call these threshold points 'supports' and 'resistances'. The terms refer to the idea

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that buying and selling decisions are partly due, on both the individual and market levels, to psychological reasons. Critical events thus become very significant. A level is considered as a support if, every time a stock tries to break this threshold down, the stock does not achieve that and heads back up. Resistances are psychological levels on the rising of stock that stops the stock from rising above certain levels. *Non-linear*. Evolution experiences non-linear effects in the sense that its path is erratic and can vary extensively. What can be predicted is very limited. A small change in the environment could lead to an unpredicted change in the ecosystem. Another way of looking at non-linearity is that the whole is greater than the sum of the parts. The whole has characteristics and capabilities beyond that of its constituents.

An example from the natural sciences is that the reaction time of a single fish is much slower than the reaction time of a shoal of fish. A human brain is more than the collection of the constituent cells, and depends on the interconnection of its neural networks. Stock markets exhibit non-linear effects as the combined actions of each person feed back upon itself.

Battram (1999) extends the analogy to communication. People generate a multitude of interpretations when they talk about an event. Certain views and ideas will come to dominate the group. The behaviour is non-linear in nature, as certain comments will have a disproportionate effect on others. A tension will often arise from what is in the group's interest and what is the interest of the individual.

Increasing returns and lock in. Increasing returns is positive feedback. It refers to a group of events which cause feedback loops that augment the outcome of the actions. This is how well-adapted species of animals proliferate exponentially in their environment. Certain breeds of bird dominate the urban bird scene, pigeons being a prime example, because of their adaptability. Smaller populations of more delicate birds are weeded out. Our linguistic expressions reflect this trait with phrases such as ''the rich grow richer'', ''success breeds success'', and so on. These type of phrases are echoed by Kelly (1994), as quoted by Battram (1999): Each time you use and idea, a language or a skill you strengthen it, reinforce it, and make it more likely to be used again. That's known as positive feedback or snowballing . . . The law operates in economics, biology, computer science, and human psychology. Life on earth alters earth to beget more life. Confidence builds confidence. Order generates more order. Them that has, gets. Increasing returns cause economic lock-in. Lock-in arises whenever a species is so successful that it dominates the ecosystem, spreads widely, and makes it virtually impossible for other species to rise. The human species is such an example. In the commercial world Microsoft, the VHS videos, and the QWERTY keyboard are classic examples. PC users all over the world are locked into using Microsoft's Windows desktop operating environment, as it became the standard software in offices. VHS tapes outran Betamax tapes, even thought the latter had a superior technology. Most films were on VHS in the early days of introduction. VHS hit its critical mass earlier than Betamax, thereby overtaking the market. The QWERTY keyboard was designed to slow down typists and to reduce the incidence of jamming. Jamming is no longer an issue with electronic keyboards but the diffusion of the layout is so widespread that few people would hazard to train on a different system such as Dvorak, even though it is faster.3

Emergence of novelty. The mainstream theories of evolution deal with the emergence of new processes from different perspectives. The Natural Selection and Probability mainstreams view the emergence of mutation, or novelty, as a chance event that cannot be driven by the intention of an organism. The Complexity mainstream looks at the emergence of novelty as nature's way of changing complicated systems into more organized complex ones. It implies that novelty is a generated out of the predisposition of a system to self-organize, as discussed earlier.

Prigogine shows *why* the emergence of novelty is possible in mathematical terms. Holland (1998) shows *how* novelty is created. He explains how a small number of rules can produce structures of surprising intricacy. Chess would be a classic example. It is defined by less than two dozen rules, but the numerous models that result create continuous novelty and emergence. It took centuries of observation of the game to acknowledge patterns of play, such as the control of pawn formations. Once they were recognized, the patterns enhanced the possibility of winning the game. More new

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strategies of play emerged, fuelled by previous discoveries and the all-encompassing objective of winning. The recognition of similar examples in other facets of our world opens the way to a deeper understanding of the complexity of life.

Conclusion

The adoption of evolutionary analogies to explain commercial behaviour often works sufficiently well to help understand a complex and ever-changing web of scenarios and players. As with other theories and approaches, it cannot encompass the full picture, and has inherent bias and assumptions. Removing assumptions is like working with a map on a 1:1 scale. The map includes everything, but therefore provides no additional value. The school of strategy (Alchian 1950; Henderson 1989) has historically advocated commercial competition as a process of survival of the fittest. Traditional and evolutionary concepts of competition emphasize different aspect of the competitive processes (Bauer 1997). According to Bauer, evolutionary theory's merits lie in its ability to: offer an understanding of the dynamics of change in companies and the regulation affecting them improve our awareness that such processes are continuously in progress concentrate analysis on long-run processes rather than short-run minimal changes include qualitative as well as quantitative change deal with variation and diversity with none equilibrium as well as equilibrium states, and with the possibility of persistent and systematic error-making and thereby non optimizing behaviour (Hodgson 1993) explain path dependence in economic processes and avoid the presumption that economic change necessarily increases efficiency.

If the limitations of evolutionary theory are understood, a more rational basis for its use can be developed. Evolutionary theories cannot explain why organisms and organizations behave in certain ways. At best, it can explain the predominance of the least foolish of fools (Khalil 2000). More generally, it can account for the dissemination of productive qualities, but not of their source. The theory of selection fails to provide the necessary grounds for the rise of such traits. It rather appeals to blind mutation and chance. For natural selection to operate, there must be a trial and error system. The theories of Probability and Complexity provide an enhanced view of change and transformation in organizations, bringing in a variety of process dynamics. They provide a better explanation than Selection theory, although they contribute more to insights for system design, rather than describe the reasons for system behaviour.

Particularly indeterminacy of corporate change has been recognized in the literature in the field of longitudinal time studies and organization evolution. Research which applies evolutionary models is able to explore the complex, stochastic ways in which change emerges and will develop a framework that allows for an appreciation of conflicting rationality, objectives and behaviours.

An evolutionary approach to change and transformation complements the established practices in longitudinal research. Evolutionary frameworks can focus on the significance of circumstances effecting change in the context of interconnected levels of analysis. Change will be traced through different time frames located in the past, present and future. Context and action will be explored as products of each other. The central assumption of indeterminacy will remain as evolutionary theory tolerates it. Causation in this kind of holistic analysis of change is neither linear nor singular. For instance Juarrero (1999) calls for a return to an Aristotelean plurality of causes and a serious scrutiny of modern Humean, positivist science. Research, which applies an evolutionary perspective, can look into the ongoing cycle of change and transformation at a multiple levels of analysis, thereby providing a more comprehensive explanation and interpretation.

Notes

1 The principle of Occam's razor is originally found in philosophy but is applicable in science. It states that, when several theories model the available facts adequately, the simplest theory is to be preferred. The principle is named after William of Occam (1280–1349).

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2 As a number of very distinguished commentators have pointed out, Adam Smith himself did not give great emphasis to the 'invisible hand' specifically in his writings: for instance it only occurs once in his *Wealth of Nations*: ''He (every individual) generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it . . . by directing that industry in such as a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention. Nor is it always the worse for society that it was no part of it.''

3 As one might expect, it would appear the history of the development of the QWERTY keyboard is a little more complicated than this common version. In fact, there are questions about both the degree to which in the technology of the time it actually reflected an efficient rather than inefficient solution as well as the evidence for the degree of benefit of the Dvorak option (see http://home. earthlink.net/~dcrehr/whyqwert.html).

References

Alchian, A.A. (1950). Uncertainty, evolution and economic theory. *Journal of Political Economy*, 58, 211–221.

Aldrich, H. (1999). *Organizations Evolving*. Thousand Oaks, CA: Sage.

Aldrich, H.E. (1979). *Organizations and Environments*. Englewood Cliffs, NJ: Prentice-Hall.

Anderson, P., Arrow, K. and Pines, D. (eds) (1988). *The Economy as an Evolving Complex System*. Redwood City, CA: Addison-Wesley.

Axelrod, R. (1997). *The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration*. Princeton, NJ: Princeton University Press.

Barkow, J.H., Cosmides, L. and Tooby, J. (eds) (1992). *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*. New York: Oxford University Press.

Barnett, W.P. and Sorenson, O. (1999). *The Red Queen in Organizational Creation and Development*. Research Paper Series, Graduate School Of Business Stanford University.

Battram, A. (1999). *Navigating Complexity: The Essential Guide to Complexity Theory in Business and Management*. London: Industrial Society.

Bauer, J. (1997). Competition in network industries: an evolutionary perspective. Paper presented at the Annual Conference of the Transportation and Public Utilities Group of the American Economic Association, New Orleans, Louisiana, 4–7 January.

Baum, J.A.C. and Singh, J.V. (1994). Organizational hierarchies and evolutionary processes. In Baum, J.A.C. and Singh, J.V. (eds), *Evolutionary Dynamics of Organizations*. New York: Oxford University Press, pp. 3–20.

Beckerman, L. (1999). *The Non-Linear Dynamics of War. Science Applications*. Florida: International Corporation.

Beer, M., Eisenstat, R.A. and Spector, B. (1990). Why change programs don't produce change. *Harvard Business Review*, November–December, 158–166. Blackmore, S. (1998). *The Meme Machine*. Oxford: Oxford University Press.

Boeker, W. (1988). Organizational origins: entrepreneurial and environmental imprinting in founding. In Carroll, G. (ed.), *Ecological Models of Organization*. New York: Ballinger.

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Reference of published article Sammut-Bonnici, Tanya and Wensley, Robin (2002) Darwinism, probability and complexity: market-based organizational transformation and change explained through the theories of evolution. International Journal of Management Reviews, Volume 4 (Number 3). pp. 291-315. ISSN 1460-8545

Bowman, E.H. and Helfat, C.E. (2001). Does corporate strategy matter? *Strategic Management Journal*, 22, 1–23.

Burgelman, R.A. and Mittman, B.S. (1994). An intraorganizational ecological perspective on managerial risk behavior, performance, and survival: individual, organizational and environmental effects. In Baum, J.A.C. and Singh, J.V. (eds), *Evolutionary Dynamics of Organizations*. New York: Oxford University Press, pp. 53–75. Campbell, D. (1969). Variation and selective retention in socio-cultural evolution. G*eneral Systems*, 14, 69–85.

Capra, F. (1983). *The Turning Point*. London: Fontana Flamingo Series.

Capra, F. (1996). *The Web of Life.* New York, Anchor Books.

Carroll, G.R. (1984). Organizational ecology. *Annual Review of Sociology*, 10, 71–93.

Carroll G.R. (1993). A sociological view on why firms differ. *Strategic Management Journal*, 14, 237–249.

Carroll, G.R. and Hannan, M.T. (eds) (1995). *Organizations in Industry*. Oxford: Oxford University Press.

Carroll, G.R. and Harrison, J.R. (1994). On the historical efficiency of competition between organizational populations. *American Journal of Sociology*, 100, 720–749.

Chandler, A.D. Jr (1962). *Strategy and Structure: Chapters in the History of American Industrial Enterprise*. Cambridge, MA: MIT Press.

Cohen, J. and Stewart, I. (1994). *The Collapse of Chaos: Discovering Simplicity in a Complex World*. Harmondsworth: Penguin Books.

Coveney, P. and Highfield R. (1995). *Frontiers of Complexity*. London: Faber & Faber.

Darwin, C. (1859). *On the Origin of Species by Means of Natural Selection: or the Preservation of Favoured Races in the Struggle for Life*. London: John Murray.

Dawkins, R. (1976). *The Selfish Gene.* Oxford: Oxford University Press.

Delacroix, J. (1991). Cosmetic, speculative, and adaptive organizational change in the wine industry: a longitudinal study. *Administrative Science Quarterly*, 36, 631–662.

Depew, D.J. and Weber, B.H. (1995). *Darwinism Evolving: Systems Dynamics and the Genealogy of Natural Selection*. Cambridge, MA: MIT Press.

DiMaggio, P. and Powell, W.W. (1983).The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, 48, 147–160.

Ditto, W.L. and Pecora, L. (1993). Mastering chaos. *Scientific American*, 269, 78.

Eigen, M. and Schuster, P. (1979). *The Hypercycle*. Berlin: Springer.

Eisenhardt, K.M. and Schoonhoven, C.B. (1990). Organizational growth: linking founding team, strategy, environment, and growth among U.S. semiconductor ventures, 1978–1988. *Administrative Science Quarterly*, 35, 504–529.

Pre print copy

Reference of published article Sammut-Bonnici, Tanya and Wensley, Robin (2002) Darwinism, probability and complexity: market-based organizational transformation and change explained through the theories of evolution. International Journal of Management Reviews, Volume 4 (Number 3). pp. 291-315. ISSN 1460-8545

Eldredge, N. and Gould, S.J. (1972). Punctuated equilibria: an altenative to phyletic gradualism. In Schopf, T.J.M. (ed.), *Models in Paleobiology*. San Francisco: Cooper, pp. 82–115.

Freeman, C. (1994). The economics of technical change. *Cambridge Journal of Economics*, 18, 463–514.

Futuyma, D.J. (1986). *Evolutionary Biology*. Sunderland, MA: Sinnauer Associates. Gersick, C.J.G. (1988). Time and transition in work teams: toward a new model of group development. *Academy of Management Journal*, 31, 9–41.

Gersynk, C.J. (1991). Punctuated equilibria as a model for organisational change. *Academy of Management Review*, 16,10–23.

Ghiselin, M.T. (1992). Biology, economics, and bioeconomics. In Radnitzky, G. (ed.), *Universal Economics: Assessing the Achievements of the Economic Approach*. New York: ICUS, pp. 55– 104.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scottand, P. and Trow, M. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: Sage.

Gould, S.J. (1996). *Life's Grandeur: The Spread of Excellence from Plato to Darwin*. London: Jonathon Cape.

Hamel, G. and Prahalad, C.K. (1989). Strategic intent. *Harvard Business Review*, May–June, 63–76.

Hannan, M.T. and Freeman, J. (1977). The population ecology of organizations. *American Journal of Sociology*, 82(5), 929–964.

Hannan, M.T. and Freeman, J. (1984): Structural inertia and organizational change. *American Sociological Review*, 49, 149–164. Hannan, M.T. and Freeman, J. (1989). Organizations and social structure. In *Organizational Ecology*. Cambridge, MA: Harvard University Press, pp. 3– 27.

Henderson, B. (1989). The origins of strategy. *Harvard Business Review*, 67, 139–143.

Hodgson G.M. (1993). *Economics and Evolution: Bringing Life Back into Economics*. Cambridge: Cambridge University Press.

Holland, J.H. (1998). *Emergence: From Chaos to Order.* Reading, MA: Addison-Wesley. Horgan, J. (1995). From complexity to perplexity. *Scientific American*, 272, 74–79.

Huff, J. and Huff, A.S. (1995). Stress, inertia, opportunity and competitive position: a SIOP model of strategic change in the pharmaceuticals industry. In Moore, D. (ed.), *Academy of Management Best Paper Proceedings*, Vancouver, pp. 22–26.

Hull, D.L. (1988). *Science as a Process: An Evolutionary Account of the Social and Conceptual Development of Science.* Chicago: University of Chicago.

Juarrero, A. (1999). *Dynamics in Action: Intentional Behavior as a Complex System*. Cambridge, MA: MIT.

Kahneman, D. and Tversky, A. (1996). On the reality of cognitive illusions. *Psychological Review*, 103, 582–591.

Kauffman, S.A. (1995). *At Home In The Universe*. Oxford: Oxford University Press.

Pre print copy

Reference of published article Sammut-Bonnici, Tanya and Wensley, Robin (2002) Darwinism, probability and complexity: market-based organizational transformation and change explained through the theories of evolution. International Journal of Management Reviews, Volume 4 (Number 3). pp. 291-315. ISSN 1460-8545

Kelly, K. (1994). *Out of Control: The New Biology of Machines, Social Systems, and the Economic World*. Reading, MA: Addison-Wesley.

Kelly, D. and Amburgey, T.L. (1991). Organizational inertia and momentum: a dynamic model of strategic change. *Academy of Management Journal*, 34, 591–612.

Khalil, E.L. (2000). Survival of the most foolish of fools: The limits of evolutionary selection theory. *Journal of Bioeconomics*, 2, 203–220.

Koza, M.P. and Lewin, A.Y. (1999). The coevolution of network alliances: a longitudinal analysis of an international professional service network. *Organization Science*, 10, 638–653.

Levinthal, D.A. (1991). Organizational adaptation and environmental selection: interrelated processes of change. *Organization Science*, 2, 140–145.

Lewin, A.Y. and Volberda, H.W. (1999). Prolegomena on coevolution: a framework for research strategy and new organizational forms. *Organization Science*, 10, 519–534.

Lichtenstein, B.M. (1995). Evolution or transformation: a critique and alternative to punctuated equilibrium. In Moore, D. (ed.), *Academy of Management Best Paper Proceedings*, Vancouver, pp. 291–295.

Lissack, M.R. (1996). Chaos and complexity – What does that have to do with knowledge management? Working Paper. Henley Management College. Lloyd, T. (1990). *The Nice Company*. London: Bloomsbury.

Lopreato, J. and Crippen, T (1999). *Crisis in Sociology: The Need for Darwin*. New Brunswick, NJ: Transaction.

Lorenz, E.N. (1993). *The Essence of Chaos*. Seattle, WA: University Of Washington Press.

Malerba, F. and Orsenigo, L. (1999). Technological entry and diversification in Europe, the Unites States and Japan. In Gambardella, A. and Malerba, F. (eds), *The Organization of Economic Innovation in Europe*. Cambridge: Cambridge University Press.

Mandelbrot, B.B. (1983). *The Fractal Geometry of Nature*. San Francisco: W.H. Freeman.

March, J.G. (1994). *A Primer on Decision Making: How Decisions Happen*. New York: Free Press. Masters, R.D. and Gruter, M. (eds) (1992). *The Sense of Justice: An Inquiry into the Biological Foundations of Law*. Newbury Park, CA: Sage.

Maynard Smith, J. (1997). *The Theory of Evolution*, 3rd edition. Cambridge: Cambridge University Press.

Mayr, E. (1982). *The Growth of Biological Thought: Diversity, Evolution, and Inheritance*. Cambridge, MA: Belknap Press of Harvard University Press. McGahan, A.M. and Porter, M.E. (1997). How much does industry matter, really? *Strategic Management Journal*, 18, (Summer), 15–30.

McGee, J (2001). Strategic groups: theory and practice. Working Paper, Warwick Business School.

McGee, J. and Thomas, H. (1986). Strategic groups: theory, research and taxonomy. *Strategic Management Journal*, 7, 141–160.

Pre print copy

Reference of published article Sammut-Bonnici, Tanya and Wensley, Robin (2002) Darwinism, probability and complexity: market-based organizational transformation and change explained through the theories of evolution. International Journal of Management Reviews, Volume 4 (Number 3). pp. 291-315. ISSN 1460-8545

McKelvey, B. (1982). O*rganizational Systematics: Taxonomy, Evolution, Classification*. Berkeley, CA: University of California Press.

McNamara, G. and Vaaler, P.M. (2001). Evolving corporate effects: reconciling mainstream and revisionist views of corporate strategy. Work in Progress. Broad School of Management, Michigan State University.

Merrel, D.W. (1984). The organization – a living system. *The Management Psychologist*, 6, 3–14. Metcalfe, J.S., Fonseca, D. and Ramlogan, R. (2000). Manchester University innovation, growth and competition: evolving complexity or complex evolution. Paper presented at the Complexity and Complex Systems in Industry Conference 2000, University of Warwick.

Meyer, J.W. and Rowan. B. (1977). Institutionalized organizations: formal structure as myth and ceremony. *American Journal of Sociology*, 83, 340–363.

Miner, A.S. (1990). Structural evolution through idiosyncratic jobs: the potential for unplanned learning. *Organization Science*, 1, 195–210.

Miner, A.S. (1995). Organizational evolution and the social ecology of jobs. In Sproull, L. and Cohen, M. (eds), *Organizational Learning*. New York: Sage, pp. 376–402.

Moore, J.F. (1993). Predators and prey: a new ecology of competition. *Harvard Business Review*, May– June, 75–86.

Moore, J.F. (1996). *The Death of Competition*. New York: Harper Business.

Nelson, R.R. (1994). The co-evolution of technology, industrial structure, and supporting institutions. *Industrial and Corporate Change*, 3, 47–63. Nelson, R.R. (1995). Recent evolutionary theorizing about economic change. *Journal of Economic Literature*, 33, 48–90.

Nelson, R.R. and Winter, S.J. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Oaksford, M. and Chater, N. (1998). *Rationality in an Uncertain World: Essays on the Cognitive Science of Human Reasoning*. Hove, Sussex: Psychology Press.

Pascale, R.T. (1991). *Managing on the Edge*. New York: Simon & Schuster.

Price, I. (1995). Organisational, memetics? Oorganisational learning as a selection process. *Management Learning*, 26, 299–318.

Price, I. and Evans, L. (1999). Punctuated equilibrium: an organic model for the learning organization. *FORUM*, 93, 1–7.

Prigogine, I. and Stengers, I. (1984). *Order Out Of Chaos.* New York: Bantam Books.

Quinn, J.B. (1980). *Strategies for Change: Logical Incrementalism*. Homewood, IL: Irwin.

Rehr, D. (1992). In Hayek's legacy of the spontaneous order. T*he Region*, June. Federal Reserve Bank of Minneapolis.

Reynolds, C.W. (1987). Flocks, herds and schools: a distributed behavioural model. *Computer Graphics*, 21(4), 25–34.

Pre print copy

Reference of published article Sammut-Bonnici, Tanya and Wensley, Robin (2002) Darwinism, probability and complexity: market-based organizational transformation and change explained through the theories of evolution. International Journal of Management Reviews, Volume 4 (Number 3). pp. 291-315. ISSN 1460-8545

Richerson, J. and Boyd, R. (1999). The evolutionary dynamics of a crude super organism. *Human Nature*, 10, 253–289.

Rothschild, M. (1992). *Bionomics: The Inevitability of Capitalism*. London: Futura.

Rumelt, R.P. (1991). How much does industry matter? *Strategic Management Journal*, 12, 167–185.

Schaffer, R.H. and Thompson, H.A. (1992). Successful change programs begin with results. *Harvard Business Review*, January–February, 80– 89.

Schmalensee, R.H. (1985). Do markets differ much? *American Economic Review*, 75, 341–351.

Schumpeter, J.A. (1939). *Business Cycles*, Vol. 1. New York: McGraw-Hill.

Simon, H.A. (1962). The architecture of complexity. *Proceedings of the American Philosophical Society*, 106, 467–482.

Singh J.V. (ed.) (1990). *Organizational Evolution*: *New Directions.* Newbury Park, CA: Sage. Smith, M. (1993). Changing sociological perspectives on chance. *Sociology*, 27, 513–520.

Stenning, K.E. and van Lambalgen, M. (2001). Semantics as a foundation for psychology: a case study of Wason's selection task. *Journal of Logic, Language and Information*, 10, 273–317.

Tullock, G. (1994). *The Economics of Non-Human Societies*. Tucson, AZ: Pallas Press.

Tushman, M. and Murmann, J. (1998). Dominant designs, technology cycles and organizational outcomes. *Research in Organizational Behavior*, 20, 231–266.

Tushman, M. and Romanelli, E. (1985). Organizational evolution: a metamorphosis model of convergence and reorientation. *Research in Organizational Behavior*, 7, 171–222.

Vincenti, W.G. (1990). *What Engineers Know and How They Know It: Analytical Studies from Aeronautical History*. Baltimore, MD: Johns Hopkins University Press.

Von Foerster, H. and Zopf, G.W. (eds) (1962). *Principles of Self-Organization*. Oxford: Pergamon.

Waldrop, M. (1992). *Complexity: the Emerging Science at the Edge of Chaos*. New York: Simon & Schuster. Wason, P.C. (196 6). Reasoning. In Foss, B.M. (ed.), *New Horizons in Psychology I*. Harmondsworth: Penguin.

Witt, U. (ed.) (1993). *Evolutionary Economics*. Aldershot: Edward Elgar.

Wollin, A.S. (1996). A hierarchy-based approach to punctuated-equilibrium: an alternative to thermodynamic self-organisation in explaining complexity. Paper presented to INFORMS National Meeting. Working Paper.