Transcendental Foresight:
Using Complexity Science to Foster Distributed Seeing

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1 INTRODUCTION

This article is about "*transcendental foresight*." This phrase reflects the "*transcendental realism*" of Roy Bhaskar (1975), one of the founders of modern scientific realist philosophy of science. Foresight is about peering into the future to discern which events are likely to cause other events. By using the term "transcendental," Bhaskar simply reminds us that causality stems from levels different from the plane of our directly observable experience. It is for this reason that the Vienna Circle logical positivists eschewed causality as being metaphysical and therefore outside the realm of scientific findings and discourse directly accessible by the human senses. This leads me to focus on '*supra-drivers*' and '*sub-drivers*'.

The conference CALL leading to this special issue quotes Alfred North Whitehead as saying, *foresight* is "…the ability to see through the apparent confusion, to spot developments before they become trends, to see patterns before they fully emerge, and to grasp the relevant features of social currents that are likely to shape the direction of future events" and being able to "… look for generality where there is variety, and to look for idiosyncrasy where there is generality" (????). More easily said than done, I suppose. The conference aimed to "explore ways in which…organizations make sense of their environments and of themselves" (my underlining). This reduces to: Who is doing the looking? What are they looking at?

There are three ways to think about the future—ordered by "foresight doability."

1. Yes, the future—that hasn't happened yet—is uncertain and unknowable, but from the perspective of any given observer, much of what appears to be "an uncertain future" has already happened and is "uncertain" only because the observer is lacking information. In this view, *foresight* is simply learning about the knowable part of what, to the less perspicacious, appears uncertain. No smoke and mirrors here; it is simply a matter of getting out there and studying what has happened before competitors do so.
2. To the perspicacious, future events are dimly indicated by developments that will become trends and by dots that once filled in will become patterns already in place—as suggested by the CALL. This is sort of a pre-trend and pre-pattern view. This presumes a linear, unbroken predictability—the faint glimmerings that we discern now will eventually unfold, as buds slowly turn into flowers. This view assumes that the more perspicacious see the unfolding future sooner than their competitors. This view is closer to the "let history predict the future" view than one might like to think. Except that instead of from past-to-present it is present-into-the-future. The presumption of the underlying dynamic is the same—linear predictability.
3. The path toward the future as fraught with discontinuities, suggesting that what lies before a discontinuity offers little insight as to what lies beyond. This is the view of chaos and complexity theorists. It sees a world of āperiodic, nonlinear, coevolutionary, discontinuous events.

I take the third path, which is the most conservative, if not most realistic.

Astronomers' use the "VLA" observation system in New Mexico, where, instead of one single localized lens (the visionary CEO version), 27 radio telescopes, each movable over a wide geographical area, are distributed so as to maximally "see" and collect the radio signal coming from some distant quasar—equivalent to a single lens 22 miles across! They get a tremendous advantage from "***distributed seeing***." *How to make distributed seeing work better in organizations*? *Can a CEO produce future-oriented, strategically useful, distributed seeing in a world of nonlinear discontinuities?* I begin with a few lessons from recent philosophy of science that point to the use of context to get a grip on predictability and to microcoevolution within the target object—a firm—to get a grip on dynamics. I answer the question, Who's Looking? by focusing on the microcoevolutionary processes comprising the corporate brain. Especially, I study how to speed up the functioning of the corporate brain and how to sharpen its "seeing" ability by using phase transitions to initiate self-organizing activity aimed at collective, foresight-related search behaviors. These are the *sub-drivers* of transcendental foresight.

Key to this process are the adaptive tensions set up to motivate self-organization. This, then, gets at the, Looking at What? question. These are the *supra-drivers*. Here the emphasis turns to the study of longer-run, extant trends at the level above a firm-in-an-industry perspective of most extant strategic analyses—specifically analyses *above* Porter's (1980, 1985) "industry drivers," and efficiency curve perspectives.

Analyses of where a firm stands with respect to these broader adaptive tensions provides information that can be used to both motivate and steer phase transitions, coevolutionary events, and self-organizing behaviors. Bottom line? Supra-drivers and sub-drivers coevolve to improve organizational foresight.

2 DEFINING TRANSCENDENTAL FORESIGHT

To begin, it is important to set the competitive circumstances within which we study organizational foresight.

> The only thing that gives an organization a competitive edge—the only thing that is sustainable—is what it knows, how it uses what it knows, and how fast it can know something new! (Prusak 1996: 6)

Good strategy is no longer just picking the right industry; it is being at the right place in the industry—at the cutting edge of industry evolution—new technology, new markets, new moves by competitors. For firms in high-velocity environments (Eisenhardt 1989), emphasis needs to shift from the competitive dynamics of industry selection and interfirm competition to intrafirm rates of change (McKelvey 1997). Others writing about competitive strategy and sustained rent generation parallel Prusak's emphasis on how fast a firm can develop new knowledge. D'Aveni (1994) focuses on hypercompetitive environments. Porter (1996) emphasizes staying ahead of the efficiency curve. As high-velocity product life-cycles and hypercompetition have increased, speed of knowledge appreciation has become a central attribute of competitive advantage (Leonard-Barton 1995), as has organizational learning (Argote 1999). Learning is seen as a key element of core competence (Barney 1991). Much of the concern about human capital appreciation bears on high-technology based industries (Leonard-Barton 1995, Boisot 1998). Eisenhardt and colleagues have focused on "high-velocity" high-tech firms for some time (Eisenhardt and Tabrizi 1995). In these firms the classic "organic" organizing style is just too slow to keep pace with changes in high-velocity firms, as Eisenhardt (1989) and Brown and Eisenhardt (1997) observe.

It is not just any kind of learning and knowledge that is at stake. Fast learning and knowledge acquisition stemming from foresight is surely more functional in high-velocity environments than, say, catching up quickly. Given high-velocity environments, Hamel and Prahalad (1994) view foresight as seeing economic rents stemming from learning about industry trends before competitors, and imposing "*stretch*," which I will later equate with the energy differentials of the Bénard (1901) process, and generalize into "*adaptive tensions*" (McKelvey 2001). Slywotzky (1996), in his studies of value migration, ostensibly focuses on strategy as a chess game, complete with seven essential chess-like patterns managers need to know about. Underlying this, however, his view actually tells foresight managers to do the kinds of analysis that uncover *how* customers go about discovering what their needs and priorities are—if you know their prioritizing process, you can uncover their priorities as soon or sooner than they do. Collins and Porras (1994) and O'Reilly and Pfeffer (2000) focus on core ideologies—underlying their foresight management processes—that allow some firms to constantly get to new ideas and products before their competitors.

Seeing into, and learning about, trends into the future takes special kinds of learning and special kinds of knowledge development. The lesson from astronomy is that distributed seeing is far better than the vision of a single CEO. To this I add the argument that CEO charisma may actually undermine a firm's distributed seeing ability.

Improving distributed seeing is not only about the "distributed" aspect, but also about where the "seeing" is aimed and at what rate faint signals are magnified to the point that new product development is instigated.

2.1 BHASKAR, EXPLANATION, AND THE PLANE OF OBSERVATION

I mentioned Bhaskar's *transcendental realism* right at the outset. This is the understructure supporting my notion of transcendental foresight. Salthe (1985) devotes an entire book based on his argument that all of science focuses explanation around a "*triadic*" structure. Any focal population of entities (firms in this case) exists in a hierarchy in which there are both upper- and lower-level constraints—environmental ***Context*** and intrafirm ***Agents***, as I use these terms in this paper. Salthe might well have drawn on Bhaskar's (1975) classic discussion of transcendental realism.

Bhaskar makes a clear distinction between developing theory based on identified *regularities*—which could be accidental—and experimentally contrived *invariances* in which repeated experiments produce an outcome regularity by manipulating what is hypothesized to be an *underlying* force, process, mechanism, or structure. Contrived invariances better fit the counterfactual conditional basis of law-like statements about generative forces that might seldom if ever be discernible naturally in complex open systems (like organizations) because of the many countervailing influences. Initially, the mental models of idealists and realists both contain *"imagined"* (Bhaskar's term, p. 145) conceptual, intangible, unmeasurable theory terms. The difference is that for idealists they remain forever intangible, interpreted, socially constructed, metaphysical, and *unreal*, whereas for realists the better detection of theoretical terms, repeated experiments, and other kinds of empirical research that eventually give reason to believe that what were initially imagined metaphysical terms and entities become *real*. Bhaskar notes, however, that the world becomes a construction of the human mind and of a scientific community (pp. 27, 148–167). He says:

> Transcendental realists regard "…objects of knowledge [in the models] as the structures and mechanisms that generate phenomena; and the knowledge as produced in the social activity of science. These objects are neither phenomena (empiricism) nor human constructs imposed upon the phenomena (idealism), but real structures which endure and operate independently of our knowledge, our experience and the conditions which allow us access to them. Against empiricism the objects of knowledge are structures, not events; against idealism, they are intransitive…. (p. 25)

Bhaskar (p. 25) takes an "updated dynamized" version of Kant's famous *transcendental argument* that reason and experience presume a priori objectively valid phenomena (Audi 1995, p. 808). "…[I]ntransitive objects of knowledge are in general invariant to our knowledge of them: they are the real things and structures, mechanisms and processes, events and possibilities of the world…." (p. 22). *Intransitive* means that objects of scientific discovery exist independently of human perceptions, interpretations, and social constructions, and by *structured* Bhaskar means they are "…distinct from the patterns of events that occur" (p. 35). "Generating structures" are underlying forces that may occur independent of observed regularities and may not be observable or measurable except via contrived experiments and the creation of invariances.

In this "transcendental" view, true explanation comes from above or below the plane of direct human observation. To pick a simple example, consider a pot of water coming to a boil on a stove. What we see at the plane of observation is the fire, the pot of water, and the beginning of emergent steam from its spout. What we don't see are the causes (outside the pot) of why the fire occurred and is hot and (inside the pot) why the molecules, as agents, change their governing rules as they go (1) from mild heat and increased vibration while maintaining position; (2) to the rolling boil in which they move around in the pot; and finally (3) to emerging from the pot as steam. It seems logical to me that attempts at gaining foresight should be rooted in philosophical views as to how changing phenomena are best explained—presumably by truthful theories.

2.2 FOCUS ON TRANSCENDENTAL DRIVERS

Peering into the Future. The term, foresight,[1] obviously, has two parts, "*fore*" and "*sight*." I detailed three variants of the "fore" part in the Introduction, saying I was going to focus on the third variant. Neoclassical economists view the world as composed of long periods of equilibrium separated by momentary (inconvenient) periods of discontinuous new order creation (Hinterberger 1994, Rosenberg 1994), and have patterned their view of good science after that of classical physics (Mirowski 1989). Their use of linear differential mathematical models has spilled over into other social sciences (Henrickson and McKelvey 2001). The equilibrium assumption allows them to focus on instrumentally predictive variables, as advocated by Friedman many years ago (1953). Chaos and complexity scientists, in contrast, see order creation in the world as mostly the result of nonlinearities separated by periods of equilibrium. The European school of complexity scientists focuses on nonlinearities resulting from energy differentials (Prigogine 1955) and phase transitions (Lorenz 1963, Haken 1977). The American school (mostly the Santa Fe Institute—Arthur 1988, Holland 1988, Kauffman 1988, 1993) sees agent coevolution as the primary source of nonlinearities. Unlike classical physicists and neoclassical economists, who assume agents are homogeneous because the math works better, the American school assumes that agents are heterogeneous (Holland 1975, 1996, Kauffman 1993, Epstein and Axtell 1996).

Besides the doability triad, the "fore" part also subdivides into three levels of analysis. For purposes of exposition, I will take the "firm-in-its-industry" level as the *plane of observation*. Porter's (1980) competitive strategy and its emphasis on the five drivers of industry competition is an exemplar. For many people, foresight is nothing other than trying to figure out what the future effects of the five drivers are likely to be. The population ecology movement in the study of organizations (Hannan and Freeman 1977) is another example of attention to the industry (population) plane of observation. Following Salthe and Bhaskar, however, the industry level plane of observation is the set of agents operating between forces above and below the plane of observation—the *environmental context* <u>above</u> and *coevolving lower-level agents* <u>below</u>—within a target firm itself. Building on Porter's language, elements in the environmental context become the *supra-drivers* and coevolving agents within a firm become the *sub-drivers*. One of the reasons why Hamel and Prahalad's book, *Competing for the Future* (1994), has had such an impact is that it bases its notions of foresight on *both* the supra- and sub-drivers. Thus, on the one hand they say, "Industry foresight must be informed by deep insight into trends in lifestyles, technology, demographics, and geopolitics…" (p. 89)—a supra-driver orientation. But on the other, they focus on core competencies of the agents within firms (Ch. 10)—a sub-driver orientation. I will use elements of

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[1] Presumably the use of softer "foresight" term rather than "prediction" is in recognition of the unlikelihood of making solid predictions in the nonlinear world posited by complexity scientists, while at the same time not giving up on the idea.

complexity science to expand on Hamel and Prahalad's "transcendental" insights.

Who's Looking? The "sight" part raises the question: "Sight" by whom? Henry Ford[2] is notorious for asking,

> Why is it that whenever I ask for a pair of hands, a brain comes attached?

In this view, foresight is only possible by the person, or perhaps a few people, at the very top of firms. Leadership gurus such as Bennis (1996), focusing charismatic visionary leaders, make the same mistake. Since Ford's time economics has been broadened to include human capital throughout a firm (Becker 1964) and the social capital that interconnects human capital (Burt 1992). Even more recently attention has focused on distributed knowledge management (Davenport 1997), distributed organizational learning (Argote 1999), and distributed intelligence (McKelvey 2001, Stacey 2001). Distributed intelligence rests on distributed information input, that is, "*distributed seeing*." I use the latter as the second key component of "*distributed foresight*." Key questions are: Who is looking? How many are looking? How hard are they looking? What are they looking at? Therefore, a study of organizational foresight needs to pay as much attention to who is doing the looking and how to manage that, as it does to what they are looking at or looking for. The idea that foresight comes only from the few people at the top is surely archaic. Given the importance of gaining more foresight than one's competitors (Hamel and Prahalad 1994), I begin by outlining some ideas about how to better develop and manage distributed foresight—the "who is looking" and "how do they do it collectively" part.

3 MANAGING THE SUB-DRIVERS—DISTRIBUTED SEEING

3.1 DEFINING DISTRIBUTED SEEING

> My work is in a building that houses three thousand people who are essentially the individual 'particles' of the 'brain' of an organization that consists of sixty thousand people worldwide.

Zohar (1997, p. xv) starts her book by quoting Andrew Stone, a director of the retailing giant, Marks & Spencer: Each particle has some intellectual capability—Becker's *human capital*. And some of them talk to each other—Burt's *social capital*. Together they comprise *distributed intelligence*. Human capital is a property of individual employees. Taken to the extreme, even geniuses offer a firm only minimal adaptive capability if they are isolated from everyone else. A firm's core competencies, dynamic capabilities, and knowledge requisite for competitive advantage increasingly appear as *networks* of human capital holders. These knowledge networks also increasingly appear throughout firms rather than being narrowly confined to upper management (Norling 1996). Employees are now responsible for adaptive capability rather than just being bodies to carry out orders. Here is where networks become critical. Much of the effectiveness and economic value of human capital held by individuals has been shown to be subject to the nature of the social networks in which the human agents are embedded (Granovetter 1985, Burt 1997, Nohria and Eccles 1992).

Intelligence in brains rests entirely on the production of emergent networks among neurons—intelligence IS the network. Neurons behave as simple "threshold gates" that have one behavioral option—fire or not fire (Fuster 1995, p. 29). As intelligence increases, it is represented in the brain as *emergent* connections (synaptic links) among neurons. Human intelligence is "distributed" across really dumb agents! In computer parallel processing systems, computers play the role of neurons. They are more "node-based" than "network-based." Artificial intelligence resides in the *intelligence capability* of the computers as agents, with emergent network-based intelligence rather primitive (Garzon 1995). Artificial intelligence (AI) models increasingly are used to simulate learning processes in firms, though their intelligence capability is not fully connectionist and the intelligence of their agents is minimal—far below that, even, of PCs (Masuch and Warglien 1992, Carley and Prietula 1994). My focus on distributed intelligence/seeing places most of the emphasis on the emergence of constructive networks. Of course, firms that have constructive networks among geniuses usually will fare better than those having great networks among idiots. The lesson from brains and computers is that organizational intelligence is best seen as "distributed" and that increasing it depends on fostering network development along with increasing agents' human capital. Thus, "Who is doing the looking?" is a function of the *distributed* intelligence and seeing capability of an organization.

3.2 BASIC COMPLEXITY THEORY

How can CEOs improve distributed seeing in their firms? *How can they steer it toward more fruitful directions*? Complexity theory points the way. It emphasizes critical values in adaptive tension and consequent phase transitions. By emphasizing one adaptive tension over others, CEOs can steer distributed seeing in one direction or another. Cramer (1993) identifies three levels of complexity—defined in Table 1—depending on how much information is necessary to explain the complexity: *Newtonian complexity*, *emergent complexity*, and *stochastic complexity*. Complexity science (Nicolis and Prigogine 1989) shows that the separation of the region of emergent complexity

[2] Quoted in Hamel (2000, p. 102).

from the other kinds is a function of the ambient energy impinging on a system of agents.

> > > Insert Table 1 about here < < <

The boundaries of emergent complexity are defined by "*critical values*" (Cramer 1993). Nicolis and Prigogine (1989, Ch. 1) describe the function of critical values in natural science. Nothing is so basic to their definition of complexity science as the Bénard cell—two plates with fluid in between. An *energy* (heat) *differential* between the plates—defined here as '*adaptive tension*', *T*—creates a molecular motion of some velocity, *R*, as hotter molecules move toward the colder plate. The energy-differential in the Bénard cell parallels that between hot surface of the earth and cold upper atmosphere—hotter air molecules move upward and if they move fast enough, create storm cells. Complexity science cannot be understood without appreciating the role that *T* plays in defining the region of complexity "at the edge of chaos." If *T* increases beyond the 2nd critical value, the agent system jumps into the region of chaotic complexity. Here the system is likely to oscillate between different states—centred around different *basins of attraction*—thereby creating chaotic behaviour. Definitions of *attractors* are given in Table 2. Thus, for molecular agents:

- **Below the 1st critical value** of *T*, agents show minimal response in reducing *T*—molecules vibrate in place but "conduct" energy by colliding with each other.
- **Above the 1st critical value** of *T*, agents show collective action toward reducing *T*. Gas molecules start bulk currents of "convection" movement, as the molecules actually circle around from hot to cold and back to hotter plate, or generate strong bulk currents of air flowing up and down from earth's surface to upper atmosphere—the air turbulence and storm cells that create rough aeroplane rides.
- **Above the 2nd critical value** of *T*, the molecular movements become chaotic. For example, if *T* between hot lower air and cold upper air increases further, perhaps by the conflation of warm moist air from the south and cold air from the north, say over Kansas, the *2nd critical value* may be exceeded. At this point the storm cell may oscillate between two basins of attraction, tornadic and nontornadic behaviour.

> > > Insert Table 2 about here < < <

Translating to firms, suppose a large firm acquires another firm needing a turnaround. Suppose *T* stays below the 1st critical value, in which existing management stays in place and little change is imposed by the acquiring firm. There is little reason for people in the acquired firm to create new structures. Instead, there might be only "conduction" type changes in the sense that new turnaround ideas percolate slowly from one person to another person adjacent in a network. If *T* goes above the 2nd critical value, complexity theory predicts chaos. Suppose the acquiring firm changes several of the acquired firm's top managers and sends in "MBA terrorists" to change the management systems "over-night"—new budgeting and information systems; new personnel procedures, promotion approaches, and benefits packages; new production and marketing systems. And suppose that the acquired firm's culture and day-to-day interaction patterns are changed as well. In this circumstance, two basins of attraction could emerge: one basin defined around demands of the MBA terrorists and the other centred around the comfortable pre-acquisition ways of doing business and resistance to change. The activities of the system could oscillate between these two basins, seemingly exhibiting the characteristics of a strange attractor.

Between the 1st and 2nd critical values lies the organisational equivalent of Cramer's emergent complexity. Here, network structures emerge to solve *T* problems. Using the storm cell metaphor, in this region the "heat conduction" of interpersonal dynamics between sporadically communicating individuals is insufficient to reduce the observed *T*. To pick up the adaptive pace, the equivalent of organisational storm cells consisting of "bulk" adaptive work-flows starts. Formal or informal structures emerge, such as new network formations, informal or formal group activities, departments, entrepreneurial ventures, and so on. Though the *T*s in organisation science are unlikely to have the precise values they appear to have in some natural sciences (Johnson and Burton, 1994) it seems likely that a probability distribution of such values will exist for individual firms and each of their subunits. Though precise values of *T* for firms do not exist, we do know about symptoms indicating whether a firm is below the 1st, in between, or above the 2nd critical value (B/E 1998) .

3.3 STEPS TOWARD BETTER DISTRIBUTED SEEING

Adaptive Tension. For distributed intelligence and seeing to be improved a CEO's first task is to make sure the corporate brain is exposed to the full range of "*T*s" "out there"—that surround the agents—that might energize emergent order. At GE, Jack Welch uses "*Be #1 or 2 in your industry*," with a very clear motivational valance. *Respond to the T or your division will be sold!* Thus, *T*s are the root motivation causing agents to self-organize.

While agents in a Bénard cell face just one *T*, the adaptive tension confronting the many agents within a firm—as receivers—appears as countless *T*s. In addition, there are many *T*s reflecting forces and constraints in the environment, not to mention *T*s created by numerous agents within competing firms—from the CEO down to the people in engineering, production, marketing, sales, and so on. An agent network could emerge virtually anywhere in a firm around an initiative to produce a better part, product, marketing approach, new strategy, and so forth. Consequently, there is danger in *a priori* trying to focus certain kinds of *T*s toward specific kinds of agents. This might preclude the emergence of the most effective new networks. But there is an equal danger in trying to flood every agent with every kind of *T*. It is also clear that "selecting" the nature of the incoming *T*s based on preconceived CEO-level notions, as Roger Smith did at GM for a decade (Hunt and Ropo 1998) puts blinders on the corporate brain. Toyota is well known for its system of increasing the awareness of workers about how well their designs and products compete against the competition—a small set of narrowly defined *T*s. Welch accomplishes the same objective by defining *T*s very broadly as, "Be #1 or 2 in your industry!" This is a perfect example of using a simple piece of information to focus attention on a particular aspect of the competitive environment—everything is boiled down to one *T* that *drives* the lower level systems without the command-and-control structure *defining* them. Strong corporate leadership is shown without setting up a suppressive command-and-control-structure or otherwise inhibiting emergent DI.

Critical Values. Assuming agents are confronted by the appropriate *T*s, managing the critical values aspect of adaptive tension requires three basic activities: (1) checking whether behavioral symptoms of *T*s impinging on one or more agents are below, between, or above the critical values; (2) altering motivational valances to move the *T* levels into the region between the 1^{st} and 2^{nd} critical values; and (3) widening the distance between the critical values.

Critical values are not precisely determined in firms—as they are in natural science. Nor does research indicate what levels of *T*s are below, between, or above the critical values. For now we have to rely on behavioral symptoms for evidence about *T* effects. B/E (1998)[3] identify some symptoms. For example, as indications that *T* is *below the* 1^{st} *critical value*, B/E point to overbearing structure, fiefdoms, little novelty, and reactive strategizing. For evidence that *T* is *above the* 2^{nd} *critical value* B/E point to random communication, over coordination, politics, modular structures disconnected, and sporadic intense experimentation too narrowly focused.

There are also direct symptoms of emergence. In general *T* between the critical values produces emergent dissipative structures, which then start reducing *T*, at which point they dissipate:

1. Emergent social networks such as dyadic or triadic communication channels, informal or formal teams, groups, or other network configurations;
2. More effective networks within or across groups, more structural equivalence, better proportions of strong and weak ties, increased numbers of structural holes (Burt 1992), more networks emerging between hostile groups—marketing with engineering, or with production, with suppliers, with customers, and so forth;
3. Emergent networks of any kind, networks that produce novel outcomes, new strategies, new product ideas, new directions of knowledge accumulation; and
4. Networks that speed up rates of adaptive-event occurrence.

Widening the region of emergence requires operating on the location of the critical values themselves—lowering the 1^{st}, raising the 2^{nd}—rather than only trying to adjust the *T*s to fall in between. Anything that gets networks to form more easily is essentially lowering the 1^{st} critical value. Raising the 2^{nd} critical value requires training agents to develop (1) more effective emergent structures—so tension stops rising and starts dissipating; and (2) higher 'tension tolerance' to handle higher tension levels before "going chaotic." For example, employees in high-velocity firms in Silicon Valley work routinely in an atmosphere of adaptive tension far higher than might ever appear in large dinosauric firms or government agencies.

Attractors. The previous two sections work on the "fostering-and-speeding-up-emergence" part. Now I turn to the problem of "steering" without inadvertently fostering the emergence of a suppressive command-and-control-bureaucracy. Recall the definitions of *point* and *strange attractors* in Table 1.

Bureaucratic negative feedback systems center around point attractors. A visionary CEO operates as one—the vision is the goal, which becomes the equilibrium point toward which negative feedback, managerial control processes define the system. Since firms do need strong leaders, and since some people like being strong leaders and behave like strong leaders, it is pointless to think of avoiding point attractors. The trick is to aim these "strong leader types" toward using point attractors that "*drive*" the system toward reducing the *T*s but do not "*define*" it in the command-and-control ways that inhibit emergence. *T*s *are* point attractors. Activities that serve to reduce *T*s, thus, are point attractors.

Remaining strong leader activities are best redefined to be strange attractors. This is probably the best way in which to view Bennis's (1996) "herding cats" metaphor—the "cage" effect of the rabbit and dog metaphor in Table 1. We may use what Morgan (1997, p. 98) refers to as "*cybernetic reference points*" and "*avoidance of noxiants*" to define the reflective cage of a strange attractor without defining goals that act as point attractors. Strange attractor "definitions of the cage" must be created without determining specific or repeating paths—characteristics of point attractors and opposite the definition of novelty.

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[3] Though the B/E book offers useful advice to practicing managers the impression they give of complexity theory could be misleading to naïve readers. They argue that managers should balance their firms between too much rigid bureaucratic structure and chaos—as if these are God-given and etched in stone. Instead, complexity science shows that a complex adaptive system is caused to exist below, between, or above the 1^{st} and 2^{nd} critical values by an adaptive tension (energy-differential) acting on the system as an exogenous variable, that naturally (as in the weather) or artificially (as with a Bénard cell) is subject to change and/or manipulation. Put simply, CEOs don't respond to complex adaptive systems as fixed entities—they can inadvertently or purposefully create all three kinds of them!

Incentives should encourage the proper delineation, separation, and development of point and strange attractors. It is easy to define point attractor incentives—"Here is the goal and I will pay more if you achieve it." Saying "No" is all too easy in firms and seldom needs to be encouraged. Setting up "inexpensive experiment" strange attractor systems seems more risky and learning when to say "No" to continuing an experimental product development activity is problematic. Strange attractors also need to be made attractive for agents "inside the cage."

Agency Problem. Economists define the agency problem as the likelihood that managers, as agents of shareholders, will substitute their own personal interests for those of shareholders (Jensen and Meckling 1976). If slack resources (March and Simon 1958) are made available for DI development, then there is the possibility that the slack could be used against shareholder interests. Slack targeted for DI development should be managed by strange attractors rather than allocated to point attractors. Slack imported into basic research parks is adaptive, but the tension is low as the agents are disconnected from market defined *T*s. Connecting slack with specific *T*s, but still steering the DI system by strange rather than point attractors seems optimal. The more market-connected *T*s are used to create the conditions leading to emergent order, the more likely networks will emerge in response to market related adaptive problems rather than in response to the interests of individual agents. In light of my goal of finding ways that CEOs can produce sustainable rents, CEO activities that inhibit DI appreciation actually contribute to the agency problem. DI appreciation depends on staying in the region between the critical values, which in turn depends on "pointing" agents' attention toward the *T*s (defined to include incentives).

3.4 THE DARK SIDE OF CHARISMATIC VISIONARY LEADERSHIP

Could it be that leadership theory is antithetical to CEOs trying to create distributed seeing? Dansereau and Yammarino's (DY) (1998a,b) summary table (1998a: xxxix) shows leadership theory to be focused on attributes of leaders and their effects on groups of followers and on individual followers in dyads—corroborated by Klein and House (1998, p. 9). To use Dubin's (1979) phrases, this is mostly "leadership in organisations" rather than "leadership of organisations." In the DY books, only Hunt and Ropo (1998) concentrate on leadership *of* organisations via their case analysis of Roger Smith's years as CEO of General Motors. The Klein and House (1998) chapter on charismatic leadership focuses on leadership of subordinates at different levels *in* firms—leader-subordinate dyads at different levels—rather than leadership *down through* a firm's several levels.

Leadership in the DY books is multilevel. Visionary leadership cascades down one level at a time. Bennis and his colleagues (Bennis and Nanus 1985, Bennis and Biederman 1996) zero in on leaders who successfully reorient multilevel sets of followers in organisations. They abandon trait and situational theories for a skill-based theory built around leaders able to get subordinates to follow their vision. Bennis (1996: 149) says:

> The problem facing almost all leaders in the future will be how to develop their organisation's social architecture so that it actually generates intellectual capital.

But he also says leadership is like "herding cats;" and:

> Leading means doing the right things…creating a compelling, overarching vision.… It's about *living* the vision, day in day out—embodying it—and empowering every other person…to implement and execute that vision…. The vision has to be shared. And the only way that it can be shared is for it to have meaning for the people who are involved in it. Leaders have to specify the steps that behaviourally fit into that vision, and then reward people for following those steps. (his italics)

Bennis follows the charismatic leadership theory of House (1977) and Nanus (1992). Klein and House (1998, p. 3) say "charisma is a fire that ignites followers' energy, commitment, and performance." In dwelling primarily on the "mythic," "heroic," "visionary," upper echelon leaders, such as Jack Welch, Bennis works at cross purposes with distributed sensemaking and speeding up the rate of distributed seeing.[4] In the last quote above it is the brain of the leader that creates the vision and followers are rewarded (in the context of command-and-control structure) for carrying it out. And yet, as Bennis himself says, "…people at the periphery of organisations are usually the most creative and often the least consulted" (1996: 152). Bennis does not answer the question: *How to lead the corporate brain without damaging its distributed intelligence or seeing ability*?

How does the visionary CEO suppress emergent DI? First, heroic visionary leaders tend to create "strong cultures" (Peters and Waterman 1982, Schein 1990). The role of entrepreneurs as visionary creators of organisational culture has been noted (Siehl 1985). Kotter and Heskett (1992) observe that organisational performance is connected to adaptive cultures and that leaders play a key role in culture change. Sorensen (1998) shows that strong cultures are assets in stable environments but liabilities in changing times. Leaders are seen as moulding employees' views about a firm and defining their roles within it (Bryman 1996). Willmott (1993) claims that culture management is simply a new form of managerial control. Bryman

[4] In fact, Welch gets around the problem by promulgating a "process" vision which is actually based on the "adaptive tension" I discuss below. The trouble emerges when the top-level visionary insists upon specific "content agendas" that subordinates are supposed to carry out.

(1996: 285) notes that Martin's (1992) "integration perspective" points to leaders who go about "creating, maintaining or changing cultures" in the normative manner outlined by the foregoing authors.

Second, consider a recent discussion of CEO-level charismatic leadership by Waldman and Yammarino (1999). They focus on strategy formulation by upper echelon managers, that is, leadership *across several levels*, using an "eleven-box-plus" theory. Three propositions are:

- Charismatic attributions toward the CEO at lower echelons will result in heightened organisational member effort and intergroup cohesion, especially under conditions of perceived environmental volatility. (p. 276)
- Intergroup cohesion will result in linkages regarding the performance objectives of units within an organisation so that the subsequent performance of units will be co-ordinated toward higher-level organisational performance. (p. 277)
- Co-ordinated operational performance of subunits will lead to higher organisational performance, especially when units are interdependent. (p. 278)

These propositions are telling because they: (1) focus on leadership across several intervening levels of organisation, thus fitting my focus on CEOs leading the entire firm to foster emergent distributed seeing among the lower participants; (2) are developed in the context of environmental volatility, thus fitting very well my interest in high-velocity firms; and (3) reflect a vast amount of prior single-level research about leadership at the CEO level and at lower levels.

Some leaders may have visions that are correct, innovative, and up-to-date in high velocity environments. But what if the heroic leader's one brain is not up to the job? How to get the corporate brain to come to the rescue? Left unsaid, but nevertheless supported by the Waldman/Yammarino propositions, is the idea I wish to stress: Upper echelon charismatic leadership produces cohesion and leader defined "group-think" (Janis 1972) across intervening levels where one would instead want to see emergent distributed seeing ability. Charismatic leadership, thus, produces a corporate brain mirroring the CEO's, and once it is made pervasive via incentive systems, it also may emerge as a pervasive, rigidifying corporate culture preserving thestatus quo.

4 FORESIGHT FROM THE SUPRA-DRIVERS

As you can see, there are three important lessons from complexity science so far:

1. Distributed seeing is a function of coevolving heterogeneous agents and emergent self-organization in the form of social networks, groups, hierarchy and upward and downward causality. The corporate brain "sees" better when it draws on all of its distributed intelligence and seeing capabilities.
2. CEOs can foster emergent self-organization and distributed seeing by bringing adaptive tension to bear on the agents so as to activate them.
3. CEOs' focus on adaptive tension also is a means of steering agent self-organization toward more efficacious distributed seeing—or they can undermine it.

There is an irony—and coevolution—here. On the one hand, organizational foresight is better if distributed seeing—of the supra-drivers—by all of the "sub-driver" agents is better. On the other hand, the sub-drivers work better if they, the agents, are steered and activated by CEOs' use of adaptive tension, critical values, and phase transitions, to mobilize and focus the effect of the supra-drivers. They coevolve because (1) the more the sub-drivers "see" the supra-drivers, the more they can self-organize with respect to them and (2) the more the supra-drivers are crystallized and focused, the stronger their effect on the sub-drivers. In short, to focus on only one or the other doesn't make much sense: Without distributed seeing we are thrust back into the world of Henry Ford. Without crystallization and focus of the supra-drivers there is the risk of the sub-driver agents seeing everything and nothing. There is also the danger that CEOs can shut down the sub-driver agents, or destroy their required heterogeneity by exercising too much "Fordist" top-down vision, charisma and/or control (McKelvey forthcoming).

The environmental context of supra-drivers of a typical firm could seemingly appear unlimited. To get an idea of what I mean by a firm's supra-drivers, about which foresight is desired, begins with a biological analogy. Consider a species (population) evolving in some niche along with other competing populations. This is the plane of observation—the level equivalent to Porter's drivers. What are the forces most crucial to the survival of a niche or most likely to change it? To see these we need to look beyond Darwinian selection processes. Consider:

- ✓ Lava Plumes, Plate Tectonics, Plate Subduction
- ✓ Rising and Falling Continents
- ✓ Volcanoes, Smoke & Ash, Mountains
- ✓ Rivers, Lakes, Ponds, and Oceans
- ✓ Forests, Plains, Deserts, Climate Zones

These are the supra-drivers on biological diversity and speciation. These are the things that give rise to the "punctuated equilibrium" of Eldredge and Gould (1972), who argue that these are the forces that serve to explain the gaps in the fossil record. If one speeds up the "movie" of the past 3.8 billion years of life on earth, one sees that it is the self-organization of biological agents in the face of the forces mentioned in the foregoing bullets (McKelvey forthcoming).

With this analogy and lesson in mind, lets consider parallel supra-drivers for firms. This is like going from ecological to geological implications in biology. :

- ✓ Basic research and New Knowledge
  - —Basic science activities and findings
  - —Cues about trends and implications of basic science developments
- ✓ Technology and Knowledge Applications

- ✓ Japan/Europe economic time-bomb—low birthrate & low immigration;
  which leads to lower tax-base; compounded by increasing pension costs
- ✓ Petroleum depletion
- ✓ Global resource depletion
- ✓ Global warming
- ✓ Demography
- ✓ Globalization
- ✓ Multicultural
- ✓ Terrorism
- ✓ Poverty: G7 & vs. 3rd World
- ✓ Hunger
- ✓ 3rd world education
- ✓ Effects of 3rd world economic development
- ✓ Changes in Economic Regimes
- ✓ Global and local Politics
- ✓ Small Wars here and there
- ✓ China
- ✓ Islam

Of course, many of these are very broad trends, very much in the future, and quite unresolved as to their business implications. On the other hand, the "terrorism trend" has resolved very quickly after the World Trade Center attack. Many businesses have figured out that there are many fall-outs from this, security, encryption, and protection against weapons of mass destruction being the most obvious. Presumably, each one of the foregoing broad trends will, at some point, resolve just as the terrorist trend recently has. My point here is that underneath each of these broad trends is a hierarchy of more specific, narrow foresight possibilities, calling for CEOs to work on sub- and supra-driver foresight capabilities. Each of the broad trends, as they resolve, also can be further subdivided into foresight-based implications for marketing, production, R&D, and finance.

There are other hierarchical implications. One can also refine the broad trends into implications for firms at various levels of the SIC code. Thus perhaps only the largest (2-digit) "food-production" firms can, at this time finance the technological R&D implications and subsequent organizational implications of, say, demographic and world-hunger related trends. But, as Slywotzky (1996) observes, firms can gain much insight into the future by trying to anticipate how their customer firms are, in turn, going to respond to their customer's needs. Thus, "trends" for small "supplier" firms resolve from an understanding of how larger firms are trying to anticipate solutions to the broader trends. It follows that the resolution of one broad trend, say terrorism or hunger, resolves into implications for other broad trends such as R&D and technology development.

Surely useful foresight starts with understanding the long effects of these forces on one's firm. Who best to imagine possible outcomes of these forces? This is where the power of distributed seeing comes to play. Presumably, the many lower-level (sub-driver) agents have a higher collective probability of seeing these forces and having the intelligence (ideas) to create ideas about how to respond. But, if they look in too many places all at the same time, their seeing ability is out of focus and apt to yield poor results. Here is where the critical-value lesson from complexity science becomes important. CEOs can "herd the cats" as it were, by creating strange attractor equivalents. That is, steering ***not*** by command and control and by goal direction (by point attractors) from visionary leaders, but by using critical values of selected adaptive tensions to activate and steer the sub-driver agents all at the same time.

5 CONCLUSION

BIBLIOGRAPHY

Argote, L. (1999). *Organizational Learning: Creating, Retaining and Transferring Knowledge*. Norwell, MA: Kluwer.

Arthur, W. B. (1988). "Self-Reinforcing Mechanisms in Economics," in P. Anderson, K. J. Arrow, and D. Pines, eds., *The Economy as an Evolving Complex System*. Reading, MA: Addison-Wesley, 9–31.

Arthur, W. B. (1990). "Positive Feedback in the Economy," *Scientific American*, February, 92–99.

Audi, R. (Ed.) (1995), *The Cambridge Dictionary of Philosophy*, Cambridge, UK: Cambridge University Press.

Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, **17**, 99–120.

Becker, G. S. (1975). *Human Capital*, 2nd ed. Chicago, IL: University of Chicago Press.

Bénard, H. (1901). "Les Tourbillons Cellulaires dans une Nappe Liquide Transportant de la Chaleur par Convection en Régime Permanent," Ann. Chim. Phys. **23**, 62–144.

Bennis, W. G. (1996). Becoming a leader of leaders. R. Gibson, ed. *Rethinking the Future*. London: Brealey.

Bennis, W. G. and B. Nanus. (1985). *Leaders: Strategies for Taking Charge.* New York: Harper & Row.

Bennis, W. G. and P. W. Biederman. (1996). *Organizing Genius: The Secrets of Creative Collaboration.* Reading, MA: Addison-Wesley.

Bhaskar, R. (1975), *A Realist Theory of Science*, London: Leeds Books [2nd ed. published by Verso (London) 1997].

Boisot, M. (1998). *Knowledge Assets.* New York: Oxford University Press.

Brown, S. L. and K. M. Eisenhardt. (1997). The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative Science Quarterly*, **42**, 1–34.

Brown, S. L. and K. M. Eisenhardt. (1998). *Competing on the Edge: Strategy as Structured Chaos.* Boston, MA: Harvard Business School Press.

Bryman, A. (1996). Leadership in organizations. S. R. Clegg, C. Hardy, and W. R. Nord, eds. *Handbook of Organization Studies.* Thousand Oaks, CA: Sage. 276–292.

Burt, R. S. (199). *Structural Holes: The Social Structure of Competition.* Cambridge, MA: Harvard University Press.

Burt, R. S. (1997). The contingent value of social capital. *Administrative Science Quarterly*, **42**, 339–365.

Collins, J. G., and J. I. Porras. (1994). *Built to Last.* New York: HarperCollins.

Cramer, F. (1993). *Chaos and Order: The Complex Structure of Living Things*, trans. D. L. Loewus. New York: VCH.

D'Aveni, R. A. (1994). *Hypercompetition: Managing the Dynamics of Strategic Maneuvering.* New York: Free Press.

Dansereau, F. and F. J. Yammarino, eds. (1998a). *Leadership: Multiple-Level Approaches: Classical and New Wave.* Stamford, CT: JAI Press.

Dansereau, F. and F. J. Yammarino, eds. (1998b). *Leadership: Multiple-Level Approaches: Contemporary and Alternative.* Stamford, CT: JAI Press.

Davenport, T. H. (1997). *Information Ecology: Mastering the Information and Knowledge Environment*. New York: Oxford University Press.

Dubin, R. (1979). Metaphors of leadership: An overview. J. G. Hunt and L. L. Larson, eds. *Cross-Currents in Leadership.* Carbondale, IL: Southern Illinois University Press. 225–238.

Eddington, A. (1930). *The Nature of the Physical World*. London: Macmillan.

Ehrlich, P. R. and P. H. Raven. (1964). Butterflies and plants: A study in coevolution. *Evolution*, **18**, 586–608.

Eisenhardt, K. M. (1989). Making fast strategic decisions in high-velocity environments. *Academy of Management Journal*, **32**, 543–576.

Eisenhardt, K. M. and B. N. Tabrizi. (1995). Accelerating adaptive processes: Product innovation in the global computer industry. *Administrative Science Quarterly*, **40**, 84–110.

Eldredge, N. and J. S. Gould (1972). "Punctuated Equilibrium: An Alternative to Phyletic Gradualism," in T. J. M Schopf (ed.), *Models in Paleobiology*, San Francisco: Freeman, Cooper, 82–115.

Epstein, J. M. and R. Axtell (1996), *Growing Artificial Societies: Social Science from the Bottom Up*, Cambridge, MA: MIT Press.

Friedman, M. (1953). "Methodology of Positive Economics," in M. Friedman, *Essays in Positive Economics*. Chicago, IL: University of Chicago Press.

Fuster, J. M. (1995). *Memory in the Cerebral Cortex: An Empirical Approach to Neural Networks in the Human and Nonhuman Primate.* Boston, MA: MIT Press.

Garzon, M. (1995). *Models of Massive Parallelism.* Berlin: Springer-Verlag.

Gell-Mann, M. (1994). *The Quark and the Jaguar*. New York: Freeman.

Gleick, J. (1987). *Chaos: Making a New Science.* New York: Penguin.

Granovetter, M. (198). Economic action and social structure: A theory of embeddedness. *American Journal of Sociology*, **82**, 929–964.

Haken, H. (1977). *Synergetics, An Introduction: Non-Equilibrium Phase Transitions and Self-Organization in Physics, Chemistry, and Biology*. Berlin: Springer-Verlag.

Hamel, G. (2000). Reinvent your company. *Fortune*, June, 99–118.

Hamel, G. and C. K. Prahalad. (1994). *Competing for the Future.* Boston, MA: Harvard Business School Press.

Hannan, M. T. and J. Freeman. (1989). *Organizational Ecology.* Cambridge, MA: Harvard University Press.

Henrickson, L. and McKelvey, B. (2002). "Foundations of New Social Science," *Proceedings of the National Academy of Sciences*, **99**, 7288–7297.

Hinterberger, F. (1994). "On the Evolution of Open Socio-economic Systems," in R. K. Mishra, D. Maaβ, E. Zwierlein (eds.), *On Self-Organization: An Interdisciplinary Search for a Unifying Principle*, Berlin: Springer-Verlag, 35–50.

Holland, J. H. (1975). *Adaptation in Natural and Artificial Systems*. Ann Arbor, MI: University of Michigan Press.

Holland, J. H. (1988). "The Global Economy as an Adaptive Process," in P. Anderson, K. J. Arrow, and D. Pines, eds., *The Economy as an Evolving Complex System*. Reading, MA: Addison-Wesley, 117–124.

Holland, J. H. (1995). *Hidden Order.* Cambridge, MA: Perseus Books.

House, R. J. (1977). A 1976 theory of charismatic leadership. J. G. Hunt and L. L. Larson, eds. *Leadership: The Cutting Edge.* Carbondale, IL: Southern Illinois University Press. 189–207.

Hunt, J. G. and A. Ropo. (1998). Multi-level leadership: Grounded theory and mainstream theory applied to the case of General Motors. F. Dansereau and F. J. Yammarino, eds. *Leadership: Multiple-Level Approaches: Classical and New Wave.* Stamford, CT: JAI Press. 289–327.

Janis, I. L. (1972). *Victims of Group Think.* Boston, MA: Houghton Mifflin.

Jensen, M. C. and W. H. Meckling. (1976). Theory of the firm: Managerial behavior, agency costs, and ownership structure. *Journal of Financial Economics*, **3**, 305–360.

Johnson, J. L. and B. K. Burton. (1994). Chaos and complexity theory for management. *Journal of Management Inquiry*, **3**, 320–328.

Kauffman, S. A. (1988). "The Evolution of Economic Webs," in P. Anderson, K. J. Arrow, and D. Pines, eds., *The Economy as an Evolving Complex System*. Reading, MA: Addison-Wesley, 125–146.

Kauffman, S. A. (1993). *The Origins of Order: Self-Organization and Selection in Evolution.* New York: Oxford University Press.

Kauffman, S. A. (1993). *The Origins of Order: Self-Organization and Selection in Evolution.* New York: Oxford University Press.

Klein, K. J. and R. J. House. (1998). On fire: Charismatic leadership and levels of analysis. F. Dansereau and F. J. Yammarino, eds. *Leadership: Multiple-Level Approaches: Contemporary and Alternative.* Stamford, CT: JAI Press. 3–21.

Kotter, J. P. and J. L. Heskett. (1992). *Corporate Culture and Performance.* New York: Free Press.

Leonard-Barton, D. (1995). *Wellsprings of Knowledge.* Boston, MA: Harvard Business School Press.

Lorenz, E. N. (1963). "Deterministic Nonperiodic Flow," *Journal of the Atmospheric Sciences*, **20**, 130–141.

March, J. G. and H. A. Simon. (1958). *Organizations*. New York: Wiley.

Martin, J. (1992). *Cultures in Organizations: Three Perspectives.* New York: Oxford University Press.

McKelvey, B. (2001). "Energizing Order-Creating Networks of Distributed Intelligence," *International Journal of Innovation Management* **5**, 2001, 181–212.

McKelvey, B. (1997). Quasi-natural organization science. *Organization Science*, **8**, 351–380.

McKelvey, B. (forthcoming-a). "MicroStrategy from MacroLeadership: Distributed Intelligence via New Science," in A. Y. Lewin and H. Volberda (eds.), *Mobilizing the Self-Renewing Organization*, Armonk, NY: M. E. Sharp.

McKelvey, B. (forthcoming-b). "Social Order-creation Instability Dynamics: Heterogeneous Agents and Fast-motion Science—on the 100^{th} Anniversary of Bénard's Dissertation," *Journal of Bioeconomics*.

Mirowski, P. (1989), *More Heat than Light*, Cambridge, UK: Cambridge University Press.

Morgan, G. (1997). *Images of Organization*, 2^{nd} ed. Thousand Oaks, CA: Sage.

Morrison, F. (1991). *The Art of Modeling Dynamic Systems*. New York: Wiley Interscience.

Morrison, F. (1991). *The Art of Modeling Dynamic Systems*. New York: Wiley Interscience.

Nanus, B. (1992). *Visionary Leadership.* San Francisco, CA: Jossey-Bass.

Nicolis, G. and I. Prigogine (1989). *Exploring Complexity: An Introduction*. New York: Freeman.

Nohria, N. and R. G. Eccles, eds. (1992). *Networks and Organizations: Structure, Form, and Action.* Boston, MA: Harvard Business School Press.

Norling, P. M. (1996). "Network or Not Work: Harnessing Technology Networks in DuPont," *Research Technology Management*, Jan.-Feb., 289–295.

O'Reilly, C. A. III, & Pfeffer, J. (2000). *Hidden Value.* Cambridge, MA: Harvard Business School Press.

Peters, T. J. and R. H. Waterman. (1982). *In Search of Excellence: Lessons from America's Best-Run Companies.* New York: Harper & Row.

Porter, M. E. (1985). *Competitive Advantage.* New York: Free Press.

Porter, M. E. (1996). What is strategy? *Harvard Business Review*, **74**, 61–78.

Prietula, M. J., Carley, K. M., and Gasser, L. (eds.). (1998). *Simulating Organizations: Computational Models of Institutions and Groups*. Cambridge, MA: MIT Press.

Prigogine, I. (1955). *An Introduction to Thermodynamics of Irreversible Processes*. Springfield, IL: Thomas.

Prigogine, I. (with I. Stengers) (1997). *The End of Certainty: Time, Chaos, and the New Laws of Nature*. New York: Free Press.

Prusak, L. (1996). The knowledge advantage. *Strategy & Leadership*, **24**, 6–8.

Rosenberg, A. (1994). "Does Evolutionary Theory Give Comfort or Inspiration to Economics?" in P. Mirowski (ed.), *Natural Images in Economic Thought*. Cambridge, UK: Cambridge University Press, 384–407.

Salthe, S. N. (1985). *Evolving Hierarchical Systems*. New York: Columbia University Press.

Schein, E. H. (1990). Organizational culture. *American Psychologist*, **45**, 109–119.

Siehl, C. (1985). After the founder: An opportunity to manage culture. P. F. Frost, L. F. Moore, M. R. Louis, C. C. Lundberg, J. Martin, eds. *Organizational Culture.* Newbury Park, CA: Sage. 125–140.

Slywotzky, A. (1996). *Value Migration.* Boston, MA: Harvard Business School Press.

Sorensen, J. B. (1998). The strength of corporate culture and the reliability of firm performance. Unpublished manuscript, University of Chicago, Chicago, IL.

Stacey, R. D. (2001). *Complex Responsive Processes in Organizations: Learning and Knowledge Creation*. London: Routledge.

Waldman D. A. and F. J. Yammarino. (1999). CEO charismatic leadership: Levels-of-management and levels-of-analysis effects. *Academy of Management Review*, **24**, 266–285.

Whitehead, A.

Willmott, H. (1993). Strength is ignorance: Slavery is freedom: Managing culture in modern organizations. *Journal of Management Studies*, **30**, 515–552.

Zohar, D. (1997). *Rewiring the Corporate Brain.* San Francisco, CA: Berrett-Koehler

Table 1. Definitions of Attractors by Gleick (1987)

*"**Point attractors**"* act as equilibrium points. A system, even though oscillating or perturbed, eventually returns to repetitious behavior centered around the point attractor—traditional control style management decision structures may act in this manner (appearing as Newtonian complexity);

"***Periodic attractors***" or "*limit cycles*" (pendulum behavior) foster oscillation predictably from one extreme to another—recurrent shifts in the centralization and decentralization of decision making, or functional specialization vs. cross-functional integration fit here (also appearing as Newtonian complexity);

If adaptive tension is raised beyond some critical value, systems may be subject to "***strange attractors***" in that, if plotted, they show never intersecting, stable, low-dimensional, nonperiodic spirals and loops, that are not attracted by some central equilibrium point, but nevertheless appear constrained not to breach the confines of what might appear as an imaginary bottle. If they intersected, the system would be in equilibrium (Gleick 1987, p. 140) following a point attractor. The attractor is "strange" because it "looks" like the system is oscillating around a central equilibrium point, but it isn't. Instead, as an energy importing and dissipating structure, it is responding with unpredictable self-organized structure to tensions created by imposed external conditions, such as tension between different heat gradients in the atmosphere caught between a hot surface of the earth and a cold upper atmosphere, or constraints in a fluid flow at the junction of two pipes, or tension created by newly created dissipative structures, such as eddies in a turbulent fluid flow in a canyon below a waterfall, or "MBA terrorist" structural changes imposed in an attempt to turnaround an acquired firm.

As a metaphor, think of a point attractor as a rabbit on an elastic tether—the rabbit moves in all directions but as it tires it is drawn toward the middle where it lies down to rest. Think of a strange attractor as a rabbit in a pen with a dog on the outside—the rabbit keeps running to the side of the pen opposite from the dog but as it tires it comes to rest in the middle of the pen. The rabbit ends up in the "middle" in either case. With the tether the cause is the *pull* of the elastic. In the pen the cause is *repulsion* from the dog unsystematically attacking from all sides.

Table 2 Definitions of Kinds of Complexity by Cramer (1993) *

Below the 1st critical value '***Newtonian complexity***' exists where the amount of information necessary to describe the system is less complex than the system itself. Thus a rule, such as $F = ma = md^2s/dt^2$ is much simpler in information terms than trying to describe the myriad states, velocities, and acceleration rates pursuant to understanding the force of a falling object. "Systems exhibiting subcritical [Newtonian] complexity are strictly deterministic and allow for exact prediction" (1993, p. 213) They are also "reversible" (allowing retrodiction as well as prediction thus making the 'arrow of time' irrelevant (Eddington 1930, Prigogine 1997).

Above the 2nd critical value is '***chaotic complexity***'. Cramer lumps both chaotic and stochastic systems into this category, although deterministic chaos is recognised as fundamentally different from stochastic complexity (Morrison 1991, Gell-Mann 1994) since the former is 'simple rule' driven, and stochastic systems are random, though varying in their stochasticity. For random complexity, description of a system is as complex as the system itself—the minimum number of information bits necessary to describe the states is equal to the complexity of the system. Probabilistic distributions in stochastically complex systems allow some algorithmic compressibility. Thus, three kinds of stochastic complexity are recognised: ***purely random***, ***probabilistic***, and ***deterministic chaos***. For this essay I narrow the label to deterministic chaos, at the risk of oversimplification.

In between Cramer puts '***emergent complexity***'. The defining aspect of this category is the possibility of emergent simple deterministic structures fitting Newtonian complexity criteria, even though the underlying phenomena remain in the stochastically complex category. It is here that natural forces ease the investigator's problem by offering intervening objects as 'simplicity targets' the behaviour of which lends itself to simple rule explanation. Cramer (1993, p. 215–217) has a long table categorising all kinds of phenomena according to his scheme.

* For mnemonic purposes I use 'Newtonian' instead of Cramer's "subcritical," 'stochastic' instead of "fundamental," and 'emergent' instead of "critical" complexity.