MicroStrategy from MacroLeadership:
Distributed Intelligence via New Science

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1 INTRODUCTION

When share prices fall, CEOs often lose their jobs. The best way to keep share prices high is to produce economic *rents*—defined as profits above the industry average (Besanko, Dranove and Shanley 1996). Traditionally corporate strategy theorists advised CEOs in terms of economists' theory of the firm—CEOs invest capital and then order labor, as muscle, to carry out those tasks that cannot be turned over to machines—and aimed firms at the low cost or high differentiation parts of the efficiency curve (Porter 1985). Now, hitting the efficiency curve is not seen as a guarantee of sustained rents; these come from staying ahead of the curve (Hamel and Prahalad 1994, Porter 1996). To accomplish this, CEOs are advised to add *human capital* (Becker 1975) and *social capital* (Burt 1992) to the production function.

But how should CEOs lead firms toward speedier human and social capital appreciation? Jack Welch (1991) realizes that aggressive command-and-control leaders do not work well in the modern world because their top-down management style shuts down the emergent intelligence and social networking of their employees. Current leadership theory (Daft and Lengel 1998, Ulrich, Zenger and Smallwood 1999) does not respond to this problem. Bennis (1996) and other leadership theorists focus on the "heroic visionary leader" atop a firm's command-and-control structure (Waldman and Yammarino 1999). Not only does this approach put all of the rent-seeking "eggs" in one visionary basket, the charisma of the heroic visionary leader may bring human and social capital appreciation among lower-level participants to a standstill, as Jack Welch realizes, and opposite what modern strategic thinking calls for. Most leadership theorists focus on lower level group or dyadic relations (Dansereau and Yammarino 1998a, b) and hence are irrelevant to firm-wide CEO leadership.

New Science leadership theory proposes an alternative (Wheatley 1992), "New Science" being a popularized application of chaos/complexity theory to management (Maguire and McKelvey 1999). New Science authors typically couple the emergent structure aspect of complexity theory (Nicolis and Prigogine 1989) with leadership theories aimed at enhancing motivation via employee empowerment (Galbraith et al. 1993). In contrast to empowering managerially defined groups or teams by giving them increased responsibility or self-leadership (Markham and Markham 1998), my focus is on how to foster and speed up the emergence of *distributed intelligence* (DI) in firms. DI is a function of strategically relevant human and social capital assets—the networked intellectual capabilities of human agents (Masuch and Warglien 1992, Argote 1999). The question is: *What should CEOs do to foster emergent DI in their firms, speed up its appreciation rate, and steer it in strategically important directions, all the while negating emergent bureaucracy*?

This chapter is organized as follows. I first argue that rent generation stems mostly from speeding up rates of intrafirm change. Then I propose the emergence of optimal levels of DI as a New Science-based CEO objective. Existing leadership theories are found inadequate. Next I introduce basic elements of complexity science, focusing on *adaptive tension* and the *critical values*, in firms, that serve to create the phenomena studied by complexity science. This identifies a number managerial activities CEOs can use to produce and steer rent generating dynamics in their firms.

2 COEVOLUTIONARY DYNAMICS

> The true and stunning success of biology reflects the fact that organisms do not merely evolve, they *coevolve* both with other organisms and with a changing abiotic environment. (Kauffman (1993, p. 237; his italics)

The term, coevolve, originates in a paper by Ehrlich and Raven (1964) in which they focus on "…the joint evolution of two (or more) taxa that have close ecological relationships but do not exchange genes and in which *reciprocal selective pressures* operate to make the evolution of either taxon partially dependent on the evolution of the other" (quote from Pianka 1994, p. 329; italics added). Futuyma (1979) emphasizes the *evolution of interactions* and *reciprocal evolution*. Of late it has come to be even more broadly applied, as Kauffman indicates, to a variety of *intra*- as well as interpopulation and organism–abiotic environment interactions. Coevolution has now become an umbrella term "for a variety of processes and outcomes of reciprocal evolutionary change" (Thompson 1994, p. viii).[1]

Biological coevolutionary analysis has become a study of *adaptive agents* at various levels of analysis (Slatkin 1983). "Agents" may be nucleotides, acids, genes/proteins, chromosomes, molecules, organelles, cells, organs, organisms, and species. Coevolution typically exists at multiple levels within an organism, with "*micro*" coevolution applying to microagents, that is, agents at the lowest levels representing the behaviors of the most fundamental components. Biologists analyze the coevolutionary relations of agents and their networks from the most micro levels to macro levels, often using the same models. For example, Kauffman (1993) applies his *NK* model at gene, chromosome, cell, and species levels. Maynard Smith and Szathmáry (1995, p. 7) observe that the same agent-based model may be used for both micro and macro levels. This point sets up the realization that interagent networks and their relative rates of coevolutionary change apply at all levels of analysis in biology.

Premise[2] **1:** *As the microcoevolution of agents speeds up, niche separation effects predominate over environmental context or population level selection effects.*

Higher rates of reproduction and mutation cause faster coevolution between bacteria and mites than between Kuala bears and Eucalyptus trees (Futuyma 1979, Ch. 18). Since the 1930s biologists have debated the principle causes of selection, whether individual, species, population, or geographical. Fisher's (1930) fundamental theorem of natural selection holds that "*the rate of evolution of a character at any time is proportional to its additive genetic variance*…" (Slatkin 1983, p. 15; my italics). This theorem is moderated, however, by density- and frequency-dependent effects, that is, population-level effects. This focuses our attention on the relative rates of *intra*individual variation vs. population/ecological/geographic variation (Slatkin 1983).

M*icrocoevolution* is defined as coevolution of biomolecules or other components (agents) at various levels *within* organisms or populations. *Rapid microcoevolution* <u>*among microagents within*</u> two ecologically similar populations increases the probability that the inferior population (in the current niche) will survive by evolving toward a different population/niche configuration and stop competing directly against the stronger population. The populations avoid the Red Queen Paradox (Van Valen 1992) since, instead of running faster and faster in place, one moves into a new niche. Again, we see the effects of the differing rates of *micro*coevolution based individual selection vs. population, ecological, or geographical *macro*coevolution. Slow microcoevolution means either that population regulation effects will balance the size of the populations or that the inferior one will suffer competitive exclusion. Needless to say, the "inertia argument" upon which population ecology depends (Levins 1968) is the opposite of rapid microcoevolutionary capability.

Forgotten, however, is Levins observation that the mutation rates driving microcoevolution should be higher in changing environments (1968, p. 97). Arguing that genes are the "memory of a population," therefore, old unchanging genetic memories are not favored in changing environments. But, on the occasion that populations enter into a more stable situation, competing head-to-head over a fixed resource, it follows that the population with the higher mutation rate has the potential to drift into a separate niche rather than continue head-to-head competition.

Premise 2: *The rate at which agent fitness and connections coevolve at any level determines the relative importance of lower vs. higher levels of analysis, and ultimately whether the generation of rents is a function of the broader ecology or the knowledge and networks of intrafirm agents (employees, units or other process agents).*

Micro and macro selection appear in organization science (McKelvey 1982, Nelson and Winter 1982, Aldrich 1999). Population ecologists (Baum 1996) and institutional theorists (Scott 1995) claim that population designs are the result of downward selection pressure—

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[1] A more detailed discussion of definitions of coevolution appears in Futuyma and Slatkin (1983). Of particular importance is their attention to the rates at which organisms coevolve and when "coevolution" stops being coevolution and turns into mimicry, evolution, or preadaptive development of traits found, later, to have selective advantage.

[2] The supporting argument follows each premise. Following evolutionary epistemology (Azevedo 1997, McKelvey 1999c), a *premise* stands as the *best current collective belief* in the pertinent literature. Generally premises are more solidly researched toward the beginning of the paper and

competitive ecological contexts and institutional structures determine firms' fates. This is the invisible hand. Visible hand proponents (Child 1972, Chandler 1977) claim the opposite—that individuals (mostly managers and visionary leaders) create upward causal pressures leading to the survival of their firm.

The invisible hand works among agents inside firms as well (Burgelman and Mittman 1994, Miner 1994, McKelvey 1997 and Miller 1999). Microcoevolutionary perspectives also appear in organization science (March 1991, McKelvey 1997, Koza and Lewin 1998, Baum and McKelvey 1999). Microcoevolutionary agents could be: discourse or process elements; and people, units, departments, or divisions—all within firms. Two points relate to strategy.

Premise 3: *As the rate of microagent coevolution increases, at some point microcoevolution dominates macrocoevolution for increasing the likelihood of rent generation.*

As in biology, the relative importance of intrafirm vs. interfirm selection depends on the rate of microcoevolution. March (1991) focuses on different learning rates of employee/agents within simulated firms. Rosenkopf and Nerkar (1999) illustrate the general point that the rate of coevolution at one level affects the rate of coevolution at other levels. Ingram and Roberts (1999) theorize that the rate at which firms introduce new products depends on intrafirm dynamics—specifically the rate at which internal selection takes place. Madsen, Mosakowski and Zaheer (1999) link internal rate of variation with firm performance. Lomi and Larson (1999) and McKelvey (1999a, b) both use computational agent-based models to explore the relation between rates of microcoevolution and firm-level outcomes. Firms also avoid the Red Queen Paradox (Barnett and Hansen 1996) by moving into new product/niche configurations.

Premise 4: *To be effective in increasing the probability of creating rent-generating initiatives, microcoevolution rates must exceed technology, market, and institutional change rates as well as the microcoevolutionary rates of a firm's niche competitors.*

Biologists can study microcoevolution where time is measured in weeks (Futuyma 1979, p. 461). Even in the coevolution of notebook computer manufacturers—a rapidly changing population of firms—weeks may be too short a time span. There is enough evidence of structural inertia (Hannan and Freeman 1989; Meyer and Zucker 1989) and resistance to change (Kotter 1996) in firms to suggest that the speed of microcoevolution in most firms may be attenuated, though Baum (1996) finds limits to the inertia claim as well. Individual resistance to change, strong culture rigidities, personal chemistry effects, boundary rigidities, "not invented here" attitudes, limited absorptive capacity, and so forth, all serve to inhibit learning, knowledge accumulation, and network development. How fast is fast when it comes to microcoevolutionary effects on firm-level adaptation? At a minimum, it is a function of the rate of technological, market, and institutional changes and the rate at which competitors make their moves. To have an effect, microcoevolution in PC firms must be grossly faster than in violin makers, for example.

Can microcoevolution rates be increased? Jack Welch, GE's CEO, has "created more shareholder wealth than any other CEO in history." How? (1) "It is the story of how GE leverages its intellectual capital" and (2) "There is nothing so special about these changes except the speed with which GE does them" (Stewart 1999, p. 124, 127). The cover story of *The Economist* (1999a, b) spotlights "speed and adaptability" (p. 17). Speed is also critical at Hewlett-Packard: "We've got to beat the Japanese through speed of development…." (Schoonhoven and Jelinek 1990, p. 106). While stories in *FORTUNE* and *The Economist* good science do not make, nevertheless, no one is saying these things about GM, which has gone in the opposite direction in wealth creation during the time that Welch has run GE. More generally, *How should CEOs accelerate microcoevolution*?

2.1 STRATEGY AS A MICROCOEVOLUTIONARY PROBLEM

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, p. 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 this shifts competitive dynamics from industry selection and interfirm competition to intrafirm rates of change.

Premise 5: *Human and social capital appreciation (relevant to a competitive context) is a necessary, though not sufficient, condition for sustained rent generation.*

Recent writing about competitive strategy and sustained rent generation parallels Prusak's emphasis on how fast a firm can develop new knowledge. Rents are seen to stem from seeing industry trends (Hamel and Prahalad 1994), staying ahead of the efficiency curve (Porter 1996), winning in hypercompetitive environments (D'Aveni 1994), and keeping pace with high-velocity environments (Eisenhardt 1989) and value migration (Slywotzky 1996). Further, advocates of the resource- and competence-based view emphasize unique resources, distinctive/dominant/core competencies, dynamic capabilities, learning, and knowledge creation (Wernerfelt 1984, Rumelt 1987, Prahalad and Hamel 1990, Barney 1991, Teece, Pisano and Shuen 1994, Heene and Sanchez 1997). It advocates moving firms toward more sophisticated skills and technologies. As a result, the increased level of causal ambiguity (Mosakowski 1997), and complexity (ogilvie 1998), learning and innovation are not only more essential (Ambrose 1995), but also more difficult (Auerswald et al. 1996). Dynamic ill-structured environments and learning opportunities become the basis of competitive advantage if firms can be *early* in their industry to unravel the evolving conditions (Stacey 1995). Drawing on Weick (1985), ogilvie (1998, p. 12) argues that strategic advantage lies in developing new useful knowledge from the continuous stream of “unstructured, diverse, random, and contradictory data” swirling around firms. Becker (1975) defines knowledge/skills held by employees and their intellectual capabilities as *human capital* (*H*), and having given knowledge and capability economic value, adds it to the production function.

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 knowledge requisite for competitive advantage increasingly appears as *networks* of human capital holders. These knowledge networks also increasingly appear throughout firms rather than being narrowly confined to upper management. Employees have become responsible for adaptive capability rather than just being bodies to carry out orders. Here is where networks become critical. Especially in the last two decades, 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, 1992; Burt 1997), as a reading of the various chapters in Nohria and Eccles (1992) also suggests. Burt (1992) goes so far as to move networks into the realm of economic value by terming them *social capital* (*S*), saying that competitive advantage is a function of network relations, not individual knowledge attributes (1992, p. 3). Combining the need for both *H* and *S*, the Cobb Douglas production function, thus, becomes $Y = f(K, L, H, S)$, where Y = income. But, since Porter (1996) now argues that *K* and *L* portions of the equation no longer guarantee sustainable rents, this leaves all the emphasis on *H* and *S*.

Premise 6: *In high-velocity firms, rent generation rests primarily on speeding up the development of H and S.*

As high-velocity product life-cycles (Eisenhardt 1989) and hypercompetition (D’Aveni 1994) have increased in recent decades, speed of knowledge appreciation has become a central attribute of competitive advantage (Leonard-Barton 1995, Prusak 1996) with learning fundamental to change in knowledge (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.

2.2 DISTRIBUTED INTELLIGENCE VS LEADERSHIP THEORY

“Why is it that whenever I ask for a pair of hands, a brain comes attached?” (Henry Ford)[3]

Enhancing rent generation by improving *H* and *S* is alien not only to strategy science but also to organization science and leadership theory as well. True, speeding up the knowledge, skills, or intellectual capabilities of employees and improving interpersonal communications and networking in groups are old ideas, dating back at least to the use of individual and group incentives in autonomous workgroups (Trist and Bamforth 1951, Herbst 1970). But the emphasis in those days was on productivity. Micro OB added social influence, interpersonal and group dynamics, satisfaction, and felt-worth to theories about motivating employees (Katz, Kahn and Adams 1980). Now there is self-, charismatic, visionary, and transformational leadership (Dansereau and Yammarino 1998a, b). In all of this, strategic corporate intelligence—and ideas for rent generation—remains in the brain of the heroic visionary CEO (Bennis and Nanus 1985, Bennis 1996). For neoclassical economists as well, a firm’s strategic intelligence is in the head of the owner, with capital and labor’s muscle employed to bring it to life, hence: $Y = f(K, L)$. But at GE they say it is more than just Jack. They say it’s the *collective brainpower* of people throughout the firm. If so, then, *What is organizational intelligence*? and *How to improve the corporate brain*?

2.2.1 DISTRIBUTED INTELLIGENCE

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. (Andrew Stone)

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 *H*. And some of them talk to each other—Burt’s *S*. Together, *H* and *S* comprise *distributed intelligence*. I draw on both brain and distributed computer systems research to demonstrate that Becker and Burt each are half right. They naïvely could be interpreted to imply that “isolated geniuses” or “networked idiots” can generate rents. More likely, they would agree that *H* and *S* are *jointly* important. If

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

so, the theory of the firm most relevant to rent generation appears as: $Y = f(K, L, D)$, where *D* stands for the configuration of *H* and *S* likely to produce optimal DI for a particular firm. DI—in brains and in parallel processing computer systems—is a function of both the knowledge in the nodes (minimal in brains) and in the emergent connections among nodes (primitive in computer systems).

Premise 7: *DI in a brain is entirely a function of its capability for producing emergent networks among neurons.*

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!

Premise 8: *DI in parallel processing computer systems is mostly a function of the built-in intelligence capability of computers-as-agents, with minimal DI improvement stemming from emergent networks among the computer/agents.*

In computer DI 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). Garzon's analysis notwithstanding, the distributed computer literature shows only marginal progress toward computer-embedded *emergent* DI, whether in agents *or* networks.

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 DI as emergent order 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.

Premise 9: *Above threshold levels of H and S yet to be identified, the optimum amounts, and ratio, of H to S, that is, D, for rent generation is equifinal, nonlinearly mutual causal, and subject to local firm idiosyncrasies.*

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. Is there an actual optimal mix of *H* and *S* in *D*? In general? In a specific firm? Optimality could result from independent linear increases in *H* and *S* to the point where DI is maximized, but there is no reason to believe that, like "area," optimality always results from equal amounts of the two dimensions. Optimality seems more likely the nonlinear result of mutually causal emergence depending on specific agents and firm contexts. Zucker and Darby (1996, Darby, Liu and Zucker 1999) find that one genius appropriately networked is superior to larger networks comprised of less talented agents. Oppositely, knowledge transfers via networks among workers from "lesser schools or the armed forces" "lie at the heart of GE's success" according to *The Economist* (1999b, p. 24). *D* operates as a nonlinear mutual causal function of *H* and *S* with optimality the "multifinal" outcome, to use an old systems term.

There are also thresholds and redundancy effects. Genius may not automatically lead to denser networks—though this could be implicit in the Zucker/Darby findings and could be concluded from the Liebeskind et al. (1996) study. Nor do "social" agents automatically become smarter. A firm starting with the extremes of "isolated geniuses" or "networked idiots" cannot assume that the missing dimension will willy-nilly appear. At GE, for example, *H* and *S* are embedded within an hospitable organizational culture. Redundancy is a critical element in DI, both in brains and in parallel processing computers. Holographic[4] *H* formations can withstand some agent losses without performance deterioration, meaning that not all holders of *H* need to be in the network all the time. And structurally equivalent (Lorrain and White 1971) network formation means that some network links can fail without performance deterioration. Once achieved, optimality often may be quite robust against agent and network deterioration. But, given some highly capable holders of *H*, the intelligence of an entire firm likely correlates quite well with the density of their connections to other less endowed agents.

2.2.2 Emergent DI vs. Visionary Charismatic Leadership

Premise 10: *The visionary, charismatic CEO strategist, given the condition of intervening levels, creates a climate within the firm of intra- and intergroup homogeneity that inhibits (1) diversity in H appreciation; by (2) inhibiting emergence of S connecting employees holding the diverse human capital; that in turn (3) inhibits the creation of the kinds of new product/niche strategies most likely to lead to sustainable rent generation.*

Is it true, as I claim in the introduction, that leadership theory is irrelevant to rent seeking CEOs trying to create DI and increase its appreciation rate? Leadership theory is old—Merrill (1960) cites Jethro in *Exodus* on delegation. It has a vast empirical base (Bass 1981) and continues richly diverse in its theories (Dansereau and Yammarino 1998a, b). Surely every nuance of leadership has been studied. How could leadership aimed at improving DI be overlooked?

Dansereau and Yammarino's (DY) summary table

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[4] Meaning that the ability to recreate the whole is carried in redundant parts. For example, the human genome resides in every cell and when appropriately activated can create any aspect of the whole.

(1998a, p. 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 organizations" rather than "leadership of organizations." In the DY books, only Hunt and Ropo (1998) concentrate on leadership *of* organizations 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.

From Fayol (1916), who defined leadership as "command," to most of the 34 "complexity-theory-applied-to-management" books reviewed in the *Emergence* special issue (Maguire and McKelvey 1999), "leadership" has routinely appeared in the context of "command-and-control" structures. Every single chapter in the DY books focuses on how leaders influence followers within the frame of an existing command-and-control structure. Markham and Markham's (1998) chapter on self-leadership assumes a stable formal structure with followers taking responsibility for self-administering rewards as a means of cutting out first-line supervisors. Their chapter builds mainly on the earlier work of Manz and colleagues who define self-leadership in terms of self-reinforcement, self-observation/evaluation, self-expectation—all within an unchanging formal structure (Manz and Sims 1987, p. 120). Avolio and Bass (1998, p. 58) note that transactional leadership works within existing rules and then, drawing on Bass (1985), they define transformational leadership as redefining the rules to *better connect the leader's vision to follower needs*. "Rules" for them are in organizational culture. Left intact are the rules of the formal structure of command and control. They invoke the notion of "cascading" (Bass et al. 1987, Yammarino 1994) in explaining that transformation moves down the hierarchy one level at a time.

One ray of hope in the DY books is Day (1998b, p. 195), who translates Hall and Lord's (1998) view of multi-level information processing into *distributed sensemaking*, building on Weick (1993, 1995). Troubling, however, is his quote of Weick (1993, p. 643): "When formal structure collapses, there is no leader, no roles, no sense." Day would broaden this to say "no structure therefore no distributed sensemaking." Presuming that the latter applies to firms puts it in direct conflict with the complexity-applied-to-management books, which say, "command-and-control kills emergence." Consequently, leadership theory faces a dilemma: Leaders need to create structure to foster distributed sensemaking but if they create structure they suppress distributed sensemaking.

Leadership in the DY books, is multilevel, yes, but always cascading down across only one level at a time. Weick's quote comes from his study of the Mann Gulch disaster, a one-level group situation. Waldman and Yammarino (1999) get closer to strategic upper echelon leadership in considering leadership across several levels, where followers are not direct-reports—followers are separated from the CEO by levels of intervening managers. Bennis and his colleagues (Bennis and Nanus 1985, Bennis and Biederman 1996) zero in on leaders who successfully reorient multilevel sets of followers in organizations. They abandon trait and situational/contingency theories for a skill-based theory built around leaders who are able to get subordinates to follow their vision.

Presaging my concern about how CEOs can increase DI, Bennis (1996, p. 149) says:

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

He calls for "organized anarchy" saying leadership is like "herding cats." True, he begins by zeroing in on how CEOs might foster DI. Consider the following quotes (1996, pp. 149–151):

> "Human resources people will have to…develop ways of trying to generate intellectual capital."
>
> "Major challenge for leaders…how to release the brainpower of their organizations."
>
> "Leaders…have to make sure that they are constantly reinventing the organization."
>
> "How do you deploy your workforce so that it…can start reinventing [the firm] and creating new ideas?"

So far he is with me. But, when he gets to defining leader attributes, trouble begins:

> "Leaders need to have a strongly defined sense of purpose. A sense of vision."
>
> "Leading means doing the right things…creating a compelling, overarching vision."
>
> "The capacity clearly to articulate a vision."
>
> "It's about *living* the vision, day in day out—embodying it—and empowering every other person…to implement and execute that vision." (his italics)
>
> "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 behaviorally fit into that vision, and then reward people for following those steps."

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 DI formation. 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 organizations are usually the most creative and often the least consulted" (1996, p. 152). Bennis does not answer the question: *How to lead the corporate brain without shutting it down*?

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 organizational culture has been noted (Siehl 1985). Kotter and Heskett (1992) observe that organizational 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 molding 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 (1996, p. 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 organizational 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 organization so that the subsequent performance of units will be coordinated toward higher-level organizational performance. (p. 277)
- Coordinated operational performance of subunits will lead to higher organizational performance, especially when units are interdependent. (p. 278)

These propositions are telling because they: (1) focus on leadership across several intervening levels of organization, thus fitting my focus on CEOs leading the entire firm to foster emergent *H* and *S* 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 have visions that are always correct, innovative, and up-to-date in high velocity environments. But what if the heroic leader's 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 visionary charismatic leadership produces cohesion and leader defined "group-think" (Janis 1972) across intervening levels, where one would instead want to see emergent novelty and new product/market combinations. Charismatic leadership, thus, produces a corporate brain mirroring the CEO's.

A possible alternative to the heroic visionary CEO appears as "*dispersed leadership*" (Bryman 1996). Hosking (1988) emphasizes the network building functions of effective leadership and the cultivation of social influence. Katzenbach and Smith (1993) focus on a kind of leader who fosters the emergence of small teams in which members have common purpose and performance goals. These leaders help the teams build commitment, create opportunities, remove obstacles, and facilitate team solidarity. Kouzes and Posner (1993, p. 156) move even closer to a DI perspective when they say that good leaders "turn their constituents into leaders" and liberate employees "so that they can use their abilities to lead themselves and others" (Bryman 1996, p. 283). Bryman also connects Martin's (1992) "fragmentation perspective" with a decentering of leadership and the "imaginative consumption of culture" idea suggested by Linstead and Grafton-Small (1992). They view culture formation as "dispersed" rather than flowing monolithically from the vision of a heroic leader. Thus, depending on conditions—largely unspecified and unresearched—organizational cultures may comprise: (1) a homogeneous solidarity group flowing from a leader's vision; (2) a group fairly uniformly resisting the leader's normative efforts; (3) a group fragmented in many directions; or (4) in the same power-equalized manner of fragmented cultures, a group may respond to environmentally imposed problems as a result of the dispersed efforts of its members in a process outlined by Schein (1985). At this reading, I do not see that dispersed leadership theory provides a focused offset to the suppressive effects of aggressive top-down visionary leadership.

3 SOME NEW SCIENCE 'MACRO-LEADERSHIP' ACTIVITIES

3.1 COMPLEXITY THEORY

How should CEOs accelerate the rate of DI increase? Most New Science authors say "Take away the command- and-control-structure." They equate the *emergence process* in complexity theory with the *empowerment process* that has existed for years in the Organization Development (OD) literature—hardly a new idea. This is like picking a mattress up off the grass—the grass, having gone flat, straightens back up again. But suppose a CEO needs more growth than what lifting the command-and-control "mattress" leads to? *What is the "fertilizer" that speeds up DI growth*?

Complexity science studies how and under what conditions networks such as DI come about. These are termed "*complex adaptive systems*" (Cowan, Pines and

Meltzer 1994). More specifically, How do *stochastically idiosyncratic agents* (whether particles, molecules, genes, neurons, human agents, or firms), self-organize into emergent aggregate structure. Cowan (1994) observes:

> …Complexity…refers to systems with many different parts which, by a rather mysterious process of self-organization, become more ordered and more informed than systems which operate in approximate thermodynamic equilibrium with their surroundings. (p. 1)
>
> …Complex systems contain many relatively independent parts which are highly interconnected and interactive and that a large number of such parts are required to reproduce the functions of truly complex, self-organizing, replicating, learning, and adaptive systems. (p. 2)

I focus on agents and what creates the region of emergent complexity "at the edge of chaos."

Premise 11: *A system of agents subject to the tension, T, of an energy differential will form emergent structures showing different kinds of complexity that (1) form as a result of importing energy into themselves; and (2) dissipate this energy (and themselves) as they act to reduce the impinging adaptive tension.*

Table 1 Definitions of Kinds of Complexity by Cramer (1993)*

'***Newtonian complexity***' exists when 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 and Stengers 1984).

At the opposite extreme is '***stochastic complexity***' where the 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. Cramer lumps chaotic and stochastic systems into this category, although deterministic chaos is recognized as fundamentally different from stochastic complexity (Morrison 1991), since the former is 'simple rule' driven, and stochastic systems are random, though varying in their stochasticity. Thus, three kinds of stochastic complexity are recognized: ***purely random***, ***probabilistic***, and ***deterministic chaos***. For this essay I narrow stochastic complexity 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 behavior of which lends itself to simple rule explanation. Cramer (1993, p. 215–217) has a long table categorizing 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.

Complexity theorists define systems in the emergent complexity category as being in a state "*far from equilibrium*" (Prigogine and Stengers 1984) and "*at the edge of chaos*" (Kauffman 1993). Prigogine and colleagues observe that energy importing, self-organizing, open systems create structures that in the first instance increase negentropy, but nevertheless ever after become sites of energy or order dissipation. Consequently they are labeled "*dissipative structures.*"

Self-organized—and self-contained[5]—dissipative structures may exhibit persistence and nonlinearity. Complexity caused self-organizing structures are now seen as a ubiquitous natural phenomenon (Mainzer 1994) and presumed broadly applicable to firms (Stacey 1995; Zimmerman and Hurst 1993, Goldstein 1994, Levy 1994, Thiétart and Forgues 1995, Anderson 1999, McKelvey1999a, b).

Premise 12: *The region of emergent complexity exists when T stays between the 1st and 2nd critical values, with the 2nd value defining "the edge of chaos."*

The boundaries of emergent complexity in Premise 12 are defined by "*critical values*" (Mainzer 1994). 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. If *T* increases beyond the 2nd critical value, the agent system jumps into the region of chaotic complexity. Complexity science cannot be understood without appreciating the role that *T* plays in defining the region of complexity "at the edge of chaos." Here the system is likely to oscillate between different states—centered around different *basins of attraction*—thereby creating chaotic behavior. 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 airplane rides.
- **Above the 2nd critical value** of *T*, the molecular movements become chaotic. For example, if *T* between hot lower air and cold

[5] According to a recent conversation between Mike Lissack and Ilya Prigogine, the latter has long regretted not having originally included "self-contained" along with "self-organized" when defining dissipative structures (personal communication from Mike Lissack, Brussels, June 26th, 1999).

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 behavior.

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 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 centered 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.

Premise 13: *Emergent social capital dissipative structures (networks) in firms form in a region of complexity bounded by the 1st and 2nd critical values of T (T being probabilistically defined).*

Table 2 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.

Between the 1st and 2nd critical values lies the organizational equivalent of Cramer's emergent complexity—the region of complexity at the edge of chaos that Brown and Eisenhardt (B/E) (1998) aim at. 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 organizational 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 organization 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)—see Section 3.2.2.

3.2 CEO ACTIVITIES

My analysis takes strategy out of the hands of economists and population ecologists and turns it into a ***macro-leadership challenge***—rents are more apt to come from speeding up microcoevolution within firms—that is, speeding up the DI appreciation rate and boosting the corporate brain's IQ. In addition, the typical heroic visionary CEO at the top of a large hierarchical firm could easily be out of touch with changing technology, markets, and competitor moves, and even worse, could inadvertently create command-and-control conditions inhibiting emergent DI. Complexity theory emphasizes the role of the critical values in defining and enlarging the region of emergent social capital structures. I identify *T*, the adaptive tension energy gradient, as the factor controlling whether a firm's DI system is within the region of emergent complexity or not. Now the question is, *How can CEOs use adaptive tension and other related activities to speed up the DI appreciation rate and steer* *it away from the least promising directions without inadvertently creating the negative effects of an emergent command-and-control structure*?

The activities I emphasize are adaptive tension and critical values which produce emergent DI, and attractors and the agency problem which pertain to "steering" the emergence. I ignore four relevant issues due to space limitations, recognizing that there could be others as well:

- Modular design—discussed by Sanchez (1995, 1999) and Schilling (1999);
- The (auto)catalytic process—discussed as the "coaching" process in the OD literature for decades and is covered very well in the New Science context in books by Goldstein (1994) and Kelly and Allison (1998);
- Dysfunctional anxiety—discussed in depth in Stacey's (1996) book;
- Kauffman's (1993) complexity catastrophe—discussed by Levinthal (1997) and McKelvey (1999a, b).

3.2.1 DEFINING AND MANAGING ADAPTIVE TENSION

Premise 14: *Manage adaptive tension, T, by assuring that agents are confronted with an appropriate set of Ts, to each of which is attached an appropriate intrinsic or extrinsic motivational valence.*

Definition 1: *T is the product of (1) the difference between a firm's or agent's current state and a different, more desirable state relevant to the firm or agent;* times *(2) the intrinsic or extrinsic motivation of an agent to respond.*

A CEO's first task in mobilizing the corporate brain is to make sure it is exposed to the full range of "T_os" "**o**ut there"—that surround the agents—that might energize emergence. But a T_o that is "out there" but ignored by agents has no impact on agents' behavior. In natural systems, so far as we know, agents—particles, molecules, cells—do not ignore T_os impinging on them. Agents in firms can. Welch uses "Be #1 or 2 in your industry…," with a very clear **m**otivational valance—respond to the *T* "…or your division will be sold!"[6] Thus, T_ms—simply *T*s hereafter—need to have an intrinsic or extrinsic motivational valance attached before they can be expected to be felt as tension by agents. *T*s are the root motivation causing agents to import negentropy—from whatever source available—that is the cause of emergent networks aimed at dissipating them.

Definition 2: *Adaptive tension is defined by "an effective sampling" of Ts that agents at various levels within the firm can use to define their adaptive state relative to that of competing agents/firms.*

Definition 3: *"An effective sampling" is defined as ranging "adroitly" between (1) a set of Ts (a) not delimited by the CEO's or others' visions; (b) not narrowly defined by the specific responsibilities of a specific agent; and (c) not mindlessly flooding all agents indiscriminately with all kinds of information, on the one hand, and (2) T prioritizations based on (a) indications of value migration and industry, technological, and market trends; (b) the firm's path dependencies, idiosyncratic resources and competencies, and (c) larger groupings of agents (the sampling of Ts relevant to agents in one division may be reasonably different from Ts relevant to another).*

Definition 4: *"Adroitly" is defined as that mix of Ts getting the corporate brain to produce emergent initiatives showing the highest probability of rent generation over time.*

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 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.

Definition 5: *Ts may also be defined as rates of: product introductions, positive and negative bottom-up leadership events, process improvement events, network transaction events, novelty occurrences; rates at which dysfunctional events are reduced; rates of effective coordination events; information flow rates, etc.*

Another aspect of tension is the felt sense of urgency, defined as the rate at which adaptive events take place—a firm's metabolic (energy conversion) *rate* (McKelvey 1997). This is the rate at which the DI system seeks to reduce the *T*s. A cursory review of the OD literature (see French, Bell and Zawacki 1994) suggests that little attention is paid to *rates* at which organizational events happen. An exception is an article by Beatty and Ulrich (1991) in which they talk about "re-energizing" mature firms. They mention in passing Welch's interest in "speed" of event flows at GE, a point noted again by Stewart (1999). Schoonhoven and Jelinek (1990) bear witness to the concern over speed at Hewlett-Packard. Eisenhardt and colleagues (Eisenhardt and Tabrizi 1995, B/E 1998) zero in on the use of "time pacing" strategies

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[6] Actually, "…we would fix, sell, or close" (Tichy and Sherman 1994, p. 108).

for cranking up the metabolic rates of firms.

If a firm is construed as a place where events take place that improve fitness, then, how often do these take place—process improvement events in general, bottom-up leadership events, network transaction events, novelty occurrence rates, dysfunctional-event reduction rates, and so forth. CEOs have used “management by walking around” to raise metabolic levels while staying outside the bureaucratic command-and-control structure. Rates at which DI systems check in with top leaders are important and may be speeded up as appropriate. Ashkenas et al. (1995) identify four critical elements that serve to raise or lower metabolic flow rates in the DI system: information, competence, authority, and incentives—they call them leverage points. Information flow rates may be managed, as can rates at which learning, knowledge accumulation, and as a result, competence, improve. The relative mix of point attractors and strange attractors used also may be managed (more on this in Section 3.2.3). And surely incentives have a tremendous effect on the rate at which events take place in organizations. In the secondary value chain, differentials in rates of new product research and products brought to market, human and social capital accumulation, requisite variety development, and so forth, are important.

3.2.2 MANAGING AROUND THE CRITICAL VALUES

Premise 15: *Manage targeted elements of the firm into the emergent complexity region by altering the portfolio of Ts impinging on the relevant agent(s) and/or attached motivational valences to produce observable behaviors characterized as "between the 1st and 2nd critical values," and avoid behaviors below or above the 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 1st and 2nd critical values; and (3) widening the distance between the critical values. For now I assume *T*s impinging on an agent are averaged, though in real life some *T*s have far more adaptive significance than others and agents may respond to some more than others with heightened intrinsic motivation.

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)[7] identify some symptoms. As indications that *T* is *below the 1st critical value*, B/E point to (a) high bureaucratic level: all rules followed, overbearing structure, strictly channeled communication (p. 30); (b) too low alliance coadaptation: fiefdoms, overlapping effort, little coordination or learning, uncoupled strategies (p. 60); (c) too low a regeneration level: no modular structures, little novelty, too much path dependency, too many rules (p. 94); (d) kind of experimentation: little agent vision, reactive, focused on present competition (p. 130). For evidence that *T* is *above the 2nd critical value* B/E point to (a) minimal bureaucracy: rule breaking, loose structure, random communication (p. 30); (b) too high alliance coadaptation: over coordination, politics, poorly adapted products (p. 60); (c) too high a regeneration level: too much novelty, no building on the past, modular structures disconnected (p. 94); (d) kind of experimentation: intense experimentation but too narrowly focused, sporadic (p. 130). The B/E symptoms do not identify the full range of *T*s I define earlier, but they make a good start and point the way toward a broader set of symptoms. Some other indications of the system tipping over into the chaotic region could be: Emergent groups that subsequently inhibit intergroup networks—the groups become isolates themselves; emergent structure gone wild; the breaking down of structures—such that individual agents tend toward more isolation; oscillation between individual or network domination; and unstable emergent groups.

B/E focus on symptoms showing when a system is *outside* the region of emergence. 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. Examples are:

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, 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 metabolic (energy or adaptive tension conversion) rates of event occurrence.

Recall that "*T*" is really $T_o \times T_m$, adaptive tension × motivation. Thus, the "felt-impact" of a *T* on an agent could be altered by changing T_o or T_m, or both. An agent's behavioral symptoms, therefore, can be altered relative to the critical values by operating on T_o or T_m, or both.

Premise 16: *"Adroitly" includes managing the portfolio of Ts impinging on one or more agents so that the total effect of the several Ts produces symptoms landing between the critical values.*

Not only does the level of an imposed *T* fall below, between, or above the critical values, the *felt adaptive tension* and the consequent behavioral symptoms could be a function of the number and nature of *T*s hitting any given agent. One *T* per agent, even though significant may not get the agent's behavior above the 1st critical value and too many may shoot it over the 2nd value. This augments the definition of "adroitly" mentioned in Definition 4.

Premise 17: *Lower the 1st critical value by using various OD methods, for example, to increase the ease and pace at which agents form new networks.*

Premise 18: *Raise the 2nd critical value by (1) increasing: requisite variety and strength of human capital, experience in adaptation and change, networking capability, tolerance for ambiguity; and (2) using related OD methods aimed at raising the adaptive skills of agents.*

In addition to the B/E material, symptoms showing the agent system oscillating from below the 1st to above the 2nd critical value, and vice versa—thereby missing the region of emergence—are worth noting. Oscillation could be a sign that either:

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[7] 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 1st and 2nd 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!

1. An agent system is above the 2nd value and subject to a strange attractor in which the two basins of attraction are agents' oscillating attempts to (a) respond to the more extreme values of the impinging *T*s; or (b) respond by retreating to the region below the 1st value;

2. The region between the two values is so narrow that the only responses possible are (a) or (b) above; and

3. The *T*s themselves are fluctuating to the point where the agent system does not stay in the emergence region long enough for emergent structure to form coherently or with stability.

Leaders can deal with (1) above simply by reducing *T* to the point where it falls below the 2nd value. A better strategy is to widen the region of emergent structures as much as possible—the larger the region of emergence the easier it is for the system to avoid oscillating or bifurcating.

Widening the region of emergence requires operating on the location of the critical values themselves—lowering the 1st, raising the 2nd—rather than only trying to adjust the *T*s to fall in between. Much of OD is aimed at getting employees to communicate more—"Increased interaction and communication…underlies almost all OD interventions. The rule of thumb is: Get people talking and interacting in new, constructive ways and good things will result" (French and Bell 1995, p. 161). Anything that gets networks to form more easily is essentially lowering the 1st critical value. Raising the 2nd 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. What seems above the 2nd value in Detroit or Washington may be below the 1st value in Silicon Valley. What seems chaotic to agents with little experience at managing adaptation and forming new networks may seem well below the 2nd critical value to agents experienced in adapting to high-velocity environments. Many OD methods also respond to this issue as well. In fact, most of the 34 "complexity-theory-applied-to-management" books apply elements of OD to these issues.

3.2.3 Managing the Attractors

Speeding up the corporate brain's search for new initiatives, could easily lead to lots of newly empowered agents running around out of control wasting funds on silly projects. 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 2.

Premise 19: *Leader activities are best limited to managing the Ts—portfolio design and motivational valances.*

Bureaucratic negative feedback systems center around point attractors. A visionary leader operates as one—the vision is the goal, which becomes the equilibrium point toward which managerial negative feedback and 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. These should become the focus of strong leaders' attentions. In managing DI it is essential to have point attractors limited to the *T* symptoms relevant to agents in the DI system. Any other use of point attractors by strong charismatic leaders seems most likely to start defining lower level behaviors, thus working against constructive emergence. Needless to say, there is a vast literature on goal-setting theory that is relevant here (Locke and Latham 1990).

Premise 20: *Leader behaviors not aimed at managing the Ts are best limited to managing strange attractors.*

Premise 21: *Reference points and noxiants used to define strange attractor cages are best defined so as to avoid moves (1) away from building on existing core competencies and idiosyncratic resources; and (2) away from the more easily discerned "dry wells," and activities apt to endanger the firm.*

Remaining strong leader activities are best redefined to be strange attractors. This is probably the best way in which to view Bennis's "herding cats" metaphor—the "cage" effect of the rabbit and dog metaphor in Table 2. 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. Core values, core ideologies (Collins and Porras 1994), and Hewlett-Packard style strong cultures (Schoonhoven and Jelinek 1990), that keep agent systems from falling off the track of seeking emergent networks and novel approaches to rent generation, can be particularly effective in defining limits without setting up point attractors.

Premise 22: *Incentive systems for strange attractor management are necessarily of the long term variety, encouraging "No's" only to emergent network initiatives likely to endanger the firm, while avoiding easy "No's" that would shut down emergent networks and inexpensive experiments.*

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." Entrepreneurial incentive systems and strange attractor champions seem relevant, following the new product champion idea (Clark and Wheelwright 1993). Selection processes seem relevant since goal-setting theory (Locke and Latham 1990) indicates that some people thrive better in basins created by point attractors than by strange attractors. As Stacey (1996) discusses at great length, operating in a strange attractor organization could raise anxiety to dysfunctional levels and, thus, needs to be managed carefully. For a general review of managing incentives and innovation, see Tushman and Anderson (1997).

3.2.4 Managing the Agency Problem

Premise 23: *Connecting slack resources to the Ts—as point attractors (that have incentives attached)—aids the reduction of adaptive tension while at the same time mitigating the agency problem—by focusing agent interests toward activities aimed at increasing shareholder wealth.*

Premise 24: *The mechanics of stimulating the corporate brain toward speedier DI appreciation rates foster more effective adaptation and rent generation while at the same time reducing the agency problem.*

Visionary leadership theorists could say that a strong vision at the top (with stock options) is the best defense against the agency problem. Absent this, the DI system will tend to seek the missions of its own agents rather than shareholder wealth. Economists agree, putting their faith in the owner/operator who presumably has the vision (Jensen and Meckling 1976, Besanko, Dranove and Shanley 1996). However, if sustainable competitive advantage and rent generation lies within the DI system, adhering to strong visions held by leaders at the top surely works against shareholder interests—witness Smith's decade of isolated vision at GM (Hunt and Ropo 1998). Strong visions that create conditions of emergent DI can work for shareholders—as in the shareholder wealth resulting from Welch's approach toward "workouts," the empowerment of lower participants (Tichy and Sherman 1993), and the Hewlett-Packard vision. Even so, if responsibility for strategy lies within the DI system, then the agency problem is relevant. Human and social capital holders could choose to put their own interests ahead of shareholder interests.

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. Agency theorists define slack as resources used for nonowner purposes. But slack may be seen constructively as resources available for importation into an emergent system as negentropy, thereby putting dissipative structures in motion. So viewed, slack is another means, in addition to managing the *T*s, to tune agents' symptoms toward the emergent complexity region. High *T*s that would produce symptoms above the 2nd value without slack—because developing emergent structures without negentropy is more difficult—could produce symptoms between the values if more slack was available.

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 emergence, the more likely networks will emerge in response to market related adaptive problems rather than in response to the interests of individual agents. In most organizations, lack of effective strange attractors (leader activities that define the "cage" without creating an emergent command-and-control bureaucracy), coupled with strong bureaucratically driven point attractors, are the forces giving rise to the classic anti-management informal groups and pursuit of aberrant individual interests. Random agent interests—lacking a unity of response toward *T*s—are not likely to give rise to emergent networks absent oppressive command-and-control point attractors uniformly seen as undesirable by the agents. In short, *T*s serving to heighten and steer the adaptive tension felt by agents, if designed properly—meaning an adroit mix of point and strange attractors—also serve to mitigate the agency problem.

In light of our goal of finding ways that leaders can produce sustainable rents, leader 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). Failure to do this leaves more leeway for agents to pursue their own interests. Furthermore, energetic agent campaigns of experimentation, novelty generation, and new product initiations are less likely to deviate from shareholder interests if they are "caged" within a strange attractor framework.

4 CONCLUSION

Narrowly, I suggest that CEOs wishing to generate sustainable rents in a changing world would be more successful if they used a "microcoevolutionary theory of the firm" focused on human and social capital appreciation rates, distributed intelligence, complexity theory and '*macro-leadership*' activities. More broadly, I show how the relevance of several disciplines bearing on organization science reduces to dependence on dynamics, thereby producing a single overarching framework. The several literatures, dynamically integrated, boil down to the following lessons:

1. Economic rents and competitive advantage depend on human and social capital—micro-strategy.
2. Rapid microcoevolution of distributed intelligence (DI)—a

function of optimal levels of human capital and emergent social networks—forms the basis of novelty, and offsets population competitor effects.

3. High-velocity and hypercompetitive contexts require rapid microcoevolution of human and social capital.

4. Current leadership theories, if followed, are more likely to suppress than enhance DI.

5. In firms, the "critical values" of adaptive tension—most likely identified by behavioral symptoms—define the complexity region that stimulates the emergent social capital networks necessary for improving DI.

6. Macro-leadership activities are identified for CEOs to use in speeding up DI appreciation rates for the purpose of producing rents and shareholder wealth.

While New Science advocates still see leadership as crucially important in a rapidly changing nonlinear world, many writers also see a disconnect between a vision-led command-and-control hierarchy and the kind of emergent distributed intelligence giving rise to sustainable economic rents. I use complexity theory's adaptive tension to show how CEOs can speed up the rate of DI appreciation while at the same time suppressing the emergence of bureaucracy. Complexity science recognizes that kinds of complexity are not immutable; they are the result of adaptive tension. Knowing this, if leaders alter the adaptive tension imposed on a system, its kind of complexity changes. Specifically, tuning adaptive tension to between the 1st and 2nd critical values produces emergent network structures. Complexity science, thus, not only offers a more comprehensive means of explaining social phenomena but also offers explicit methods by which CEOs may create fundamental changes in the intrafirm systems for which they are responsible.

I argue that heroic visionary leadership is dysfunctional because of the problem of "leading down" through several intervening levels—it is more apt to suppress the corporate brain than increase its IQ. In contrast, *macro-leadership* produces emergent DI without emergent command-an-control structures. Macro-leadership theory is not just another multi-level approach to leadership, many of which appear in Dansereau and Yammarino (1998a, b). It builds on the distributed leadership notions discussed by Bryman (1996) and upper echelon leadership ideas by Waldman and Yammarino (1999). It identifies activities for CEOs to use who have to lead entire firms, that is, "lead down" through several intervening levels of organization. It avoids the cascading leader-follower, incremental, one-level-at-a-time approaches of existing leadership writers (see chapters in Dansereau and Yammarino 1998a, b). Though my use of microcoevolution, DI, and complexity theory to identify strategic macro-leadership activities is novel, the activities themselves reflect the OD literature. Given this, my essay places CEO-level leadership theory on a joint micro/macro theoretical footing and connects it to rent generation as a common objective for both CEOs and researchers. While not rejecting the psychological and social psychological bases of extant leadership theory and OD, nevertheless, I present a macro-leadership theory that moves macro-level economic, ecological, and evolutionary theories about organizational function and process into the "microrealm" heretofore left in the hands of psychologists—a new definition of micro OB!

Macro-leadership theory offers promise because it better connects to social system dynamics, specifically, microcoevolution, DI, and complexity theory—rather than just to followers' emotions. It steers leadership theory toward speeding up dynamics rather than focusing on leader attributes. In modern science, agent-based modeling approaches are increasingly pervasive and nowhere is this more true than in studies of coevolution, intelligence, and complexity. These disciplines suggest that effective leaders must focus on how to accelerate their firms' DI appreciation rates—especially in the modern world and especially for the U. S., as it grows increasingly dependent on knowledge intensive industries. Leadership theory needs to get on board with the "dynamic" approach.

Theories of bureaucracy and organization (Scott 1998) put intelligence *in the positions* and in the people holding them, and emphasize human capital appreciation as the basis of competitive advantage. Parallel-processing distributed computer systems put intelligence mostly in the agents with primitive emergent connectionism possible. In contrast, theories of the brain and human intelligence say intelligence *is the network*, a view taken up by Burt (1992) in his emphasis of social capital appreciation as the basis of competitive advantage. None of these views is correct by itself. Combined brain and computer-based distributed systems place intelligence *both* in the agents and in the network. My view of DI in firms, therefore, builds on both brain and computer analogies.

Given rapidly changing technologies and markets, the use of knowledge in rapidly changing competitive contexts depends on high levels of corporate DI at organizational levels below the CEO. I argue that human and social capital in firms are the basic building blocks of corporate DI. Given this, social networks are critical. Using a Prigogine-based interpretation of complexity theory, I outline some basic activities that CEOs can set in motion to improve stimulate the emergence of social networks, that is, emergent order. Specifically: (1) They allow CEOs to stimulate the emergent order/intelligence process without introducing the kind of strong command-and-control structure that tends to shut down emergent networks and the creation of new ideas; (2) CEO tendencies to set up point attractors are limited to identifying adaptive tensions and the strange attractor notion is used to prevent emergent DI networks from going too far afield; (3) Attention is paid to enlarging the region of emergent complexity; And (4) CEO focus on adaptive tension reduces the agency problem.

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