Complexity Leadership

Part I: Conceptual Foundations

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CHAPTER 9

EMERGENT STRATEGY VIA
COMPLEXITY LEADERSHIP

Using Complexity Science and Adaptive
Tension to Build Distributed Intelligence

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ABSTRACT

Generation of economic rents requires stimulating coevolution and distributed intelligence within firms. The question becomes, How to improve the corporate brain’s IQ? Intelligence is the network among neurons, thereby setting up social capital appreciation in firms as the means of improving corporate IQ. Heroic visionary leadership theory is dysfunctional because of the problem of “leading down” through several intervening levels—it destroys networking, thereby diminishing corporate IQ—cascading charisma does not work; it creates instead a vision-led command-and-control hierarchy. Complexity theory offers a more dynamical means of explaining social phenomena and explicit methods by which CEOs may improve corporate IQ. Complexity leadership improves corporate IQ without emergent authoritarian command-and-control structures; it does so by speeding up intrafirm coevolving network dynamics rather than focusing on leader
attributes. Complexity leadership theory moves macro-level economic, ecological, and evolutionary theories about organizational function and process into the "micorealm" heretofore left in the hands of psychologists. Effective CEO-level complexity leadership, thus, rests on a joint micro/macro theoretical footing. Various methods by which chief executive officers (CEOs) can improve corporate IQ are presented.

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, & 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 ends 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 & 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) realized 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 & Lengel, 1986; Ulrich, Zenger, & 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 & 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 Welch recognizes, and opposite what modern strategic thinking calls for. Most leadership theorists focus on lower-level group or dyadic relations (Dansereau & Yammarino, 1998a, 1998b) 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 & McKeeney, 1999; Maguire, McKeeney, Miribear, & Oztas, 2006). New Science authors typically couple the emergent structure aspect of complexity theory (Nicolis & Prigogine, 1989) with leadership theories aimed at enhancing motivation via employee empowerment (Galbraith, Lawler, & Associates, 1993). In contrast to empowering managerially defined groups or teams by giving them increased responsibility or self-leadership (Markham & 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 (Argote, 1999; Ferber, 1999; Masuch & Warglien, 1992). 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? Hereinafter, I refer to this as "complexity leadership" (see Uhl-Bien, Marion, & McKeeney, 2007). I build from Prigogine's (Nicolis & Prigogine, 1989) concept of "dissipative structures" and Kauffman's (1993) "spontaneous order-creation" theory.

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 emergent phenomena studied by complexity science. This identifies a number of managerial activities CEOs can use to produce and steer emergent rent-generating dynamics in their firms.

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, italics in original)

The term, coevolve, originates in an article 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" (quoting in Pfanka, 1994, p. 329, emphasis 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 interpersion and organism-abiota environment interactions. Coevolution has now become an umbrella term "for a variety of processes and outcomes of reciprocal evolutionary change" (Thompson, 1994, p. viii).

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. At the human level of analysis, "agents" may be
people, cognitive elements, groups, firms, societies, and so on. 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, Kauflman (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.

Higher rates of reproduction and mutation cause faster coevolution between bacteria and mites than between koala bears and eucalyptus trees (Pntyuma, 1979). 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, emphasis added). Density- and frequency-dependent effects, that is, population-level effects, moderate this theorem, however. This focuses our attention on the relative rates of intraindividual variation versus population/ecological/geographic variation (Slatkin, 1983).

Microcevoiution is defined as coevolution of biomolecules or other components (agents) at various levels within organisms or populations. Rapid microcoevolution among microagents within 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 microcoevolution based individual selection versus population, ecological, or geographical macrocoevolution. 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" on which population ecology depends (Levins, 1968) is the opposite of rapid microcoevolutionary capability.

Forgotten, however, is Levis' observation that the mutation rates driving microcoevolution are higher in changing environments (1968, p. 97). Genes are the "memory of a population;" it follows, that old unchanging genetic memories are not favored in changing environments. But, even where populations are in more stable situations and competing head-to-head over a fixed resource, it follows that the population with the higher mutation rate has the potential to more quickly drift into a separate niche rather than continue head-to-head competition.

**Premise 1a:** As the microcoevolution of agents speeds up, localized niche separation effects predominate over broader environmental context or population-level selection effects.

**Premise 1b:** As the microcoevolution of agents speeds up, adaptive changes within a population (and within its members) negate the death and replacement of populations due to broader environmental changes.

Micro and macro selection appear in organization science (Aldrich, 1979, 1999; McKelvey, 1982, Nelson & Winter, 1982). Population ecologists (Baum, 1996; Baum & Shipilov, 2006; Hannan & Freeman, 1977) and institutional theorists (Scott, 1995) claim that population designs are the result of downward selection pressure—competitive ecological contexts and institutional structures determine firms' fates. This is the invisible hand. Visible hand proponents (Chandler, 1977; Child, 1972) claim the opposite—that individuals (mostly managers and visionary leaders) create internal causal pressures leading to the survival of their firm.

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

**Premise 2a:** The rate at which agent fitness and connections coevolve at any given level determines the relative importance of lower versus higher levels of analysis.

**Premise 2b:** Rent generation at a given level is always a function of the rate of coevolution within and between lower levels within it.

As in biology, the relative importance of intrafirm versus 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 Zabean
(1999) link internal rate of variation with firm performance. Loni and
Larson (1999) and McKelvey (1999a, 1999b) both use computational
agent-based models to explore the relation between rates of microevolu-
tion and firm-level outcomes. Firms also avoid the Red Queen Parado-
x (Barnett & Hansen, 1996) by moving into new product/niche configura-
tions.

Premise 3: As the rate of microagent coevolution increases, at some point
微进化奠定了macroevolution for increasing the likelihood of
rent generation.

Biologists can study microevolution where time is measured in weeks
(Futuyma, 1979, p. 461). But, in the coevolution of laptop computer man-
ufacturers—a rapidly changing population of firms—weeks may be too
short a time span. There is enough evidence of structural inertia (Hannan
& Freeman, 1989; Meyer & Zucker, 1989) and resistance to change (Kot-
ter, 1996) in firms to suggest that the speed of microevolution 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" atti-
uances, limited absorptive capacity, and so forth, all serve to inhibit learn-
ing, knowledge accumulation, and network development. How fast is fast
when it comes to microevolutionary effects on firm-level adaptation? At
a minimum, it is a function of the rate of technological, market, and insti-
tutional changes and the rate at which competitors make their moves. To
have an effect, microevolution in PC firms must be grossly faster than in
violin makers, for example.

Can microevolution 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, pp. 124, 127). The cover story of The Economist
(“The revolutionary,” 1999) 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 & Jelinek, 1990, p. 106).
While stories in Fortune and The Economist good science do not make, nev-
evertheless, 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.³ More generally, How should CEOs accelerate microevolution?

Premise 4: To be effective in increasing the probability of creating rent-
generating initiatives, microevolution rates must exceed technology, mar-
ket, and institutional change rates as well as the microevolutionary rates of
a firm’s niche competitors.

Strategic as a Microevolutionary 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.

Recent writing about competitive strategy and sustained rent genera-
tion parallels Prusak’s emphasis on how fast a firm can develop new knowl-
edge. Rents are seen to stem from seeing industry trends (Hamel &
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, 1986). Further, advocates of the resource-based view emphasize
unique resources, distinctive/dominant/core competencies, dynamic capabilities, learning, and knowledge creation (Barney, 1991; Heene & Sanchez,
1997; Prahalad & Hamel, 1990; Rumelt, 1987; Teece, Pisano & Shuen, 1994; Wernerfelt, 1984). 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, Kaufman, Lobe, &
Shell, 1996). Dynamic ill-structured environments and learning opportu-
nities 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. Combining the need for both H and S, the Cobb-Douglas production function, thus, becomes \( Y = f(K, L, H, S) \), where \( K = \text{capital} \); \( L = \text{labor} \); \( Y = \text{income} \). But, since Porter (1996) now argues that the \( K \) and \( L \) portions of the equation no longer guarantee sustainable rents, this leaves the emphasis on \( H \) and \( S \).

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

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 & 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.

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

**Distributed Intelligence Versus Leadership Theory**

"Why is it that whenever I ask for a pair of hands, a brain comes attached?" (Henry Ford) 4

Enhancing rent generation by improving \( H \) (human capital) and \( S \) (social capital) 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 (Herbst, 1970; Trist & Bamforth, 1951). 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 & Adams, 1980). Now there is self, charismatic, visionary, and transformational leadership (Dansereau & Yammarino, 1998a, 1998b). In all of this, strategic corporate intelligence—and ideas for rent generation—remains in the brain of the heroic visionary CEO (Bennis, 1996; Bennis & Nanus, 1985). 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 (Slater, 2001, pp. 112-113). If so, then, What is organizational intelligence? and How to improve the corporate brain?

**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, the 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. Surely they would agree that \( H \) and \( S \) are both important. If 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 knowledge in the nodes (minimal in brains) and emergent connections among nodes (primitive in computer systems).

Intelligence in brains rests entirely on the production of emergent networks among neurons—intelligence “is the network” (Fuster, 1995, p. 11).
Neurons behave as simple “threshold gates” that have one behavioral option—fire or not fire (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 7:** DI in a brain is entirely a function of its capability for producing emergent networks among neurons.

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 minimal 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) computational 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 (Carley & Prietula, 1994; Ferber, 1999; Masuch & Warglien, 1992). 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 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.

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 DI? 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 the nonlinear result of mutually causal emergence depending on specific agents and firm contexts. Zucker and Darby (1996; Darby, Liu, & 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 (“General Electric,” 1999, p. 24). DI operates as a nonlinear mutual causal function of H and S with optimality the “multifinal” outcome, to use an old systems term (Buckley, 1967).

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, Oliver, Zucker, and Brewer (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 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 network formation (Lorrain & White 1971) 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.

**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 next generation is equifinal, nonlinearly mutual causal, and subject to local firm idiosyncrasies.

**Emergent DI Versus Visionary Charismatic Leadership**

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 & Yammarino, 1998a, 1998b) (DY). Surely every nuance of leadership has been studied. How could leadership aimed at improving DI be overlooked?

Dansereau and Yammarino’s summary table (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 Dansereau/Yammarino (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 subor-
ordinates 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 & 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 & 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, Waldman, Avolio, & Bebb, 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 (1998, 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 broadens this to say “no structure therefore no distributed sensemaking.” Presuming that the latter applies to firms puts it in direct conflict with the complexity-theory-applied-to-management books, which say, “command-and-control kills emergence.” Consequently, traditional leadership theory faces a dilemma: It says leaders need to create structure to foster distributed sensemaking, but it also says that 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 colleagues (Bennis & Nanus, 1985; Bennis & 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 fixing the vision, day in day out—embodies it—and empowering every other person ... to implement and execute that vision.” (emphasis in original)

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 sense-
making 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 & Waterman, 1982; Schein, 1990). The role of entrepreneurs as visionary creators of organizational culture has been noted (Siefle, 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 (2002) 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.

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? Upper echelon visionary charismatic leadership produces cohesion and leader defined “groupthink” (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 de-centering 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. For a corroborating analysis, see Marion and Uhl-Bien (2001). One recent study supporting my position is by Brown and Giota (2002) who, agreeing with Avolio, Kahai, and Dodge (2001), say that “...leadership is not solely a set of characteristics possessed by an individual, but an emergent property of a social system, in which ‘leaders’ and ‘followers’ share in the process of enacting leadership” (quote taken from Parry & Bryman, 2006, p. 455). But the prevailing view is summarized as follows:

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 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.

**SOME NEW SCIENCE ‘COMPLEXITY LEADERSHIP’ ACTIVITIES**

**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” (Gowan, Pines, & Melzer, 1994). Gell-Mann (2002, p. 17) says they “seem to have some connection with life.” They consist of heterogeneous agents having some propensity to connect. Surowiecki (2004) and Page (2007)
both present evidence substantiating the superiority of collectivities of heterogeneous agents over appointed experts. More specifically, how do heterogeneous agents (whether biomolecules, genes, neurons, organisms, people, firms, societies, etc.), 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.” For a review of relevant theories on the “0th law”—the order-creation law, see McKelvey (2004a).

Arthur, Durlauf, and Lane (1997, pp. 3-4; adapted from Holland, 1988, p. 118) set out the basic elements of complex adaptive systems at the edge of chaos, as follows:

1. “Dispersed Interaction”—dispersed, possibly heterogeneous, agents active in parallel;
2. “No Global Controller or Cause”—coevolution of agent interactions;
3. “Many Levels of Organization”—agents at lower levels create contexts at higher levels;
4. “Continual Adaptation”—agents revise their adaptive behavior continually;
5. “Perpetual Novelty”—by changing in ways that allow them to depend on new resources, agents coevolve with resource changes to occupy new habitats; and
6. “Out-of-Equilibrium Dynamics”—economies operate “far from equilibrium,” meaning that economies are induced by the pressure of trade imbalances, individual to individual, firm to firm, country to country, and so forth.

Kauffman (1993) holds that all that is needed for “spontaneous” order creation is some set of heterogeneous agents, motive to connect (such as improved fitness, performance, learning, etc.) and some number of connections with other agents—collectively, all three are necessary and sufficient for order creation. Take any one of these three away and new order does not appear. Below, I add reducing adaptive tension as one of the motives to connect.

Cramer (1993) identifies three levels of complexity—defined in Table 9.1—depending on how much information is necessary to explain the complexity: Newtonian complexity, emergent complexity, and stochastic complexity. Complexity science (Nicolis & Prigogine, 1989) shows that the separation of the region of emergent complexity from the other kinds is a function of the exogenous energy impinging on a system of agents. Emergent structures are created and maintained by negentropy® and eroded by entropy. Negentropic effects create or maintain order in the face of entropic energy/order destroying effects within any system.

Complexity theorists define systems in the emergent complexity category as being in a state “far from equilibrium” (Prigogine & Stengers, 1984) and “at the edge of chaos” (Lewin, 1992/1999). Prigogine and colleagues observe that energy importing, self-organizing, open systems create structures that in the first instance increase negentropy, but nevertheless ever

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**Table 9.1. 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 = mdv/dt, 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) making the “arrow of time” irrelevant (Eddington, 1930; Prigogine & 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 facing 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, pp. 215-217) has a long table categorizing all kinds of phenomena according to his scheme.

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®For mnemonic purposes I use “Newtonian” instead of Cramer’s “subcritical,” “stochastic” instead of “fundamental,” and “emergent” instead of “critical” complexity.

Premise 11: A system of agents subject to the tension, T, of an energy differential7 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 eventually themselves) as they act to reduce the impinging adaptive tension.

The boundaries of emergent complexity in Premise 12 are defined by "critical values" (Mainzer, 1994/2004). Nicolis & 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 (1901) cell—two plates with fluid in between. An exogenous energy (heat) differential between the plates—defined here as adaptive tension, T—creates a circular molecular motion as hotter molecules move toward the colder plate when the energy level rises above the 1st critical value. The energy differential in the Bénard cell parallels that between (1) a teapot: when the heat under the pot reaches the 1st critical value we get what cooks call a rolling boil—the water molecules change their rules from vibrating in place at a higher rate as the heat increases, to circulating from the hot to the cool part of the pot so as to dissipate the heat even faster; and (2) the 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 between the 1st and 2nd critical values. 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 9.2. Thus, for molecular agents:

- **Below the 1st critical value of T**—the edge of order, 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**—the edge of order, 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 edge of chaos, the molecular movement becomes 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; the storm cell may then oscillate between two basins of attraction, tornado-producing and non-tornado-producing behavior.

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**Table 9.2. Definitions of Attractors by Gleick (1987)**

- **"Point attractors"** act as equilibrium points. A system, even though oscillating or perturbed, eventually returns to repetitive 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, non-periodic 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 fox on the outside—the rabbit keeps running to the side of the pen opposite from the fox 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 fox unsystematically attacking from all sides.
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 the acquiring firm imposes little change. 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 chain of command, new personnel procedures, promotion approaches, and benefits packages; new production and marketing systems. And suppose the acquired firm's 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 preacquisition 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 12:** The region of emergent complexity exists when $T$ stays between the 1st and 2nd critical values, with the 1st value defining the "edge of order" and the 2nd value defining the "edge of chaos."

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 (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 workflows 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 & 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 (Brown & Eisenhardt, 1998).

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

**CEO Activities**

My analysis takes strategy out of the hands of economists and population ecologists and turns it into a complexity leadership challenge—rents are more apt to come from speeding up microevolution 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 (1) adaptive tension and critical values, which produce emergent DI, and (2) 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) and Schilling (2000);  
- 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), McKelvey (1999a, 1999b), and Rivkin (2000, 2001), among many others (see Maguire et al., 2006).

**Defining and Managing Adaptive Tension**

A CEO's first task in mobilizing the corporate brain is to make sure it is exposed to the full range of "7s" "out there"—that surround the agents—
that might energize emergence. But a T 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 Ts impinging on them. Agents in firms can. Welch uses “Be #1 or 2 in your industry,” with a very clear motivational activator—respond to the T “or your division will be sold”! Thus, Ts need to have an intrinsic or extrinsic motivational activator attached before they can be felt as tension by agents. Ts 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 1:** A 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.

While agents in a Bénard cell face just one T, the adaptive tension confronting the many agents within a firm—as receivers—may appear as countless Ts. In addition, there are many Ts reflecting forces and constraints in the environment, not to mention Ts 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 Ts 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 Ts based on preconceived CEO-level notions, as Roger Smith did at GM for a decade (Hunt & 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 Ts. Welch accomplishes the same objective by defining Ts 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 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 “adroity” 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:** “Adroity” is defined as that portfolio of Ts getting the corporate brain to produce emergent initiatives showing the highest probability of rent generation over time.

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 Ts. A cursory review of the OD literature (see French, Bell, & 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 (Brown & Eisenhardt, 1998; Eisenhardt & Tabrizi, 1995) zero in on the use of “time pacing” strategies for cranking up the metabolic rates of firms.

**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.

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 lev-
els 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, Ulrich, Jick, and Kerr (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 2.2.3). 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.

**Proposition 2:** Tension management that is "adroit" in confronting agents with appropriate sets of adaptive tension $T$s (each of which includes an appropriate intrinsic or extrinsic motivational activator) will show the highest probability of rent generation.

**Managing Around the Critical Values**

Assuming agents are confronted by an adroitly defined portfolio of $T$s, managing the critical values aspect of adaptive tension requires three basic activities: (1) checking whether the behavioral symptoms (see next paragraph) of $T$s impinging on one or more agents are below, between, or above the critical values; (2) altering motivational activators to move the $T$s 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. Brown and Eisenhardt (1998) (BE) identify some symptoms. As indications that $T$ is below the 1st critical value, BE point to:

- *High bureaucratic level:* all rules followed, overbearing structure, strictly channeled communication (p. 30);
- *Too low alliance coadaptation:* fiefdoms, overlapping effort, little coordination or learning, uncoupled strategies (p. 60);
- *Too low a regeneration level:* no modular structures, little novelty, too much path dependency, too many rules (p. 94);
- *Kind of experimentation:* little agent vision, reactive, focused on present competition (p. 130).

For evidence that $T$ is above the 2nd critical value BE point to:

- *Minimal bureaucracy:* rule breaking, loose structure, random communication (p. 30);
- *Too high alliance coadaptation:* over coordination, politics, poorly adapted products (p. 60);
- *Too high a regeneration level:* too much novelty, no building on the past, modular structures disconnected (p. 94);
- *Kind of experimentation:* intense experimentation but too narrowly focused, sporadic (p. 130).

The BE 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.

BE 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:

- Emergent social networks such as dyadic or triadic communication channels, informal or formal teams, groups, or other network configurations;
- 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, etc.:
- Emergent networks of any kind, networks that produce novel outcomes, new strategies, new product ideas, new directions of knowledge accumulation; and
- Networks that speed up metabolic (energy or adaptive tension conversion) rates of event occurrence.
Proposition 3: Tension management that is “adroit” moves the firm into the emergent complexity region by altering the portfolio of Ts impinging on the relevant agent(s) (and attached motivational activators) as evidenced by observable behaviors between the 1st and 2nd 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 Ts 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.

Proposition 4: Tension management that is “adroit” includes managing the portfolio of Ts impinging on one or more agents so that the total effect of the several Ts produces observable behavioral symptoms landing between the critical values.

In addition to the BE 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:

1. An agent system is above the 2nd value and subject to a strange attractor in which the two basins of attraction are agent oscillations in (a) response to the more extreme values of the impinging Ts, or (b) moves back and forth across the 1st and 2nd critical values;
2. The region between the two values is so narrow that the only response possible is cycling between order and chaos; and
3. The Ts 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—that is, the environment is chaotic (Ashby, 1962).

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 Ts 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 & 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 dissipation; 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 reviewed in Maguire and McKelvey (1999) apply elements of OD to these issues.

Proposition 5: Lower the 1st critical value by using various OD methods, for example, to increase the ease and pace at which agents form new networks.

Proposition 6: Raise the 2nd critical value by (1) increasing requisite variety (Ashby, 1956) 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.

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 9.2.

Bureaucratic negative feedback systems center on 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 Ts but do not “define” the system in the
command-and-control ways that inhibit emergence—as I have already noted that Jack Welch did. Ts are point attractors; activities that serve to reduce Ts, thus, are point attractors. The portfolio of Ts 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.

**Proposition 7:** Leader activities are best limited to managing the Ts, which includes portfolio design and motivational activators.

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 fox metaphor in Table 2. We may use what Morgan (1996, p. 98) refers to as “cybernetic reference points” and “avoidance of noxians” 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 & Porras, 1994), and Hewlett-Packard style strong cultures (Schoonhoven & 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.

**Proposition 8:** To improve DI, leader behaviors are best limited to managing strange attractors.

**Proposition 9:** Reference points and noxians 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.

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 (Royer, 2003). 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 & Wheelwright, 1993). Selection processes seem relevant since goal-setting theory (Locke & 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).

**Proposition 10:** 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.

**Managing 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 & Meckling, 1976; Besanko, Dranove, & 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 & 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 & 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 & 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 non-owner 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 Ts, to tune agents’ behaviors and their symptoms toward the emergent complexity region. High Ts 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 Ts. Connecting slack with specific Ts, but still steering the DI system by strange rather than point attractors seems optimal. The more that market-connected Ts 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 Ts—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, Ts 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 Ts (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.

**Proposition 11:** 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.

**Proposition 12:** 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.

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 apprecia-

tion rates, distributed intelligence, complexity theory, and “complexity 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 microstrategy.
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 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. Complexity 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,
plexity leadership produces emergent DI without emergent command-and-control structures. Complexity leadership theory (Uhl-Bien et al., 2007) 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 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 & Yammarino, 1998a, b).

Though my use of microevolution, DI, and complexity theory to identify strategic complexity 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 complexity leadership theory that moves macrolevel economic, ecological, and evolutionary theories about organizational function and process into the “microworld” heretofore left in the hands of psychologists—a new definition of micro OB!

Complexity leadership theory offers promise because it better connects to social system dynamics, specifically, microevolution, 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 (Carley & Prietula, 1994; Ferber, 1999; North & Macal, 2007) 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 United States, 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 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.

**AUTHOR NOTE**

This chapter has circulated for several years and been cited in other papers under the title of “MicroStrategy from MacroLeadership: Distributed Intelligence from New Science.”

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NOTES

1. A more detailed definition 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. I follow each argument with a premise. Following evolutionary epistemology (Azevedo, 1997; McKelvey, 1999c), a premise stands as the best current collective belief in the pertinent literature. My premises summarize elements of the more solidly researched literature. Starting in the second section, I state the summaries as propositions—seen as one step before refutable hypotheses—which call for research corroboration.

3. For more detail about how Welch unknowingly uses complexity theory to run GE see Mackey, McKelvey, & Kiousis (2006).


5. 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.

6. Schrödinger (1944) coined negentropy to refer to energy importation into an open system.

7. 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 26, 1999).

8. The force leading to a phase transition may be measured as T, the energy (temperature) imposing on, say, a teapot or the earth's atmosphere, or as R, the Reynolds number (the measure of the rate of fluid flow). In later case it is a direct function of the energy, T, causing the flow. In fluid dynamics, given a T-level causing an increased rate of R, fluid flow becomes turbulent—the phase transition. This "critical value" of R is termed the Rayleigh number, R (Lagerstrom, 1996). Hereinafter, I will simply use T in referring to an imposing force or tension to which a system responds, which I will call adaptive tension.

9. Actually, "we would fix, sell, or close" (Tichy & Sherman, 1994, p. 108).

10. How wide should the region of emergence be? If a firm spends all of its time above the edge of order it could spend all of its energy on self-organization [March's (1991) exploration] and not on being efficient and making profits (March's exploitation). Thomas, Kaminiska-Labbé, and McKelvey (2005) call for oscillation above and below the edge of order. It doesn't seem that there is a limit to raising the 2nd critical value so as to avoid crossing the edge of chaos.

11. More likely, T is are Pareto-distributed—meaning that most Ts are small (almost everyday) tensions, but infrequently there is an extreme T in the form of avoiding bankruptcy (Ford Motor Co.), or fighting off or making an acquisition, or taking advantage of a new technology (Intel, Google). See Andriani and McKelvey (in press) for a discussion of Gaussian averages versus Pareto distributions.

12. Though the RE book offers useful advice to practicing managers the impression they give of complexity theory could be misleading to naive 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!

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