Quasi-natural Organization Science

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Positing that organizational phenomena result from both individual human intentionality and natural causes independent of individuals' intended behavior, the need for a quasi-natural organization science is identified. The paradigm war is defined in terms of positivism and postpositivism, with the suggestion that a more relevant epistemology might be scientific realism. The current unconstructive paradigm proliferation is seen as resulting from an underlying cause, idiosyncratic organizational microstates, phenomena identified by postpositivists. The article develops quasi-natural organization science as an antidote to multiparadigmaticism by recognizing that mathematically, computationally, and experimentally intense 20th century natural sciences all have microstate idiosyncrasy assumptions similar to those postpositivists suggest are true of organizational phenomena. By framing a quasi-natural organization science focusing on microstates, my intent is <u>not</u> to deny the relevance of either intentionality and subjectivity *or* natural science and objectivity. The article attacks the microstate idiosyncrasy problem on four frontiers: micro- and macrocoevolutionary theory, semantic conception epistemology, analytical mechanics, and complexity theory. The **first** frontier develops the natural side of quasi-natural organization science to explain natural pattern or order. This "order" arguably results from multilevel coevolutionary behavior in a selectionist competitive context in the form of multi-level selectionist effects. The **second** frontier reviews the historic role of idealized models, as understood by historical realists and the "semantic conception of theories"—idealized constructs such as point masses or the rational actor assumption—that currently successful sciences, such as physics and economics, drew upon early in their life-cycles to sidestep the idiosyncrasy problem. Organization scientists are encouraged to develop theories in terms of idealized models. The **third** frontier attends to the role of 'instrumental conveniences' as essential constructs in the early life-cycle stages of sciences and the importance of studying rates. For example, a construct such as a pressure vessel acts as a container translating idiosyncratic gas particle movements into a directed pressure stream where particles emerge at some rate. Drawing on Sommerhoff's "directive correlation" concept as an analogous "container" in firms, this section argues that such containers can be used in organizational analysis to translate idiosyncratic microstates into probabilistic rates of occurrence, thereby allowing the use of intrafirm rate models and Hempel's deductive-statistical model of explanation. An example is given showing how human resource variables can be translated into rate concepts and then used in the context of the directive correlation and the deductive statistical model.   The **fourth** frontier draws on complexity theory as a computational/analytical approach that directly incorporates idiosyncrasy by use of nonlinear dynamical methods. Complex adaptive systems, kinds of complexity, the causal role of complexity, and levels of adaptive tension likely to foster self-organization are discussed. An example shows how a complexity theory approach differs from a conventional explanation of why participative management decision making styles have failed to proliferate. The combined effect of rate dynamics, statistical mechanics, and nonlinear dynamical analysis lays the platform for a realist, predictive, and generalizable quasi-natural organization science, thereby offering a possible resolution of the paradigm war. The mitigation of idiosyncrasy effects allows a reemphasis of background laws in organization science, as opposed to the further emphasis of contingent details advocated by postpositivists.

Key Words: Multiparadigmaticism; Microstates; Epistemology; Coevolutionary Theory; Directive Correlation; Rate Dynamics; Complexity Theory.

I.   INTRODUCTION

Even a hermit in bleakest Antarctica must be aware of the organization science paradigm war by now. The argument between objectivists and subjectivists is an old one in social science (Natanson, 1963), but recently the long standing tension has boiled up more stridently in organization science between organizational positivists and postpositivists (Hartman, 1988; Aldrich, 1992; Pfeffer, 1993, 1995; Perrow, 1994; Van Maanen, 1995a,b). Furthermore, multiparadigmaticism is unbounded. Donaldson (1995) counts fifteen paradigms. Clegg, Hardy, and Nord (1996), identify eight seemingly incommensurable paradigms. Mone and McKinley (1993) observe that organization science values uniqueness and novelty, suggesting that more are likely. Prahalad and Hamel (1994) call for even more "new" paradigms. Clegg, Hardy, and Nord also encourage "new and different approaches" (1996: xxiv), as do Cannella and Paetzold (1994).

I argue that the complex, idiosyncratic nature of organizational phenomenon is the underlying cause of the paradigm war and that its resolution calls for studying firms as *quasi-natural phenomena*. I define quasi-natural to mean the intersection of *intentionally* and *naturally* caused behavior. A useful metaphor for describing quasi-natural phenomena is illustrated in Figure 1. It is a time-lapse photograph of a juggler simultaneously changing two balls from one hand to the other. Juggling is a perfect example of quasi-natural phenomena. Once the balls leave the juggler's hands they behave according to well understood Newtonian laws of classical physics (Beek and Lewbel, 1995). The movement of the hands, however, may be governed entirely by the intentionality of the juggler, though with professional jugglers—who can juggle balls blindfolded or while reading books—the degree to which hand movements are driven by the *natural* forces governing the ball movements or the *intentionality* of the juggler may vary. The challenge for organization scientists is to better understand (1) '*intentional*' organizational effects, (2) '*natural*' organizational effects, and (3) the '*transition phenomena*' linking these two kinds of causal phenomena. The tension between these effects is clearly enunciated in the founding essay of this journal (Daft and Lewin, 1990). In this article, I focus only on the idiosyncrasy problem and only on the natural science side.

I use the natural side of a *quasi-natural organization science* to attack the idiosyncrasy problem on four frontiers, drawing on a synthesis of modern epistemology, coevolutionary theory, analytical mechanics, and

complexity theory. Any one of these taken by itself offers modest promise, but as a comprehensive package I believe they put organization science on a stronger footing. Though complexity theory is the 20th century frontier, the others also solved the idiosyncrasy problem for successful sciences earlier in their life-cycles. All four continue to be central components of modern scientific method. My attack calls for the following actions: (1) Integrate internal and external organizational analysis by focusing on *multi-level coevolutionary Darwinian selectionist behavior* as the driving force of natural order in organizational phenomena; (2) Sidestep the idiosyncrasy problem by focusing on the *idealized models* of scientific realism; (3) Use *instrumental conveniences* to translate idiosyncratic events into probabilistic distributions of occurrence rates, thereby shifting organizational analysis toward the calculus of rates; and (4) Use *microstate analysis* based on statistical mechanics, complexity theory, and computational and mathematical adaptive learning models to directly analyze how idiosyncratic phenomena self-organize into emergent aggregate structures.

In the following sections, I first argue that the paradigm war persists because current organization science method does not foster easy refutation of false paradigms, due to subjectivist epistemology and lack of testability. Next I establish stochastic idiosyncrasy as the underlying cause of the war's prolongation. This is followed by a preliminary definition of the natural side of quasi-natural organization science. Then I develop the four arguments of my attack as listed above. The article ends with Darwin's admonition that both background laws and idiosyncratic contingent details are important.

II. WHAT'S WRONG WITH ORGANIZATION SCIENCE

A. PARADIGM PROLIFERATION—THE SYMPTOM

Lincoln (1985a: 29) quotes Patton (1975: 9) in defining a paradigm as

> a world view, a general perspective, a way of breaking down the complexity of the real world. As such, paradigms are deeply embedded in the socialization of adherents and practitioners telling them what is important, what is legitimate, what is reasonable. Paradigms are normative; they tell the practitioner what to do without the necessity of long existential or epistemological considerations.

Hartman, (1988), Aldrich (1992), and Pfeffer (1993, 1995), among many others, have observed that the multiparadigmatic state of organization science has left the field in disarray. As evidence of the basic objectivist/subjectivist split, I offer several views in Table 1. While Pfeffer's (1993, 1995) analysis showing that multiparadigmatic fields are held in low esteem is compelling, his solution (a power-elite committee) has been roundly criticized by Perrow (1994) who suggests Pfeffer's concerns are vestiges of the physical sciences. Van Maanen (1995a) says Pfeffer's view of organization science is "…insufferably smug; pious and orthodox;

philosophically indefensible; extraordinarily naive as to how science actually works; theoretically foolish, vain and autocratic…." Donaldson's solution takes the field back to late 1960s style contingency theory. The authors of the eight "frameworks" in the new *Handbook of Organization Studies* (Clegg, Hardy, and Nord, 1996) seem to reinforce incommensurability rather than fostering synthesis. The war is exacerbated by: (1) organizational positivists' view of "good" science defined in terms of an antiquated view of 18th century physics in which linear deterministic laws dominate; and (2) postpositivists' focus on idiosyncrasy to the exclusion of more systematic phenomena, gross misinterpretation of positivism, and emphasis of inductive logic to the exclusion of justification logic (Reichenbach, 1938).

> > > **Insert Table 1 about here** < < <

Since Popper's (1959; German edition 1935) introduction of *falsificationism* into justification epistemology, scientists have insisted that hypotheses be phrased so as to be testable and falsifiable (Hunt, 1991). I see two primary reasons why multiple paradigms remain in organization science. **First**, and somewhat trivially, the science is relatively new, many paradigms are quite recent, and it simply takes time for the weight of incremental refutations to finally scuttle strongly entrenched claims, paradigms, or schools. **Second**, there is cause to believe that the testability criterion has failed in organization science, for two reasons: (1) Prediction, falsification, and generalization, the basic elements of normal science, do not work with organizational phenomena because much of it is idiosyncratic; and (2) Subjectivist thinking is increasingly prevalent. As Clegg and Hardy (1996: p. 7) put it, "[T]here is no denying the alternative theorists [their term for postpositivists]; they are emerging as new tenants in the citadels of power."

Is postpositivism really a cause of paradigm proliferation or a viable alternative to positivism? To clarify the primary points of contention, I simplify the paradigm war to just two sides—*scientific realists* (positivists or objectivists exemplified by Pfeffer, 1982; Camerer, 1985; Mackenzie, 1986; Hannan and Freeman, 1989) who essentially fail as scientists if the testability criterion does not work, and *postpositivists* (subjectivists exemplified by Silverman, 1971; Burrell and Morgan, 1979; Lincoln 1985c; Reed and Hughes, 1992; Alvesson and Deetz, 1996) who ignore testability. Hereafter, I will use '*scientific realism*' or simply '*realism*' instead of the abandoned "positivism" for reasons to be discussed in Section 3.2.1.

Postpositivists focus our attention on the idiosyncrasy problem, instead of glossing over it as do the realists, and for this we are indebted. Postpositivists are scholars who take a closer, richer, thicker, more subjective view of organizational phenomena, coming to appreciate its fundamentally complex, idiosyncratic, and multi- and mutually-causal nature (Lincoln, 1985c; Reed and Hughes, 1992). They conclude that the prevalence of idiosyncratic

phenomena precludes the use of conventional realist methods, calling instead for subjective, richly descriptive, natural history style case analyses (Van Maanen, 1989). It is also clear that they make no pretense of worrying about testability, that is, valid self-correcting justification logic. As evidence, I offer some quotes from Lincoln (1985b) in Table 2. It seems pointless to pretend that an argument against multiparadigmaticism is not also, in part, an argument against postpositivism—after all, the latter favors paradigm proliferation and does not appear to have any means of preventing it.

> > > **Insert Table 2 about here** < < <

B.   *STOCHASTIC IDIOSYNCRASY—THE CAUSE*

I argue that stochastic idiosyncrasy in the context of realist epistemology leads to multiparadigmaticism in organization science. I use the term, *stochastic*, to recognize that idiosyncratic process event occurrences in firms fit some probabilistic distribution. Recently, and at the value chain level, Porter (1985) and those holding the resource-based view in strategy (Teece, 1984; Wernerfelt, 1984; Rumelt, 1987; Barney, 1991; Reevis-Conner, 1991) argue that competitive advantage stems from idiosyncratic competencies held by firms. More traditionally and broadly, phenomenologists, humanists, social constructionists, and interpretists emphasize the *idiosyncrasy* of individual, group, and organizational behavior (Silverman, 1971; Burrell and Morgan, 1979; Reed and Hughes, 1992). Clark, Guba, Lincoln, and Weick (all 1985) elaborate the postpositivist paradigm in more detail, based on a summary of paradigm shifts in various disciplines developed by Schwartz and Ogilvy (1979: 13-16), shown in Table 3.

> > > **Insert Table 3 about here** < < <

In all sciences microstates form the '*molecular lower bound*' (following Schwab's (1960) definition of 'molecular reductionism' in the hierarchy of sciences). All sciences, early in their life-cycle have assumed that the lower bound microstates were uniform. The realization that their basic phenomena are *stochastically idiosyncratic* has not entered easily into any science. Although Boltzmann introduced probability theory and statistical mechanics to the kinetic theory of gases circa 1870 (Gillispie, Vol. II, 1970), it was the emergence of modern quantum mechanics (Mehra and Rechenberg, 1982) that forced physicists to accept that particle attributes, such as energy and trajectory, were stochastically idiosyncratic. Eventually thermodynamic laws were rewritten to take idiosyncratic particle and gas molecule movements into account (Prigogine, 1962). In biology the so-called "Modern Synthesis" resulted after Fisher (1930) used Boltzmann's statistical mechanics to track the trajectories of mutant genes similarly to Boltzmann's treatment of idiosyncratic gas particles (Depew and Weber, 1995: 244-245). Biologists no longer assume that cell physiochemistry is uniform (Nossal and Lecar, 1991) or

that all genes activate uniformly (Simmonds (1992). Though psychologists for decades assumed that body and brain chemistry were uniform; psychobiologists now have relaxed this assumption (Boddy, 1978; Crick, 1979).

At the level of the firm, realist organizational and related social scientists also have traditionally ignored the possible idiosyncrasy of organizational phenomena. Most social scientists use probability to account for measurement error and uncontrolled random effects rather than to accommodate the idiosyncrasy of their phenomena. By assuming uniformity, realist social scientists can make predictions across time and over space, since phenomena at one time and place (absent the effect under study) are the same as those at some other time and place. Economists rest their aggregate economic analyses on the 'rational actor' uniformity assumption about individuals (Friedman, 1953; Lucas, 1986; Hogarth and Reder, 1987), though there are exceptions (Cross, 1983; Thaler, 1991; Sargent, 1993). They have traditionally used predominantly mid-19th century linear deterministic models unsuited to the idiosyncrasy assumption (Wiener, 1964; Mirowski, 1989), though more recently nonlinear dynamical approaches have appeared (Sargent, 1987, 1993; Medio, 1992; Azariadis, 1993; Aoki, 1996). Population ecologists, exemplar realists in organization science, also depend exclusively on linear deterministic models with a uniformity assumption (Tuma and Hannan, 1984; Hannan and Carroll, 1992).

Those studying aggregate firm behavior increasingly have difficulty holding to the traditional uniformity assumption about human behavior. Psychologists have studied individual differences in firms for decades (Staw, 1991). Experimental economists have found repeatedly that individuals seldom act as consistent rational actors (Hogarth and Reder, 1987). Some management scientists have shifted to 'data envelope' or outlier analysis as a means of identifying decision making entities defining a pareto efficient performance frontier. Instead of treating such entities as chance based outliers, they emphasize that entities consistently defining the frontier do so by virtue of drawing on idiosyncratic capabilities (Charnes *et al.*, 1994).

Phenomenologists, social constructionists, and interpretists hold that individual actors in firms have unique interpretations of the phenomenal world, unique attributions of causality to events surrounding them, and unique interpretations, social constructions, and sensemakings of others' behaviors (Silverman, 1971; Burrell and Morgan, 1979; Weick, 1979, 1995; Reed and Hughes, 1992). Although the effects of institutional contexts on organizational members are acknowledged (Zucker, 1988; Scott, 1995), and the effects of social pressure and information have a tendency to move members toward more uniform norms, values, and perceptions (Homans, 1950), there are still strong forces remaining to steer people toward idiosyncratic behavior in organizations and the idiosyncratic conduct of

organizational processes, as indicated in Table 4.

For organization science, *microstates are defined as discrete random behavioral process events*. At the microstate level of analysis in firms, each process event may be assumed idiosyncratic and unpredictably different from other microstates. They form the boundary between organization science and more fundamental sciences, such as psychology, decision science, physiological psychology, biochemistry, and so forth, which might discover uniformities among microstates.

The dilemma is that it seems impossible to simultaneously accept the existence of idiosyncratic organizational events while at the same time pursuing the essential elements of justification logic defined by realists—prediction, generalization, and falsification—which requires nonidiosyncratic events (Hempel, 1965; Suppe, 1977, 1989; Hunt, 1991). The dilemma is significant since idiosyncrasy will not disappear and realism is the only scientific method available that protects organization science from false theories, whether by distinguished authorities or charlatans. *The one singular advantage of realist method is its empirically based, self-correcting approach to the discovery of truth* (Holton, 1993). The logical sequence supporting my argument that idiosyncrasy leads to multiparadigmaticism is shown in Table 5. By this logic the failure to eventually reject paradigms is caused by underlying stochastic idiosyncrasy.

C.   QUASI-NATURAL ORGANIZATION SCIENCE

My resolution of the paradigm war calls for the study of firms as quasi-natural phenomena. There are two critical features of this view. **First**, firms are composed of numerous structures and processes amenable to *natural* science methods of inquiry and justification logic, including prediction, generalization, and falsifiability. But they also comprise behaviors directly attributable to human *intentionality*—behaviors and causes that may not be fruitfully understood in terms of natural science methods (Hartman, 1988). The Daft and Lewin (1990) essay develops the intentionality side as composed of organization design, defined as including: culture, decision making, information processes, CEO values and style.... and "engineering of effectiveness" (p. 3). While I agree that their characterization of organization science as locked in an antiquated Newtonian straightjacket is correct, my contention here is that an up-dated 20th century view of natural science fits modern assumptions of organizational phenomena very well, and thus deserves to be an equal member at the high table of organization science. **Second**, rather than cloud organization science by warring over whether realists or postpositivists are correct, the quasi-natural science approach turns a significant problem in organization science—the war—into an interesting subject—the causes and consequences of transition phenomena between intentionally and naturally caused order. The transition phenomena are what make juggling challenging and interesting to watch—will the juggler toss the balls so as to be able to catch them when they come down? In firms, the transition phenomena focus on ways in which the intentional and natural phenomena influence each other—this is where most of the interesting choices and problematic errors are made and where many managerial difficulties lie.

Organization scientists have a truly archaic 18th century view of science, a worst case scenario really, in that it is a linear deterministic Newtonian mechanics epistemology without the power of mathematics—this is the "normal science straightjacket" alluded to by Daft and Lewin (1990). Now, 20th century natural science is dramatically different from the 18th century version (Prigogine and Stengers, 1984; Mainzer, 1994; Favre, *et al.*, 1995), a point I will elaborate below. The fact that we have an 18th instead of 20th century view of normal science explains why I have chosen to put most of my effort toward defining the natural part of quasi-natural organization science, and why, until modern natural science aspects of organization science are developed, I do not see much fruitfulness coming from attempts to study transition phenomena, that is, transitions between science and engineering, as Daft and Lewin characterize it.

Guba, Clark, Huff, Lincoln, and Weick (all 1985) have taken assumptions similar to those of complexity theorists as the basis of the postpositive psudoscientific methods they advocate. Their assumptions, identified in Table 3, are not unlike those of complexity theorists: complexity, negentropy, contextually emergent simplicity, multiple causality, nonlinearity, self-organization, adaptive learning (Nicolis and Prigogine, 1989; Cramer, 1993; Cowan, Pines, and Meltzer, 1994). Physicists, chemists, and biologists have taken these same assumptions and have developed a modernized 20th century natural science that still upholds the traditional tenets of "good" science, namely: objective measurement, replication, prediction, generalization, falsifiability, and most important of all, self-correction (Nicolis and Prigogine, 1989; Kaye, 1993; Mainzer, 1994; Favre, *et al.*, 1995). Figure 2 shows a circle (representing the Schwartz and Ogilvy assumptions now postulated to be true of firms) and a vector (solid line) symbolizing the direction of 18th century physics. The remarkable course of events is that the assumptions of 20th century natural scientists, in particular those defined by complexity theorists in physics, chemistry, biology, have moved in the direction shown by the dotted line, such that natural scientists' assumptions about their natural phenomena match key assumptions modern organization scientists have about organizational phenomena.

My analysis steers organization scientists away from the postpositivism of Guba, Lincoln, Weick, *et al.* toward the epistemology of 20th century natural science and complexity theory. There are seven foundation premises, shown in Table 6. My discussion so far defends the first

premise—that idiosyncrasy effects are recognized as key elements of modern natural science *and* organizational phenomena. In the following subsections I defend the remaining premises while also delineating the four frontiers of my attack on stochastic idiosyncrasy—all of which form the basis of the natural side of quasi-natural organization science.

> > > **Insert Table 6 about here** < < <

III.   ATTACKING THE IDIOSYNCRASY PROBLEM

I attack the idiosyncrasy problem by proposing four new directions in organization science epistemology: (1) Posit multi-level selectionist effects as the root causal force of natural order; (2) Sidestep idiosyncrasy by basing theory on empirically corroborated idealized models; (3) Use instrumental conveniences to translate idiosyncrasy effects into rates and event arrival probability distributions; and (4) Draw on microstate analysis, complexity theory and adaptive learning models to incorporate idiosyncrasy effects directly.

A.   NATURAL ORDER FROM A SELECTIONIST COMPETITIVE CONTEXT

Scientists explain causes of order—why things are the way they are. Four basic causes are now recognized. Physical order is reduced to the four forces of unified field theory (Barrow, 1991). Organic order is reduced to the results of selectionist effects in a competitive context (Depew and Weber, 1995). Rational order of human and social behavior has been reduced to rational actor decision effects (the literature ranges from classical management to experimental economics). Complexity theory has emerged as an alternative cause of order in physical, organic, and human systems (more on this in Section 3.4). Scientists typically explain in terms of more than one of these. For example, physicists focus on physical and complexity effects (Gell-Mann, 1994; Favre, *et al.*, 1995). Biologists focus on physical, selectionist, and complexity effects (Nossal and Lecar, 1991; Depew and Weber, 1995).

Organization scientists should consider explanations in terms of rational, selectionist, and complexity causes. The 'rational system' view of organizations (Scott, 1992), which includes the classical management (Massie, 1965), decision behavior (March and Simon, 1958), and "visible hand" (Chandler, 1962) schools, holds that order or pattern in firms results from decisions by managers. The 'natural system' view (Scott, 1992), posits that order results from emergent system behavior. In this section, I extend the natural system view by arguing that selectionist effects cause *natural order* in firms, defined as any order, structure, or pattern appearing in complex random events that cannot be attributed to some specific prepensive purposeful activity or decision by some identifiable official or unofficial component entity.

The eminent evolutionist, Theodosius Dobzhansky (1973: 125), once wrote, "nothing in biology makes sense except in the light of evolution." More fundamentally, Darwin said,

> A corollary of the highest importance may be deduced from the foregoing remarks [on the "Struggle for Existence"], namely, that the structure of every organic being is related...to that of all other organic beings, with which it comes into *competition* for food or residence, or from which it has to escape, or on which it preys (1859: 77; my italics).

Through the interaction of four processes (variation, selection, retention, and struggle) the Darwinian theory of natural selection explains order in the biological world in the context of competitive forces in impinging on organisms (Darwin, 1859; Dobzhansky, *et al.*, 1977; Lewontin, 1979; Kauffman, 1993). As the 20th century ends, Darwinian evolutionary theory is properly seen as composed of multilevel micro- and macro-coevolutionary explanations (Depew and Weber, 1995). My analysis of the natural origins of order in firms begins with a discussion of coevolution and then turns to multilevel micro- and macrocoevolution.

COEVOLUTIONARY ORIGINS OF ORDER

Evolutionary theory, *per se*, is well known in organization science (Aldrich, 1979; Weick, 1979; McKelvey, 1982; Nelson and Winter, 1982; Singh, 1990; Baum and Singh, 1994a). In fact, evolution is mostly *coevolution*. "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: 237; his italics). Views of organizational environments have shifted from early characterizations in terms of uncertainty, complexity, and munificence, to attributes such as graininess, fitness sets, and niche theory (Aldrich, 1979; Brittain and Freeman, 1980; McKelvey, 1982; Hannan and Freeman, 1977, 1989; Baum and Singh, 1994a; Lawless and Anderson, 1996). Some interest in coevolution exists. Porter (1990, 1991) identifies coevolutionary pockets as bases of the competitive advantage of nations. Organization scientists now study coevolution at community, firm, and intrafirm levels (Baum and Singh, 1994a). In the biological world, changes because of abiotic forces, such as new lakes and mountains, changes in climates, or cataclysms, are rare relative to coevolutionary changes coupled to niche resources and other biological organisms. If the same is true for firms, that environmental forces such as changes in types of societal socio-economic structure or physical and biological principles underlying technology, are rare relative to coevolutionary niche events, organizational evolutionists and ecologists may have spent the last two decades studying the tip of the iceberg, leaving the more telling theory of firm coevolution underdeveloped.

The essential elements defining niche driven coevolution are given in Table 7. The ecological definition of coevolution recognizes the fundamental interdependency between firms, competitors, and niche

resources available for harvesting—each changes as the other changes (Erlich and Raven, 1964; McKelvey 1982; Futuyma and Slatkin, 1983; J. N. Thompson, 1989; and Nelson, 1994). Three key elements of coevolution are highlighted, (1) firm vs. niche resource link; (2) firm vs. competitor link; and (3) noncoevolutionary resources and constraints in the context of which firms evolve, such as physical and biological laws, geographical spaces, population dynamics, large-scale socio-economic forces, changing technology, and so on. The primary message of classical Darwinian theory is that selection effects are the fundamental cause of order in the biological world, through the process of selective retention (Depew and Weber, 1995). I continue the emphasis of classical Darwinian theory *applied to firms* under the label, "macrocoevolutionary theory" by focusing solely on firms existing in a coevolutionary competitive context. This view also would appear to apply to many other kinds of organizations competing for resources.

> > > **Insert Table 7 about here** < < <

MULTILEVEL ORIGINS OF ORDER

Since the Modern Synthesis in biology, Darwinian theory has been separated into micro- and macrocoevolutionary theory (Eldredge, 1995), but not without debate. Biomolecular geneticists (Williams, 1966; Kimura, 1968, 1983; Maynard Smith, 1975, 1989; Dawkins, 1976, 1995), called "ultraDarwinists" by Eldredge (1995), set forth a microcoevolutionary theory that focuses on the coevolution of, and random mutation effects on, genes as replicators, with "good" genes slowly accumulating in temporary offspring "bodies" that survive. Macroevolutionists (Stanley, 1979; Gould, 1982, 1983; Vrba and Eldredge, 1984; Eldredge, 1985, 1995; Sober, 1993) counter by asserting that adaptive evolution is a multilevel process:

> The fitness at a single locus ripped from its interactive context, is about as relevant to real problems of evolutionary genetics, as the study of the psychology of individuals isolated from their social context is to an understanding of man's sociopolitical evolution. In both cases, context and interaction are not simply second-order effects to be superimposed on a primary monadic analysis. Context and interaction are of the essence (Lewontin, 1974: 318).

This section extends the debate between micro- and macroevolutionists to organizations, recognizing that coevolutionary effects take place at multiple levels within firms (microevolution) as well between firms and their niche (macroevolution). Examples of how micro and macro effects play out are given by Crowston (1996) for organizational novelty, Ruef (1996) for networks, Bruderer and Singh (1996) for organization design, and McKelvey's (forthcoming) application of Kauffman's (1993) models to competitive strategy. My exposition sides with Lewontin, taking the view that ultimately whatever variation at whatever level must produce order that has niche-based selective survival or rent generation advantage. But I also recognize that the '*order*' that has ultimate niche level survival advantage may be the result of many Darwinian variation, selection, retention, and competitive struggle effects at different levels within firms.

Multilevel coevolutionary thinking may result in confusion because the selection effect is usually from a higher or lower level of analysis than the other effects. For example, a variation such as a division manager's attempt to introduce 'reengineering' may be selected against by superiors or by subordinate production engineers—three different levels involved in one "variation, selection, and retention" sequence. To avoid this, the four Darwinian processes are best thought of as a '*Darwin machine*' (a phrase Plotkin (1993: xvii) attributes to the American neurobiologist, William Calvin). A Darwin machine is a convenient way of packaging the four processes as a unit of interacting forces which, when present, sets the process of evolutionary selection in motion. At *multiple levels* in an organism or firm, thousands of Darwin machines operate over time in the context of competitive pressures to create changes in an organism, or organization, via the systematic selection of favored over disfavored entities—components or entire bodies.

Organization scientists have been slow to recognize the nested Darwin machine effect, as a reading of Scott's (1992) popular 3rd edition of *Organizations* indicates, though Pettigrew (1985) raises the idea of internal and external contexts. March (1991) models the interaction of evolutionary (selectionist) adaptive learning at both the microstate level (changes in individual beliefs) and the firm level (changes in the organizational code), in the context of environmental turbulence. Baum and Singh's (1994a) anthology contains several chapters specifically focusing on multi-level treatments of selectionist effects. Madsen and McKelvey (1996) use an explicit Darwin machine approach in an empirical study of firm dynamic capabilities.

For the natural side of organization science, the foundation premise is that microcoevolutionary order within firms emerges in the context of macrocoevolutionary selectionist competitive pressure, what Cohen and Stewart (1994) term '*contextually emergent simplicity*'. This idea holds that Darwin machines at a higher level operate to create order at lower levels—order that may be governed, in part, by simple rules. Consider their example: carnivores have eyes on the front of their heads while herbivores have them on the side. Eyes in front help carnivores chase prey; eyes on the side help herbivores eating grass see approaching carnivores—eye placement is contextual. Yet there are many reductionist rules that explain DNA activation, cell reproduction, and eye functioning. In a firm, the market may determine the eventual successful product design, but many reductionist simple rules may explain good or bad product engineering, quality control, or delivery schedules. Order creation by lower level Darwin machines is always in the context of higher level Darwin machines. Elements

of this "contextualist logic" appear in Table 8.

Note that specific (single, discrete) intentional or naturally emergent behaviors cannot be assumed to reliably or predictively produce successful adaptive order as I define it—they produce only *variations* in existing order. Because of environmental uncertainty (McKelvey, 1982, 1994;) and causal ambiguity (Lippman and Rumelt, 1982; Mosakowski, forthcoming), it is the unrelenting, systematic effect of the incremental advantage some variations in chain competencies have over others, in the context of competitive pressures and Darwin machines, that leads to replicated success behaviors and, thus, order. In this view, specific prepensive intentional behavior events lie outside natural scientific inquiry for two reasons: (1) If they *destroy* existing natural order, they are not amenable to scientific inquiry, since order is the subject of science (though they could be studied as part of the entropic process); and (2) If they create *new* order as a variation, it is the coevolutionary selection of natural order that counts for scientific explanation for the natural side of quasi-natural organization science, not the creation of a particular variation.

B.   SIDESTEPPING IDIOSYNCRASY VIA IDEALIZED MODELS

In this section, I first suggest that organizational scientists should segue from vague notions of positivism to scientific realism. Then I argue that idealized models may serve as a means of sidestepping idiosyncrasy.

SCIENTIFIC REALISM

The true nature of organization science epistemology seems somewhat obscure, since there is no text on the subject, as compared to Hunt's (1991) comprehensive treatment of marketing epistemology. Unfortunately much of the paradigm war is driven by postpositivists' views of positivism, an example of which is shown Table 9a. Compounding the problem is the discovery that the postpositivist view is largely in error, if one has an accurate concept of positivism, as the analysis by Hunt (1994) indicates, which is shown in Table 9b. By today's understanding, organization scientists have always been much more realist than positivist, as suggested by Miner's (1980, 1982) description of the essential elements of organizational realist epistemology (shown in Table 9c), based on his review of the full range of micro and macro organizational behavior *empirical* studies, that is, the 'logic-in-use' (Kaplan's (1964) term).

Given that much of organization science stems from the disciplines of psychology, sociology, and economics, basic methodology texts in those disciplines could be construed to form the basis of realist organization science epistemology. The series on sociological methodology begun by Borgatta and Bohrnstedt (1969) clearly emphasizes causal modeling, measurement, testing, and

mathematics, all characteristic of realist 'reconstructed logic' (also Kaplan's (1964) term), as do Stinchcombe (1968), Cook and Campbell (1979), Tuma and Hannan (1984), and Hannan and Freeman (1989). Among economists, Samuelson (1947), Friedman (1953), and Blaug (1980) have had a profound realist influence. Schwab's (1960) analysis of some 4000 natural and social science empirical studies, published in *Behavioral Science* also has to be included as a basic source of realist epistemology in organization science.

Logical positivism was promulgated in response to Hegelian idealism, mechanistic materialism, quantum theory and relativity theory (Suppe, 1977).   This epistemology holds that theory terms are unreal and therefore theoretical explanations of causality are also unreal, leading to the view that theories may only be interpreted as instrumental summaries of empirical results (Hunt, 1991: 276-277; Godfrey and Hill, 1995), that is, theories "stuck-on" to empirical findings like stamps on an envelope. The "scientific truth" of theory is ascertained via verification by observation. The goal of logical positivists is to clarify the language of science by expunging metaphysical concepts and by insisting that concepts be verified as to cognitive meaning and truth, thereby "ridding it [science] of meaningless assertions by means of the verifiability principle and reconstructing it through formal logic into a precise, ideal language" (Hunt, 1991: 271). By mid-20th century, logical positivism had evolved into logical empiricism. (For a short review of logical positivism and scientific realism related to organization science, see Godfrey and Hill, 1995).

Logical empiricist philosophers such as Reichenbach (1938), Kaplan (1964) and Hempel (1965) took issue with the strict separation of theory and observation terms and the notion that all theories are instrumental, believing instead that many theory terms are in fact real and that the world has existence independently of its perception. The premise that scientific statements are false until verified, proved untenable since universal conditionals can never be universally verified (thus, for a contained gas, the statement "if temperature rises pressure rises" can never be verified as true for all time everywhere in the universe, hence it is false). Verificationism gave way to the incremental refutation or corroboration tenet of scientific realism (Hunt, 1991: 280). The most distinguishing tenet of logical empiricism is *testability*, and after Popper (1959/1935), *falsificationism*. Logical empiricism also has been abandoned (Suppe, 1977).

Scientific realism is now the most widely accepted (Leplin, 1984; Suppe, 1989; Hunt, 1991) reconstructed logic among working philosophers. Scientific realists adhere to the premise "that the long term success of a scientific theory gives reason to believe that something like the entities and structure postulated by the theory actually exists" (McMullin, 1984: 26). Basic elements of scientific realism are shown in Table 10.

Scientific realists eschew a "naive" or "dogmatic"

falsificationism in favor of incremental refutation and incremental corroboration (see Hunt, 1991: 356-358 for further discussion).

> > > **Insert Table 10 about here** < < <

While many organization scientists still hold to an epistemology vaguely rooted in positivism (Hunt, 1994), as empirical researchers they practice a logic-in-use much closer to scientific realism (Miner, 1980; Godfrey and Hill, 1995). Thus, organizational positivists' logic-in-use is predominantly *realist*. Organization science realists, therefore, believe there is enough of an objective reality "out there" that repeated attempts by various researchers, using a variety of generally approved methods of 'justification logic' eventually will discover the approximate truth of theories by successively eliminating errors. This follows the evolutionary epistemology of Popper (1972), Toulmin (1972), and Campbell (1974).

> …[T]he growth of our knowledge is the result of a process closely resembling what Darwin called 'natural selection'; that is, *the natural selection of hypotheses*; our knowledge consists...of those hypotheses which have shown their (comparative) fitness by surviving so far in their struggle for existence; a competitive struggle which eliminates those hypotheses which are unfit.... From the amoeba to Einstein, the growth of knowledge is always the same: we try to solve our problems, and to obtain, by a process of elimination, something approaching adequacy in our tentative solutions (Popper, 1972: 261; his italics).

The time has come for organization scientists to stop believing in positivism or using the term, positivism, especially if they do not know what it really stands for. It would be better to collectively adopt scientific realist epistemology. Historical realism shows that scientific realism rests on idealized models (Suppe, 1977, 1989). I now turn to this view to elaborate the second frontier of my attack on idiosyncrasy.

IDEALIZED MODELS

Postpositivists are correct in calling attention to the pervasiveness of idiosyncrasy in organizations—their assumptions about organizational phenomena are correct. The crux of the matter is, *What kind of scientific method is called for?* They call for a method focusing directly on understanding stochastically idiosyncratic phenomena— phenomena consisting of everyday human behavior governed by idiosyncratic sensemaking, as Weick (1995) puts it. I contend that if such phenomena are taken as the grist of the organization science mill, then one must surely concede that prediction, generalization, and falsification are impossible, and then so is realist scientific method— one must perforce be driven toward postpositivist methods.

Is there a natural science alternative? Two fundamental questions block pursuit of the natural side of quasi-natural organization science: 1) How best to facilitate the search for reductionist 'simple rules' or principles in complex organizations? and 2) How best to overcome the difficulties imposed by stochastically idiosyncratic phenomena when searching for and justifying simple reductionist principles? I call for three different approaches to the problem: (1) *idealized models*, (2) *translation into rates*, and (3) *direct analysis*.

In this section, I advocate sidestepping idiosyncratic complex empirical (real) phenomena via the use of idealized models, wherein idiosyncratic microstates are ignored or assumed away. Consider what happened in the early development of the natural sciences according to historical realists (Suppe, 1977, 1989; Hunt, 1991). Beth's (1961) historical realist based "*semantic conception of theories*" recognizes that natural scientists have always relied on idealized models of phenomena, such as point masses, ideal gases, pure chemicals, identical fruit flies, or rational actors. In all of these approaches idiosyncratic microstates are ignored. Scientists have been doing this for centuries—all during the rise to success of modern natural sciences. The semantic conception bifurcates scientific activity into: (1) developing theories that accurately explain analytical (mathematical) and simulation (computational) models; and (2) testing the accuracy with which the models represent attributes of interest in the underlying phenomena. Beth's seminal approach has since been elaborated, as reviewed by Lloyd (1988), Suppe (1989), and P. Thompson (1989).

Idealized models allow scientists to avoid the complexities of idiosyncratic microstate phenomena such as vibrating atoms in solids, kinetic gas particles in containers, atoms emitting alpha or beta particles, mutant genes in cells, differing galaxies, as well as other complex influences. Such idealizations, which assume uniform rather than idiosyncratic microstates, or avoid other complexities, often prove useful early in the life cycle of a science, even though they may be questioned at the time, or later proven to be false depictions of the phenomena. Newton's late 17th century adoption of point masses allowed tremendous advances in analytical mechanics, though by Einsteinian relativity theory his theory was not universally true. Friedman's (1953) 20th century statement that the irrationality of actors is irrelevant (because their firms do not survive) to economists studying aggregate economic systems is a classic statement in favor of idealized models. As most sciences mature, simple idealized models give way to more complex and realistic models of phenomena, though they are never exact representations of real phenomena. However, even after 200 years many physicists and engineers still assume point masses, many chemists assume pure elements, many biologists assume uniform cells, and many economists still assume rational actors.

Ironically, the natural sciences may have achieved early success because they were at first far removed from their phenomena—separated from the idiosyncratic "details" of their phenomena by telescopes and microscopes. Thus, it was possible for them to formulate conservation laws of motion, heat, and energy, culminating in the 1st and 2nd laws of thermodynamics—no messy details to get in the way of predictive, generalizable laws, such as $F = Gmm'/r^2$ (the Law of Gravitation, where

mm′ is the product of two masses, *r* is the distance between them, and *G* is a constant (Feynman, 1965)).

According to Gould (1989: 290), in a "celebrated exchange" with Asa Gray, Darwin made a distinction between '*laws in the background*' and '*contingency in the details*'. Gray was concerned that Darwin's scheme "left no room for rule by law, and portrayed nature as shaped entirely by blind chance." As biologists have since discovered, much biological order is explained by historical contingency; but much is also explained by background laws. As Gould notes, "ultimately the question of questions boils down to the placement of the *boundary* between predictability under invariant law and the multifarious possibilities of historical contingency" (my italics).

Because organization scientists experience firms first hand and see idiosyncratic human behavior all the time and everywhere, it is easy to focus on the idiosyncrasy, and thus miss the background law "forest" because of the idiosyncratic behavior "trees." As Barry Singer notes, every earthquake is idiosyncratic, but geologists have made much progress searching for background laws (personal communication, February 1996). Interpretists and phenomenologists place the boundary so high that only the details are thought to be of interest. Organization scientists need to find ways to distance themselves from idiosyncratic phenomena, not get even closer to them as the postpositivists would have it. Thus, the boundary might constructively be lowered so as to foster increased interest in background laws. Postpositivists might appreciate knowing that Gould himself says, "I envision a boundary sitting so high that almost every interesting event of life's history falls into the realm of contingency." With this statement Gould, the macroevolutionary paleontologist sets himself apart from the ultraDarwinist microevolutionary molecular geneticists, such as Dawkins (1976) and most other life scientists, who work with a much lower boundary.

In the life cycle of science, assuming away microstates by idealization is the most primitive approach. Given the early stage of organization science, microstate idealization might well be the most tractable approach for us. **First**, microstates are ignored. But there is more to idealization than this. **Second**, idealized models right from the outset do not attempt to represent *all* of the phenomena at hand. They compartmentalize phenomena into idealized differentiated components where complexity is simple enough that simple rules might apply. **Third**, idealized models then simplify the representation of the narrower component of phenomena to be modeled. Thus, for a study of effective strategy events in microcomputer firms, say, a primitive idealized model might attempt to represent only modal behavior toward opponents, and assume uniform body chemistry, rationality, family life, and surrounding social influence of the key executives. While perhaps still ignoring microstate idiosyncrasies, such a model would be well in keeping with traditional scientific

method. It could be elaborated considerably as to include additional independent, intervening, dependent and control variables before the assumption of microstate uniformity is relaxed. Generally, model complexification goes from 3rd to 2nd to the 1st of these options. It is important to remember, in the face of postpositivist rhetoric, that all the natural sciences and social sciences such as psychology and economics achieved their current preeminence using the idealized model approach.

The "idealized model" approach toward developing the natural science side of a quasi-natural organizational science rests on taking advantage of idealized models to simplify the effects of idiosyncratic microstate phenomena, while <u>not</u> turning away from the rigorous standards of traditional scientific method. This approach may seem primitive. A more sophisticated alternative follows.

C.   *ANALYTICAL MECHANICS AND PROBABILISTIC RATES*

Here my attack on the idiosyncrasy problem begins with a short discussion of '*rates*' in science, and how microstate energies have been translated into probabilistically distributed rates of occurrence. This is followed by an example focused around Sommerhoff's (1950) concept of directive correlation.

TRANSLATING IDIOSYNCRASY INTO RATES VIA AN INSTRUMENTAL CONVENIENCE

Rates. Early work on infinitesimals, rates, and locations of moving bodies reached maturity with Newton and Leibnitz in the late 18th century. By mid-19th century laws, of the conservation of motion had been translated into laws of the conservation of energy, culminating in Clausius's 1st law of thermodynamics (Prigogine and Stengers, 1984). This law became the basis of modern analytical economic equilibrium analysis (Mirowski, 1989). Ever since Kepler's ellipses and Galileo's falling bodies, the field of analytical mechanics has represented motion and thermodynamics in terms of the calculus of rates and accelerations.

Howard Thomas opened the Ghent Conference on competence-based competition (Heene and Sanchez, 1997) with the question, "Where is the calculus in the study of organizations?" Besides assuming away the microstates, organization scientists eschew the dynamics of "rates of change over time" in favor of changes in averages going from one snap-shot view of firms to another—thus, there is no need for calculus. Why study rates <u>inside</u> firms? Instead of focusing on seemingly imperceptible changes in the mean of a distribution, why not focus on the rate at which the really good or bad events in the tails of the distribution happen, and whether this rate getting better or worse. That is, instead of measuring the average level of leadership, satisfaction, upward communication, "garbagecanness," divisional autonomy, divisional relatedness, or whatever, why not measure the <u>rates</u> at

which good or bad things happen: good leadership events, profitable patents, new products, good employees leaving and taking new product ideas with them, best practice achievements at various parts of the value chain, reciprocal interdependencies resolved, and so forth? "Management" could be evaluated on whether they are raising or lowering rates appropriately. More generally we may turn our attention to the overall '*metabolic rate*' (defined as the rate at which firms translate input materials and energies into revenue generating outputs and adaptive progression). This general rate for a given firm comprises numerous more specific rates, besides those just mentioned. In this view, the metabolic rate (and its component rates) acts as the primary intervening variable between various independent variables and dependent variables.

Translation. Studying rates inside firms is important because there is a way of translating idiosyncratic microstate "energies" into rates. Consider Boyle's Law. Most of you probably remember the simplified version, which is good enough for us nonphysicists: **P**ressure = **Q**uantity (of a gas) × **T**emperature ÷ **V**olume. Boyle's Law makes no sense without the unmentioned container or pressure vessel. Think of the container as a device for translating all of the idiosyncratic vectored energies of the gas molecules into a predictable and directed pressure stream in which the various kinds of molecules have "rates of arrival" (at some measuring station) fitting some probability distribution.

The question now is, *Are there "container equivalents" in firms that in effect can be thought of as translating idiosyncratic microstates into pressure streams in which the force of all the microevents is translated into a more pronounced vectored response to some problem imposed by the competitive context?* The answer is yes. The idea has existed for decades as the general system theorists' concept of *equifinality*, in which a particular outcome results from a disparate and not necessarily repeatable assembly of causal forces. A constructive approach to understanding or modeling equifinality is the '*directive correlation*' concept of Sommerhoff (1950). A directively correlated system is a "container" in which the disparate causal events present in a system over some period of time can only be explained in the context of the system's goal-seeking purpose. The idea of "directively correlated" causes is apparent, for example, in understanding the seemingly random unpredictable flight path choices taken by a pilot over Kansas. Once the goal of reaching Chicago from LA is noted and the many thunder clouds are observed, the causal relation of environmental events and the pilot's responses may be explained as directively correlated. In the example which follows in Section 3.3.2, I define and illustrate the directive correlation concept further. As you might envision, any firm could be treated as an assemblage of "containers" and rates toward or away from, say, best practice everywhere in the firm, or achieving idiosyncratic advantage on multiple product lines, or achieving specified

rates of return on its products, or creation of variations or innovative trials all throughout the primary and secondary value chains.

It is possible that the various rates in a firm could change faster than they could be recorded by an observer. On the other hand, it has been fairly well established that firms suffer from considerable amounts of inertia (Hannan and Freeman, 1989; Miller, 1990). And remember the message from the previous section—rate models, like any other model, are always idealized views of a complex reality—perhaps rather simple to begin with but usually becoming more complicated as a science evolves. Consider that population ecologists already use rate models <u>outside</u> firms in trying to understand births and deaths of firms as black boxes. True, black box models are idealizations quite appropriate at the early life cycle stage of a science. But the natural adaptive progression of most sciences suggests that organization science models will eventually become less idealized on various dimensions and more internal and reductionist. Suppose that instead of stopping their "rate perspective" at the edge of the black box, organization scientists developed rate models which also include various internal rates of events that are component contributors to the overall metabolic rate at which firms achieve rents, coevolve toward best practice and marginal rates of return, and grow or disband. In this view, the overall rate of failure, say, might be taken as a composite of various internal metabolic rates. There could be other concepts of microstate "containers" than Sommerhoff's directive correlation. However, the latter has the advantage in that it gives a basic definition of directive correlation in simple mathematical terms drawn from basic thermodynamics and flow rate analysis. This is one way of responding to Thomas's question, Where is the calculus?

Deductive-Statistical Explanation. Hempel's (1965) '*deductive-nomological*' (D-N) model of predictive explanation characterizes the so-called 19th century "exact" sciences, where the use of conservation law equations allows the exact prediction of discrete events, such as the force of a falling body after 30 seconds of freefall toward the earth. Twentieth century science recognizes that once microstates are brought into the equation, nothing is ever exact, resulting in the application of statistics across the full range of analytical mechanics (Tolman, 1979). Following this development, Hempel's '*deductive-statistical*' (D-S) model is equally predictive, but for a <u>class</u> of discrete events rather than individual events, an example being the rate of radioactive decay of, say, plutonium—particle emissions from individual atoms cannot be predicted, but the rate of emission for a quantity of atoms is predictable and generalizable. There could be many "classes" of organizational phenomena fitting the D-S model that could allow use of the calculus of rates and probability-of-occurrence distributions, good examples of which are 'progress function' (learning curve) rates (Dutton and Thomas (and Butler), 1984a, b) and March's

(1991) modeling of learning, turnover, and environmental change rates. Realistically for firms, rate-of-occurrence probability distributions, such as learning curve event occurrence rates, may not be exactly predictable as compared to particle emissions. But there may be a predictable meta-distribution of these distributions showing a sharp Gaussian peak.

The message of this section stretches organization scientists in three directions: (1) It offers a solution to the idiosyncrasy problem in the form of directive correlation "containers" that translate idiosyncratic microstates into vectored pressure streams and rates of occurrence; (2) It argues for viewing firms as systems of metabolic rates toward adaptive success or failure; and (3) It recognizes that predicting individual events in organizations is seldom possible—predicting probabilistic distributions of events and event rates is much more realistic. In the development of natural science the translation of idiosyncratic microstates into predictable rates, vectors and distributions is largely a pre-20th century life cycle stage. After the translation example in the next section, I turn to the final frontier of my attack on the idiosyncrasy problem—the inclusion of microstates directly in analytical and computational analysis.

A DIRECTIVE CORRELATION EXAMPLE

As an example of how conventional "*state*" thinking could be translated into "*rate*" thinking, consider a recent article by Lado and Wilson (1994) in which a "human resource [HR] system" approach is suggested for enhancing a firm's rent generating capability, consistent with the resource-based view of strategy. They identify a number of organizational competencies and competence-enhancing and -destroying states that, if present, they claim will foster rent generation. The rate view suggests there are no such things as constant organizational competencies, given conditions such as changing competitors, changing technology and customer taste, changing personnel, changing strategies, the constant advancement of "best practice," and the constant coevolutionary erosion of idiosyncratic advantage. Instead, the following general principle applies: Competencies (1) exist at a given state because resources are spent at some rate to keep them at that state; (2) are adaptively advanced at some rate because competencies are improved at some rate by an increased rate of resource expenditure; or (3) competence states erode at some rate because of all of the contextual changes just mentioned and because the rate of resource expenditure is inadequate. By way of example, some of the Lado and Wilson competence elements are translated into rate terms in Table 11.

> > > **Insert Table 11 about here** < < <

Consider a notebook computer manufacturer's possible response to the publication in 1994 of comparative ratings of notebook components and customer survey information by *PC World*. This was an environmental shock in the form of new information from experts and customers about a wide variety of notebook capabilities and underlying value chain competencies. Suppose that prior to the shock, firm *A* attempted to compete on high-end "bells-and-whistles"—notebooks with color screens, lots of capacity, mouse controls, docking stations, service, up-gradability, etc., while firm *B* competed on efficiency, convenience, and portability, primarily abroad—chip speed, low weight, long battery life, built-in modem and fax capability, etc. After the shock, firm *A* decides to abandon its bells-and-whistles strategy to compete directly against firm *B* on all the chain competencies related to the needs of the business traveler for efficient portability and hotel room convenience and *B* decides to focus only on the U. S. market. In attempting to stay ahead of its competitor and generate rents, each firm embarks on an aggressive strategy of HR spending and training to develop competencies in its value chain along the lines of those listed above.

We can translate the key elements into the terminology that Sommerhoff uses to describe directive correlation. The (1) *cœnetic variable* (CV_{t_0})—the initiating *PC World* report—is the same for both firms; (2) the *focal condition* (*FC*) is the hoped-for adaptive goal of increased efficiency, convenience, and portability—also the same for each firm; (3) each notebook maker has different *responses*, R_{1t_1}, R_{2t_1}, R_{3t_1}, R_{4t_1}—supposing each *R* represents one of the competence investments that each firm attempts in trying to approach its *FC*; and (4) **environmental constraints** exist in the competitive context for each notebook maker, E_{1t_1}, E_{2t_1}, E_{3t_1}, E_{4t_1}—the *E*'s represent a variety of environmental changes and actions by competitors a firm encounters in trying to approach its *FC*. Managerial perceptions could be taken as subjective, but in a competitive selectionist framework subjective readings of the environment that deviate from the correct "objective" reading more likely are selected against, leaving the objective reality as the ultimate criterion. Figure 3 depicts the four elements. Sommerhoff (1950: 54-55) defines directive correlation as:

> Any event or state of affairs, R_{t_1}, occurring at a time t_1 is *directively correlated* to a given simultaneous event or state of affairs E_{t_1}, in respect of the subsequent occurrence of an event or state of affairs FC_{t_2} if the physical system of which these are part is objectively so conditioned that there exists an event or state of affairs CV_{t_0} prior to t_1, and a set of possible alternative values of CV_{t_0}, such that
>
> (a) under the given circumstances any variation of CV_{t_0} within this set implies variations of both R_{t_1} and E_{t_1};
>
> (b) any such pair of varied values of R_{t_1}, E_{t_1} (as well as the pair of the actual values) is a pair of corresponding members of two correlated sets of possible values R'_{t_1}, R''_{t_1}, R'''_{t_1},... and E'_{t_1}, E''_{t_1}, E'''_{t_1},..., which are such that under the circumstances all pairs of corresponding members, but no other pairs, cause the

subsequent occurrence of FC_{t_2}. [*FC* substituted for *G* in the original; his italics.]

Note that even though *CV* does not cause *FC*, and even though *FC* does not allow a retrodiction of *CV*, nevertheless *E*s and *R*s are causally related in such a way that *FC* is a result of *CV*, thus achieving equifinality. Also, *FC* would not happen were it not for the existence of *CV*, *R*'s, and *E*'s, but on the other hand the *R*'s and *E*'s would not follow from *CV* if *FC* did not exist. And there is nothing in the system that predicts the specific responses, *R*′, *R*″, *R*‴, etc. absent some equally unpredictable textural event, *E*′, *E*″, *E*‴, etc., except for the presence of *CV* and *FC*. However, once *CV* and *FC* are present, then constraints *E*′, *E*″, *E*‴, etc. may become causal determinants of *R*′, *R*″, *R*‴, etc., or vice versa, and the *R*'s and *E*'s may be in a mutual causal relationship (Maruyama, 1968), that is, directively correlated.

In the notebook example the directive correlation system may be treated as a hierarchy of "containers" that bottles up all the idiosyncratic microstate behaviors and eventually translates them into firm-level adaptive goal-seeking activity. The containers might be effective or ineffective depending on how well the responsible managers, teams, or emergent groups work to systematically get the microstate behaviors, or lower level directive correlation systems all working toward the same outcome objective. Each firm, *A* and *B*, runs directive correlation systems aimed at out-competing the other firm and keeping up to date with what ever competitive thrusts are effective. If one of the firms has an idiosyncratic rent producing advantage, as per resource-based theory, the purpose of the directive correlation container would be to continue organizing the microstate behaviors in the direction of finding new bases of idiosyncratic advantage.

The directive correlation allows us to translate the myriad behavioral microstate events among a number of processes and involved people over time into rates of flows of events that are effective in moving toward the goal. The question here, for example, is which firm has higher rates of flows of constructive events that lead to competitive advantage. This is opposed to taking measures of average levels of patent production, or innovation, or new product start-ups, and the like. Note, however, that as the number of *E*'s and *R*'s increases, statistical mechanics would replace the causal delineation one might achieve with just a few.

It is important to remember that the outcomes are probability distributions, not exact predictions of specific events. The microstate translation approach suggests that phrasing of hypotheses and the development of explanatory theory would shift from Hempel's (1965) D-N to his D-S model of explanation or prediction. For example, consider the following hypothesis:

Firms with configurations of competence enhancing HR system attributes that are unique, causally ambiguous, and synergistic will have sustained competitive advantage over firms that have HR system configurations that are typical, causally determinate, and

nonsynergistic (Lado and Wilson, 1994: 718).

This hypothesis follows D-N logic—if conditions *C* and covering laws *L* prevail, event *E* always occurs. D-S logic focuses on predicting *distributions*, not individual events. The hypothesis may be rephrased as:

Given conditions *C* [unique, causal ambiguity, synergistic], and covering laws *L* [to be specified], in a population *P* [to be specified], flow *rates of occurrence* of unique, causally ambiguous, synergistic HR system micro-states $s_{i,j}$, in firms showing a sustained competitive advantage, are distributed as $D_{i,j}$ [means, variances, and shapes as discovered] across firms F_j.

The D-S model recognizes that the probabilistic occurrence rate of microstates exists because they are inherently stochastically idiosyncratic, in addition to unknown random exogenous, measurement error, or transition probability effects. No matter how good the research design, and no matter how well controlled the ancillary random effects, the D-S phrasing of the hypothesis recognizes that the only things that may be predicted are distributions of microstate occurrences, not specific events.

The directive correlation math mentioned by Sommerhoff sidesteps idiosyncratic microstates by "containerizing" them. Complexity theory offers a more direct method of incorporating microstates into computational and analytical methods. It forms the fourth frontier of my attack on the idiosyncrasy problem.

D.   MICROSTATE ANALYSIS OF IDIOSYNCRATIC EFFECTS

COMPLEXITY THEORY

Complexity theory departs from classical Newtonian deterministic laws about the conservation of motion and conservation of energy as represented by the 1st law of thermodynamics. Given the 2nd law of thermodynamics, that all ordered states eventually dissipate (via entropy) into disordered states, complexity theory emphasizes dissipative dynamical systems created or maintained by negentropy and eroded by entropy (Nicolis and Prigogine, 1989; Mainzer, 1994). Negentropic effects that create or maintain order in the form of new structure, and entropic (energy dissipation) order destroying effects within any structure, form the heart of complexity theory (Schrödinger (1944) coined negentropy to refer to energy importation).

"[Newtonian] physics deals with an invented, simplified world. This is how it derives its strength, this is why it works so well" (Cohen and Stewart, 1994: 12). This idealized view of physics mirrors the "semantic conception of theories" in modern philosophy of science (see Section 3.2.2). It is predicated on the belief that the Universe is "algorithmically compressible" into simple rule explanations (Barrow, 1991: 15). But how do phenomena appear, absent the invented, idealized, simplified world of 18th century physics? Offering a view based on Kolmogorov's 'K-complexity' theory (Kolmogorov, 1965), Cramer (1993: 210) defines complexity "as the logarithm of the number of ways that a

system can manifest itself or as the logarithm of the number of possible states of the system: $K = \log N$, where K is the complexity and N is the number of possible, distinguishable states." For a parallel view of the "algorithmic information content" of complex bit strings see Gell-Mann (1994: Ch. 2). Cramer then identifies three levels of complexity, depending on how much information is necessary to describe the complexity. These are shown in Table 12a.

> > > **Insert Table 12 about here** < < <

Complexity theorists define systems in the critical complexity category as being in a state "*far from equilibrium*" (Prigogine and Stengers, 1984). The key question becomes, What keeps emergent structures in states of equilibrium far above entropy, that is, in states counter to the 2nd law of thermodynamics? Prigogine *et al*. 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, thereby accounting to the 2nd law. Consequently they are labeled '*dissipative structures*' because they are the sites where imported energy is dissipated. If energy ceases to be imported, the dissipative structures themselves eventually cease to exist. Negentropy may occur from adding energy or simply by dividing (finite) structures (Cohen and Stewart, 1994; Eigen and Winkler, 1981). Entropy occurs simply from the merging of structures. Thus, despite the wishful aspirations of Wall Street gurus and CEOs, mergers and acquisitions are mostly entropic, a classic example being the assimilation of Getty Oil into Texaco.

Self-organized dissipative structures may exhibit two key behaviors: persistence and nonlinearity. As to persistence, following Eigen's work on autocatalytic hypercycles (Eigen and Schuster, 1979), Depew and Weber observe that "the most effective way of building structure and dissipating entropy is by means of *autocatalysis*" (1995: 462; their italics) wherein some agent is produced that furthers the autocatalytic process (though remaining unchanged itself), thereby leading to a positive feedback '*autocatalytic cycle*'. Given their sensitivity to initial conditions, autocatalytic dissipative structures "are capable of generating dynamics that produce order, chaos, or complex organization at the edge of chaos" (1995: 462). As to nonlinearity, Depew and Weber note further that the behavior of dissipative structures is nonlinear and tending to create marked explosions or crashes of structure, a situation far from the gradualism of Darwin. They also observe that when "…a system is constrained far from equilibrium [because of imported energy], macroscopic order arises not as a violation of the second law of thermodynamics but as a consequence of it" (1995: 464). This kind of order may appear as Cramer's subcritical complexity. Thus self-organizing systems may come to stasis at any of the several levels of complexity. Complexity caused self-organizing structures with autocatalytic tendencies are

now seen as a ubiquitous natural phenomenon (Cramer, 1993; Kaye, 1993; Mainzer, 1994; Favre *et al*. 1995), and hypothesized as broadly applicable to firms (Stacey, 1992, 1995; Zimmerman and Hurst, 1993; Levy, 1994; Thiétart and Forgues, 1995).

If such emergent structures are in some way opposed to each other, they may themselves become tension creators giving rise to still other emergent self-organized structures, or possibly chaotic behavior. Thus, as the energy gradient increases (between a more entropic equilibrium state and the "far from equilibrium" state), and the stress of maintaining the negentropic state increases, there is a likelihood that the system will oscillate between the different states, thereby creating chaotic behavior. Oscillations that traditionally were taken as variance around an equilibrium point, now may be discovered to be oscillating around a strange attractor, or as bifurcated oscillations around two attractors, or if the stress increases beyond some additional limit, the chaotic behavior will change to stochastic behavior—no deterministic structure. Definitions of *point*, *periodic*, and *strange* attractors are given in Table 12b. By this line of reasoning, Nicolis and Prigogine (1989), Ulanowicz (1989), and Depew and Weber use thermodynamics to explain how the various states of complexity come to exist (see also Beck and Schlögl, 1993).

Complexity is now seen as both consequence and cause. The different levels of complexity (subcritical, critical, fundamental, chaotic, and stochastic) are generated by simple rules, interaction among simple rule effects, nonlinearity, and random processes. One puzzle is to discover what causes the different levels of complexity. Holland (1995) argues that adaptation leads to complexity. Alternatively, Kauffman (1993) argues that under various conditions selectionist effects are thwarted by complexity effects, leaving complexity as the true cause. The puzzle now becomes one of understanding where complexity is consequence and where it is ultimate cause.

The study of '*complex adaptive systems*' has become the ultimate interdisciplinary science (Anderson, Arrow, and Pines, 1988; Cowan, Pines, and Meltzer, 1994), focusing its modeling activities on how microstate events, whether particles, molecules, genes, neurons, human agents, or firms, self-organize into emergent aggregate structure. Also becoming important is the focus on '*critical values*' determining when a system shifts from being explainable by the simple rules of Newtonian science, to having self-organizing capability, to behaving chaotically (Cramer, 1993). The principal modeling methods are *spin-glass* (Mézard, Parisi, and Virasoro, 1987; Fischer and Hertz, 1993), *simulated annealing* (Arts and Korst, 1989), *cellular automata* (Weisbuch, 1993), and *neural network* (Wasserman, 1989, 1993; Müller and Reinhardt, 1990; Freeman and Skapura, 1993) models, *genetic algorithms* (Goldberg, 1989; Holland, 1995; Mitchell, 1996), and most recently, *population games* (Blume, 1995). These are so-called "interactive particle

systems," "particle" or "nearest neighbor" models, or adaptive learning models, in which very simple minded '*microagents*' adopt a neighboring microagent's attributes to reduce energy or gain fitness. Since the work of Fisher (1930) and Wright (1931), biologists have used the metaphor of genes walking across '*adaptive landscapes*' in adaptive learning models to study genetic mutation effects (see Maynard Smith, 1989; Kauffman, 1993). These models are related to Boltzmann's statistical mechanics for the purpose of studying large numbers of connections (Arts and Korst, 1989). Statistical treatment of microstates has also applied to social systems (Weidlich and Haag, 1983), using the Fokker-Planck master equation. Dynamic adaptive learning models seem poised to augment the more static network models described by Pattison (1993) and Wasserman and Faust (1994) currently used in organization science.

A COMPLEXITY EXAMPLE

To understand the relevance of complexity theory less abstractly, consider a firm existing in one state that suddenly experiences a force pushing it toward another state. According to McCaffrey, Faerman, and Hart (1995), academics and managers broadly agree that "participative management" is effective, yet this management style has diffused very slowly. Figure 4 reproduces their figure titled "Competing Influences on Decision Making," showing that such forces might alter the proportion of "participative" or "control" oriented "styles of decision making" in a firm. The authors report "an overwhelming majority of managers are saying one thing and doing another" (p. 605). As to why, they suggest four main reasons: (1) institutionalization of conflict; (2) number and diversity of individuals; (3) individuals having strong competing purposes and values; and (4) lack of championing or advocative leadership.

Now translate their article into complexity theory. The figure introduces the bifurcated attractors idea clearly—firms face two attractors—tradition and control vs. a new approach "everyone" says works better. The authors review the participative management and change literature which includes examples of firms (1) staying with the control attractor; (2) jumping to the participation attractor; (3) showing emergent organization that moves them from the old to the new attractor; (4) showing emergent organization positioning them at the edge of chaos—in between both attractors, each remaining strongly present; (5) jumping from one attractor to the other depending on leadership, attrition, and politics; or (6) showing behavior that appears stochastic. It is unclear, however, whether these are *point*, *period*, or *strange* attractors.

Two reasons for failure given by McCaffrey *et al.* are already complexity driven: number and diversity of individuals and the fact that they have strongly held dissimilar purposes and values. The complexity of the many interdependencies among individuals having different but strong objectives makes it difficult for a system to overcome the effects of individual idiosyncrasy,

setting up the foundation conditions of complexity theory. What causes (1) the idiosyncratic behavior to congeal into emergent self-organization that (a) moves a firm from one attractor to the other; or (b) holds a firm between both attractors such that it survives and "makes peace" with both; (2) causes a breakdown in self-organizing structures such that a firm oscillates from one attractor to the other (bifurcated chaos); or (3) causes a firm to exhibit little more than the stochastic behavior of individuals? The formal or informal emergent structures caused by energy importation are the complexity theorists' autocatalytic dissipative structures where energy is spent or lost.

The classic Harvard case, "The Slade Company," is an example of an informal work group emerging between the strong attractor of a changing market and the weak attractor of an out-of-touch management, the group reinforcing itself to the point of breaking rules. Upon discovery of the rule-breaking, management's choice is to leave the structure in place or reassert its authority (strengthening the *status quo* attractor) with the risk that the informal group will weaken and waver in its ability to deal with the market attractor, resulting in chaos. Complexity theory argues that once the attractors exceed a '*first critical value*', that is, achieve significant strength, self-organizing structures emerge to accommodate the opposing forces of the two attractors until such time as one might weaken. If the attractors exceed a '*second critical value*', emergent stable structures fail and the firm oscillates between the two attractors. If a '*third critical value*' is exceeded, structures fail altogether, leaving the firm vulnerable to the idiosyncratic behavior of individuals, thereby generating stochastic firm behavior as it tries unsuccessfully to cope with the two strong attractors.

Kurt Lewin (1951) anticipated one lesson of complexity theory many years ago in his force field analysis, in which change was brought about by lessening tension rather than increasing it; a new structure will emerge if tension is lowered by reducing the strength of an old attractor, rather than strengthening the new attractor. Instead of further institutionalizing conflict, the first reason for failure given by McCaffrey *et al.*, complexity theory suggests the wisdom of Lewin's approach, and more recently, a '*complexity stripping*' approach reported by Baden-Fuller and Stopford (1994) wherein complexity effects are reduced by stripping a firm down to its core competence (Prahalad and Hamel, 1990). Complexity theory suggests that change comes from reducing complexity, not increasing it, that is, reducing attractors, not increasing them.

In complexity terms, effective leadership, the fourth reason for successful change given by McCaffrey *et al.* needs to focus on altering the level of the critical values, or lowering the strength of the attractors. This may seem simple enough, but imagine a situation in an acquired firm where there are multiple strong attractors, such as: cost

reduction, installation of new information systems and new technologies, assimilating a new culture, new managers being given orders to take charge and bring about change, vacuums left by departing entrepreneurs or other key people, and so on. In addition to many new strong attractors, the chances of critical values being exceeded or ignored are high, further increasing the probability of chaotic behavior. Thus, complexity emerges as a fundamental cause of what the change literature has heretofore defined as resistance to change, poor leadership, inadequate rewards, or poor feedback (French and Bell, 1995). Absent emergent organization, the idiosyncrasy of individual behavior is never effectively channeled by emergent structures—hence stochastic behavior. And, given attractors that are too strong, or critical values too easily exceeded, chaotic behavior ensues.

The 'crucial experiment' (Stinchcombe, 1968) might be to identify a sample of divisions newly acquired, and now subject to the typical multiple "MBA terrorist" objectives of cutting costs, installing new systems, changing culture, changing management, charging the new management with new objectives, and so on. In half the sample, "O. D. consultants" would focus on conflict resolution, process consultation, leadership, involvement, resistance to change, and culture change. In the other half, "complexity consultants" would focus on (1) reducing interdependencies; (2) reducing competing strong attractors; and (3) altering critical values that: (a) lead to self-organization rather than individual idiosyncratic behavior; (b) determine whether self-organization or chaos occurs; (c) cause divisions to drop back below the edge of chaos if chaos does occur; (d) strengthen the core attractors.

Old hands will recognize that some lessons from complexity theory exist in the change literature from long ago—the already mentioned Lewinian force field, the autonomous work group approach of Trist and Bamforth (1951), the interdependency and differentiation approach of contingency theory (Thompson, 1967; Lawrence and Lorsch, 1967), and in some structural change approaches (French and Bell, 1995). As an exercise, an interested reader might wish to translate into microagent complexity terms the "micropolitical processes of transformation" described by Bachrach, Bamberger, and Sonnenstuhl (1996) for the purpose of applying an adaptive learning model.

A CAUTIONARY NOTE

In a timely article, Johnson and Burton (1994) wave some cautionary flags. First, drawing on Ruelle (1991), they observe that the use of evolutionary equations stemming from chaos theory typically requires (1) low dimensional systems, that is, equations having few variables; (2) precise critical values (α levels in the equations); and (3) precise longitudinal data numbering in the thousands of points. They cite Kellert (1993) as noting that the evolution equations in chaos theory are invariant

closed form solutions. Ruelle argues that in social systems the "equations of motion" (or rates as discussed in Section 3.3.1), are as yet too imprecise for the bifurcation effects of chaos theory to materialize. Though Johnson and Burton view complexity as more relaxed in its requirements, they worry about viewing organizations in terms of Prigogine's self-organizing dissipative structures, noting that "we are not sure that much is to be gained in trying to explain group and organizational systems in terms of dissipative systems that are far from equilibrium and that move through phase transitions.... [S]everal theories of organizations and groups provide as many, or more, insights, far more parsimoniously" (1994: 327). Having raised these cautions, they also follow the skeptical Ruelle (1991) and Gould (1987) in saying "researchers would be foolish to dismiss complexity theory out-of-hand...." (Johnson and Burton, 1994: 325).

Now to return to quasi-natural organization science. Johnson and Burton state their caveats in the context of the following quote: "Systems of people in organizations are usually the result of conscious, purposive actions taken by individuals with long and phenomenally complex histories and belief systems of their own" (1994: 327). This statement and their caveats are clearly from the context of the *intentional* side of quasi-natural organizational phenomena. In this article I have outlined the *natural* side, which begins with idiosyncratic microstates and recognizes that behavioral microstate systems appear to have many of the emergent self-organizing properties attended to by complexity theory. If the self-organizing emergent properties of microstate systems did not exist we would be hard pressed to explain the failure of complex firms to perform at levels reasonably expected if employees were smart, rational, perceptive, and flexible. By the Johnson and Burton thesis, business schools, in particular, would surely all be at "best practice" levels of performance, consistently up-to-date with their changing world, and most would be pushing hard for the kind of idiosyncratic competencies that generate rents—since they are full of professors who presumably are smart, rational, perceptive, flexible, and fully knowledgeable about organization design and strategy!

Can managers wait out the emergent structure arising from the stochastic idiosyncrasy of complex adaptive systems? To the extent that interdependent process microstates are causes of inertia, population ecologists (Hannan and Freeman, 1989) and institutional theorists (Meyer and Zucker, 1989) suggest otherwise, as do dinosauric examples such as GM, IBM, Sears, and the Federal Government, and the findings of Miller (1990). Are "laws" based on flow rate models or adaptive learning models apt to be invariant? This question is softened by my shift from predicting individual events to predicting stochastic distributions and distributions of distributions. As with Newtonian mechanics, under certain idealized conditions laws pertaining to the prediction of stochastic distributions could be invariant. Given the large numbers

of microstates and large numbers of links in large complex systems, it is possible that microstate laws might be quite robust against changing conditions—as more than one newly appointed CEO or Washington bureaucrat has discovered. These are empirical questions.

Though returning to recognize the interplay between both intentional and natural organizational forces, I have little to say now about 'transition phenomena'. My metaphor at this point is that organization science is like a person with one atrophied leg—the natural science one. Until this leg gets strengthened it is pointless to work on training the person to walk properly. Everyone (my referees included), wants to get to the "walking" part. I think it would be foolish for me to pretend that comments I might make now would be relevant. We do not think in terms of flow rates and we know little about the complexity effects of microstates. My hypothesis is that there are invariant background laws in the natural side, but that these may be activated or deactivated, strengthened or weakened, by actions on the intentional side. And, intentional actions may be with or against the flow of the natural forces. Firms are presumably most creative, most idiosyncratically advantaged, or most responsive to competitive pressures when the natural flows and intentional actions are *both* adaptively on target. Why don't all firms easily achieve this frontier of top performance? Well, the "conscious purposive action" that people are capable of as responsible leaders also is what drives the idiosyncratic microstates. As Lewin the physicist pointed out nearly 50 years ago, it often happens that the greater are the forces down from the top the stronger are the forces up from the bottom (microstate) level—leaving an increasingly tense system going nowhere.

IV.   CONCLUSION

I began this article by suggesting that warring over the symptom of paradigm proliferation is fruitless, absent neutralization of the underlying causal agent, stochastic idiosyncrasy. A possible resolution of the paradigm war between objectivism and subjectivism hinges on recognizing that organization science comprises both *intentionally* and *naturally* caused phenomena. Further, I suggest that the continuation of the paradigm war construes the problem as an "either-or" choice between objective/natural and subjective/intentional phenomena, when in fact the most interesting aspect of organizations is the continual transition between the two phenomena, a point so aptly indicated by the juggler metaphor. My solution appears as a synthesis of *Intentionality*, *Transition Phenomena*, *Coevolutionary Theory*, *Scientific Realism*, *Semantic Conception Epistemology*, *Analytical Mechanics*, and *Complexity Theory*. It responds to the call by Daft and Lewin (1993: i) for a science of firms as "...flexible, learning organizations that continuously change and solve problems through interconnected coordinated self-organizing processes."

Rather than have organization science relegated to the murky backwaters of postpositivism (Lincoln, 1985c), historicist social science (Perrow, 1994), or following 18th century physical equilibrium laws, as traditional economists are wont to do (Mirowski, 1989; Favre, *et al*., 1995) (though a "postneoclassical" economics is emerging as mentioned earlier), my approach rests on the observation that late 20th century natural science offers concepts and methods remarkably relevant (1) for the modern view of organizational phenomena as idiosyncratically complex; and (2) the development of the natural side of a quasi-natural organization science based on coevolutionary selectionist theory, idealized models, analytical mechanics, and complexity theory. By framing a quasi-natural organization science focusing on microstates, my intent is not to deny the relevance of either intentionality and subjectivity *or* natural science and objectivity. Ultimately, when the natural science side is more fully developed, we can look forward to exploring the most interesting part of our science—the transition phenomena lying between intentionally caused and naturally caused organizational phenomena. A quasi-natural organization science could end the paradigm war.

I argue that organizational phenomena exhibit *stochastic idiosyncrasy*, and that *coevolution in a selectionist competitive context* creates explainable "*order*" in firms. My analysis then focuses on mitigating the effects of stochastic idiosyncrasy on organization scientists' application of the traditional tenets of *justification logic*, defined as scientifically accepted activities such as prediction, generalization, falsification, and self-correction. After considering the use of idealized models, following the philosophical logic of the semantic conception of theories, I briefly review analytical mechanics for the purpose of identifying a method of translating idiosyncratic microstates into the calculus of rates and event occurrence probability distributions, an instrumental convenience natural scientists have used over the last 200 years to mitigate the idiosyncrasy problem. My method draws on Sommerhoff's (1950) directive correlation concept, and Hempel's (1965) deductive statistical model. Then I briefly review complexity theory as a 20th century natural science development offering a third alternative for developing quasi-natural organizational science.

A key element of the debate is whether any aspect of strategic organizing behaves as natural science phenomena—after all one might say all behavior in firms is intentional from each individual's perspective. This could be so. But here is where complexity theory becomes important. Given attractors that pull individuals' and groups' intentionalities in opposing directions, complexity theory suggests that autocatalytic dissipative structures or chaotic behaviors appear as a result—either of which acts to create order. These structures cause events to occur or entropically dissipate at various rates. This returns us to subcritical complexity, analytical mechanics and the

application *inside firms*, of the calculus of rates.

Another complexity theory lesson is that, once these structures are set in motion by the attractor context of complexity, the forces of "*contextually emergent simplicity*" (Cohen and Stewart, 1994) take hold, offering the possibility of "simple rule" explanation in the context of complexity. Organization scientists thus have available to them both reductionist and contextualist explanations and theories. This is the fundamental and significant new direction offered by my analysis and use of complexity theory—*intentionality*, *natural science*, *simplicity*, and *complexity* are all central components of quasi-natural organization science. I believe this approach offers a unique and exciting new direction for organization science.

The success of organizational science depends in part on finding more fruitful applications of computational and analytical methods to intraorganizational explanation, a trend recognized by the founding of an important new journal, *Computational and Mathematical Organization Theory*. Economists appear to overuse analytical methods at the expense of empirical corroboration of the models. Organization scientists focus on empirical discovery with very little effort going into the development of idealized analytical or computational models and direct empirical corroboration of them. A more appropriate approach might be a roughly 25/50/25 ratio between (1) theorizing based on idealized models; (2) empirical testing of the models; and (3) descriptive, natural history or case study investigations, a balance closer to physics and biology.

Back to Darwin. I realize that by the light of most paradigms, most of the facts in the file for the theory of organizations espoused here may line up against it. It is reputed that Darwin's file of facts against his theory considerably exceeded his file of facts for his theory—a ratio having little bearing on its eventual success. I close with Darwin's classic distinction between *laws in the background* and *contingency in the details*. The natural sciences found many ways to mitigate idiosyncratic details so they could focus on background laws—the search for these laws is based on idealized models. For natural scientists, this search may inadvertently have been aided by separation from the phenomena by telescopes and microscopes, or for geologists, miles of earth. Organization scientists necessarily live in the midst of the idiosyncratic details. Nevertheless, this proximity should not dissuade us from searching for background laws. We need more focus on background laws, not less, as the "thick description" postpositivists prefer. Without a strong scientific realist epistemology, organization science will continue to "churn" paradigms like stock brokers churn the accounts of distant customers. Strangely, organization science would probably be more successful to "consumers" of its findings if it appropriately distanced itself from microstates by the organizational equivalent of microscopes, telescopes, and earth—and searched more intensely for background laws explaining naturally occurring order in organizational phenomena.

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Table 1. Some Evidence of Multiparadigmaticism

Renewed emphasis on positivism, observable measures, less cognitive concepts (Pfeffer, 1982).
Deductive use of mathematics and economics (Camerer, 1985).
Refutable, observation based theory (Montgomery, Wernerfelt, and Balakrishnan, 1989).
Formalization techniques will play an increasingly important role (Carley and Wallace, 1995).
Culture clash of different views important for development of knowledge (Huff, 1981).
Physical science epistemology irrelevant to social science (Perrow, 1994).
Science is a social struggle among scientists to construct truth (Cannella and Paetzold, 1994, based on Astley, 1985).
Empirical evidence, objectivity, reason, truth, validity, measurement no longer sources of direction (Van Maanen, 1995a).
Need a theory that does not degenerate into simplicities of reductionism or determinism (Reed, 1996).

Table 2. Evidence of Postpositivists Rejection of Traditionally Accepted Justification Logic [†]

[Research designs] emerge, unroll, cascade, or unfold [in] interaction with the setting and its denizens…but the unpredictable nature of those interactions
    [between investigator and phenomenal setting] prevents laying out a schema for deciding or pursuing what is interesting or important ahead of time.
[The human research instrument] is one that acts in sympathy with the emotional, nonrational, spiritual, and affiliational renderings of its respondents.
Qualitative methods…are those that can accommodate and explicate multiple, conflicting, and often inherently unaggregatable realities.
…[T]acit knowledge has been legitimated as "vibes," "hunches," or "gut reaction." …[It] takes into account the constant construction of environments by the
    actors in it.
…[N]aturalists choose to work in the construction of theory from data rather than beginning with theory that constrains the seeing process.
First and foremost, inductive, rather than deductive, analysis is much more likely to be capable of reflecting multiple realities constructed out of environments.
Naturalists are alike in assuming that the particulars of any given context or site shape their data interpretations.
Case studies are part of the products and/or ends of naturalistic inquiries.
Generally, traditional trustworthiness criteria include internal validity, external validity, reliability, and objectivity. Analogous criteria for naturalistic studies
    are credibility, transferability, dependability, and confirmability.

[†] (all quoted from Lincoln, 1985b: 142-151; some items omitted)

Table 3. Paradigm shift in Other Disciplines [†] [‡]

A simple reality is now seen as "*complex and diverse.*"
Pyramidal hierarchical order is replaced by "*heterarchy*," that is, multiple orders.
The image of a machine-like universe is replaced by a "*holographic*" interactive network image.
A determinant universe is replaced by an "*indeterminant*" one.
Linear causality is replaced by "*mutual causality*."
Reductionism is replaced by a view that entities are "*morphogenically*" formed in the context of their surroundings.
Scientific objectivity is replaced by an approach that is "*perspectival*" in the sense multiple views...are entertained.

[†] Disciplines such as: quantum mechanics, evolutionary theory, mathematics, philosophy, psychology, linguistics.
[‡] Schwartz and Ogilvy (1979: 13-16; italicized terms are theirs)

Table 4. Causes of Unique Behavior in Organizations

Geographical locations and ecological contexts of firms are unique.
CEOs and dominant coalitions in firms are unique—different people in different contexts.
Individuals come to firms with unique family, educational, and experience histories.
Emergent cultures of firms are unique.
Competing firms usually have different suppliers and customers, another source of unique influences on firms' behavior.
Individual experiences within firms, over time, are unique, since each member is located uniquely in the firm, has different responsibilities and skills, and is
    surrounded by different people, all forming a unique interaction network.
Specific firm process responsibilities—as carried out—are unique because of supervisor-subordinate relationships, the unique interpretation an individual
    brings to the job, and the fact that each process event involves different materials and different involvements by other individuals.

Table 5. Idiosyncratic Events as a Cause of Multiparadigmaticism

1. Given idiosyncratic events, there is no prediction, generalization, or falsification and, thus, no event focused realist epistemology.

2. Without realist epistemology, there is no reliable and valid external ontological "objective function."

3. Without an external objective function, there is no basis of self-correction in organization science.

4. Without self-correction, there is no protection against the proliferation of false theories, false findings, false paradigms, false schools, false prophets, and false consulting advice in organization science.

5. Without self-correction, there is no stemming the proliferation of multiple paradigms.

Table 6. Foundation Premises of Quasi-Natural Organization Science

1. The assumptions critical to the modern view of natural phenomena by physicists, chemists, biologists, and philosophers are now largely isomorphic with the modern view of organizational phenomena.
2. Patterned regularities in organizational phenomena occur as a result of selectionist effects in a competitive context.
3. Coevolutionary structures and processes at various levels within and among firms exist as quasi-natural classes of phenomena exhibiting various rates of change.
4. The conceptual, theoretical, and quantitative methods developed by the natural sciences are now more amenable to natural organization science than ever before.
5. The use of such methods hinges on the availability of idealized models and instrumental conveniences that serve to mitigate idiosyncrasy effects.
6. Organizational phenomena are natural in the sense that many of the forces and fluxes (rates at which forces have effects) unleashed occur independently of the purposeful intentions of the people associated with them.
7. A synthesis of natural physical, life, and organization science rests on both 1st and 2nd laws of thermodynamics and features assumptions of idiosyncrasy, complexity, contextually emergent simplicity, self-organization, and selectionist adaptation.

Table 7. Definitional Elements of Niche Driven Coevolution

1. A niche is the "sum total of the adaptations of an organismic unit" (Pianka, 1994a: 269). It coevolves as a population changes resource consumption capabilities.
2. A niche traditionally has been defined by ecologists in terms of the resources consumed by the resident organism (Hutchinson, 1957; Levins, 1968; MacArthur, 1972). Thus, a niche is defined by the competencies a firm has available for harvesting from the ***resource pool*** comprising its niche.
3. While elements of a firm's niche are subject to manipulation as it develops relevant competencies, aspects of the broader environment, for all practical purposes, are not (Odum, 1971; McKelvey, 1982: 109).
4. The resource pool of a niche is subject to change by events in addition to the behavior of its inhabitants, such as changing economic, technological, political and social elements.
5. The resource pool must be both available and within a firm's competence for harvesting, to serve as the source of *revenues* critical to the long run survival and sustainable competitive advantage of the firm. I single out revenues because firms ultimately survive by paying their bills—human, intellectual and reputational resources are in the equation to the extent that they impact revenues.
6. Resource pools coevolve with the emergence of organizational forms suited for harvesting the resource.
7. Each niche may contain other competitors who have also coevolved along with the target firm and are able to compete more or less effectively for the resource.

Table 8. The Contextualist Basis of Order in Firms

By <u>Portarian logic</u> (Porter, 1985), value chain activities emerge in firms, at different levels (*e.g.*, primary and secondary), because they bring cost and differentiation advantages leading to competitive advantage.
By <u>resource- or competence-based</u> logic (Teece, 1984; Wernerfelt, 1984—and all the others mentioned earlier; Heene and Sanchez, 1997), intrafirm resources, dynamic capabilities, and competencies that have idiosyncratic advantage, as a result of environmentally related scarcity and value, lead to competitive advantage.
By <u>coevolutionary logic</u> (Baum and Singh, 1994b; Ginsberg and Baum, 1994; Mezias and Lant, 1994; Miner, 1994; Winter, 1994; Nelson, 1994; Rosenkopf and Tushman, 1994; Van de Ven and Garud, 1994; McKelvey, forthcoming), variations of chain competencies having coevolutionary relevance are those offering survival and competitive advantage.
By <u>contextually emergent simplicity logic</u>, (Cohen and Stewart, 1994), Darwin machines at higher levels select into existence emergent (via lower level Darwin machines) simple rule governed order at lower levels.
Organization science may include both contextual explanations and reductionist simple rule explanations.
Order may also be obscured by intentional or naturally emergent behaviors of individuals that produce "noisy" behavior, or by changing environments. These behaviors may or may not be patterned or advantageous to survival.

Table 9. Views of Positivism in Organization Science

9a—Positivism Defined by the Postpositivist Guba (1985: 82-83)

There is a single tangible reality "out there."
The inquirer is able to maintain a discrete distance from the object of inquiry.
The aim of inquiry is to develop a nomothetic [lawlike] body of knowledge…encapsulated in nomic (nomological) generalizations…independent of both time and context.
Every action can be explained as the result (effect) of a cause that precedes the effect temporally.
Inquiry is value free.

9b—Critique of Postpositivist View by Hunt (1994)

Positivism is synonymous with quantitative methods. (They are independent.)
Positivism is deterministic. (Positivism was partly in response to quantum and relativity theories which are not deterministic.)
Positivism seeks for causal laws. (Positivists believe in instrumentalism, not causal explanation.)
Positivism is synonymous with realism. (Positivists eschewed intangible unobservables, whereas realists accept them.)
Positivism reifies abstract concepts. (Since positivists use only observable terms, they had no need to reify.)
Functionalism is positivist. (Positivists say functional explanations are "devoid of objective empirical content" (1994: 229)).
Positivist research is objectivist. (In this one instance postpositivists have it essentially correct.)

9c—Definition of Organizational Positivism by Miner (1980: 5)

Concepts must be clearly defined in terms of procedures used to measure them.
Scientific observation must be controlled so that causation may be attributed correctly.
Utilize samples that are adequate in both size and conditions of their selection.
Have confidence that the results obtained are generalizable.
Propositions, hypotheses, and theories [must] be stated in terms that can be tested empirically.

Table 10. Basic Elements of Scientific Realism

A theory is a systematically related set of statements, including some lawlike generalizations, that is empirically testable (Rudner, 1966: 10).
The purpose of theory is to increase scientific understanding through a systematized structure capable of both explaining and predicting phenomena (Hunt, 1991: 149).
And, scientific progress (Hunt, 1991: 293; drawing on logical empiricism and Popper) follows from:
    a) The development of new theories for phenomena not previously explained,
    b) The falsification of existing theories and their replacement with new theories,
    c) The expansion of the scope of a theory to include new phenomena, and
    d)   The broadening of specific theories into more general theories.

Table 11. Competence Elements of the Resource-Base View Translated into Rates [†]

Rates at which employees absorb a vision articulated by top management or become party to shared meanings.
Rates at which resource stocks are utilized or accumulated to achieve advantage over competitors.
Rates at which employees learn unique knowledge, skills, and abilities on the job.
Rates at which specific capital and imitation barriers are created.
Rate at which "Schumpeterian revolutions" are generated.
Rate at which reduced variability in employee performance occurs.
Rate at which learnings coalesce into tacit knowledge and organizational routines.
Rate at which transaction costs are lowered.
Rate at which organizational culture generates positive leadership events.
Rate at which competencies are enhanced or destroyed.

[†] Drawn from Lado and Wilson (1994).

Table 12. Some Complexity Theory Definitions

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12a—Definition of Kinds of Complexity by Cramer (1993)

'*Subcritical 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 complexity are strictly deterministic and allow for exact prediction" (1993: 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 Cramer's '*fundamental 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; Gell-Mann, 1994), since the former is 'simple rule' driven, and stochastic systems are random, though varying in their stochasticity.

In between Cramer puts '*critical complexity*'. The defining aspect of this category is the possibility of emergent simple deterministic structures fitting subcritical complexity criteria, even though the underlying phenomena remain in the fundamentally 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: 215-217) has a long table categorizing all kinds of phenomena according to his scheme.

12b—Definitions of Attractors by Gleick (1987)

'*Point attractors*' act as equilibrium points around which forces cause the system to oscillate away from these points, but eventually the system returns to equilibrium—traditional control style management decision structures may act in this manner (appearing as subcritical 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 subcritical 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 cold ocean and a hot sun, 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 make-over an acquired firm.

Figure 1
Simple Exchange of Balls by a Juggler*
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Figure 2
18th and 20th Century Natural Science Assumptions
Relative to Organization Science Assumptions
See published version

Figure 3
Sommerhoff's Directive Correlation
See published version

Figure 4
Competing Influences on Decision Making*
See published version