ABSORBING STOCHASTIC IDIOSYNCRASY: SCIENTIFIC REALISM, VALUE CHAIN COEVOLUTION, AND DIRECTIVE CORRELATION ENVELOPES

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INTRODUCTION

Could organization science be stillborn? Imagine two life threatening organizational infections, one bacterial, *Sci. multiparadigmaticus,* and one viral, *Org. idiosyncraticus*. Remembering that viral infections, such as the flu, often turn into bacterial infections, such as bronchitis or pneumonia, think of *O. idio.* as a primary cause of *S. multi.*

Worrying about *S. multi.*, Pfeffer (1982) ends his insightful review of organization theory with a call for renewed emphasis on positivism, that is, focus on observable measures, and a general steering away from nonobservable attributes characteristic of the more cognitive approaches. Since that time, postpositivist and interpretist views (Lincoln 1985) have strengthened, further muddying the paradigm waters. Pfeffer (1993) renews his concern about paradigm proliferation. In contrast Perrow (1994) suggests Pfeffer's concerns are vestiges of the physical sciences and, since organizations are in the realm of social science, such concerns are irrelevant.

Also commenting on the effects of *S. multi.*, Camerer (1985) states, "I believe that deductive use of mathematics and economics is the best way to answer (and ask) corporate strategy questions" (1985: 1). Montgomery, Wernerfelt, and Balakrishnan (1989) amplify this side, emphasizing refutable, observation based theory. In contrast Thomas and Pruett (1993) focus on theoretical pluralism, which holds that "the culture clash between genuinely different points of view can be an important basis for the development of knowledge" (1993: 4, quoting Huff, 1981: 87). Mahoney (1993: 184, 185) concludes in favor of "conversational justification," following Dewey (1929) and McCloskey (1985), which is "that scientific statements are…creations or constructions of the human mind" and "…wisdom consists of the ability to sustain a conversation."

A possible cause of *S. multi.* is *O. idio.* Pointing to the widespread effects of *O. idio.*, phenomenologists, ethnomethodologists, anthropologists, postpositivists and interpretists, already studying what is inside the black box, all emphasize the *idiosyncrasy* of individual, group, and organizational behavior. Shifting from the organizational to the value chain level, Porter (1985) and those holding the resource-based view (RBV) in strategy (Wernerfelt, 1984; Barney, 1986, 1989, 1991; Rumelt, 1987; Prahalad and Hamel, 1990; Reevis-Conner, 1991; Teece, Pisano, and Schuen, 1994) all argue that competitive advantage stems from *idiosyncratic* resources and competencies held by individual firms.

To the extent that *O. idio.* prevails, accepted scientific method and the study of organizational behavior and strategic management seem incompatible. The fundamental dilemma is that it seems impossible to simultaneously accept the existence of idiosyncratic organizational phenomena while at the same time pursuing the essential elements of justification logic defined by positivists—prediction, generalization, and falsification—which require <u>non</u>idiosyncratic phenomena (Hempel, 1965; Suppe, 1977, 1989; Hunt, 1991).

Our cure of the *O. idio.* disease takes two paths. In Part I (this paper) our treatment focuses on ***vertical idiosyncrasy absorption***. Part II (McKelvey, 1995b) focuses on ***horizontal***

delimitation of idiosyncrasy by defining energic states of adaptive progression to treat *O. idio*., concluding organization science need not be any more multiparadigmatic than other sciences.

In this Part, we resolve the idiosyncrasy/positivism dilemma by looking at organizational phenomena through three "conceptual imaging scopes" focusing on: (1) ***process/event sequences***; (2) ***value chain processes***; and (3) ***multicoevolutionary firm processes*** as sources of idiosyncrasy. We point to the inherent stochastic nature of each of these kinds of phenomena, and argue further that higher levels of the phenomena absorb some of the idiosyncrasy at lower levels through Cohen and Stewart's (1994: 232) process of ***contextually emergent simplicity***. Part I ends with the development of a new analytical structure for organization science focused around ***directive correlation envelopes*** (which stem from Sommerhoff's (1950) concept of "directive correlation,") and Hempel's (1965) *deductive-statistical* (D-S) model of prediction. We argue that the understanding of idiosyncrasy absorption coupled with directive correlation envelopes and D-S logic offers a redefinition of organization science capable of curing of *O. idio*.

SCIENTIFIC REALISM

Much has been written about the flaws in logical positivism in reviews of the evolution of scientific method through logical positivism, logical empiricism, historical relativism, to ***scientific realism*** (Suppe, 1977, 1989; Holton, 1988, 1993; Boyd, Gasper, and Trout, 1991; Hunt, 1991; Ziman, 1991; Fuller, 1993; Cohen and Stewart, 1994). Scientific realists adhere to the general idea "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). Scientific realists also emphasize the following points:

1. A theory is a systematically related set of statements, including some lawlike generalizations, that is empirically testable (Rudner, 1966: 10).
2. The purpose of theory is to increase scientific understanding through a systematized structure capable of both explaining and predicting phenomena (Hunt, 1991: 149).
3. And, scientific progress (Hunt, 1991: 293 drawing on Popper and logical empiricism) 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 reduction of specific theories into more general theories.

Scientific realists give up the tight (via the correspondence rules) relation between theoretical and operational language, and with this the idea that formal mathematical developments might substitute for continued empirical investigation. Verification has been replaced by incremental corroboration and falsification. Also relinquished is the strict separation between theoretical and operational language. Though the excesses of logical positivism are removed, much remains: theoretical and operational languages; correspondence rules; and prediction and generalization all still exist. People who cannot define it easily, but "recognize it when they see it," are inclined to point to physics, chemistry, and biology over the last 200 years by way of indicating what is meant by scientific realism. Scientific realism accepts a mixture of deterministic and probabilistic views of the phenomenal world (Nei, 1987; Brody, 1993; Cohen and Stewart, 1994).

Even with scientific realism, the fundamental problem for us is: How to practice good scientific method without papering over its incompatibility with the idiosyncratic realities of firms? If what is important in explaining organizational performance and sustained competitive advantage is idiosyncratic, scientific realist method cannot apply, as suggested by the following logic:

1. If attributes that are important for explaining the performance or competitive advantage of each firm are idiosyncratic, homogeneous populations cannot exist.
2. If homogeneous populations do not exist, findings about one firm cannot be generalized to other firms.
3. If inductions from a study of some members of a population cannot be assumed to apply to other members, an induced theory cannot be justified via prediction and falsification.
4. If the nature of key attributes is ever changing, because of competitive forces for example, predictive theory induced in one time period cannot be expected to apply in a later time period, a problem since scientific progress via accumulated studies is essentially sequential.
5. If an event cannot be assumed to occur in some other place or time, corroboration or falsification of a predicting theory cannot be ascertained.

To date no acceptable alternative to positivism-evolved-into-scientific realism[1] has been proposed which protects us from the promulgation of false theories by distinguished authorities or charlatans. *The one singular advantage of scientific realist method is its empirically based, self-correcting approach to the discovery of truth* (Holton, 1993). Consider the following:

1. Given *O. idio*. there is no prediction, generalization, or falsification, and thus, no scientific realism.
2. Without scientific realism, there is no reliable and valid external ontological criterion variable.
3. Without an external criterion variable, 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 basis for preventing the florescence of *S. multi*.

With no other self-correcting alternative in sight, we find suggestions by some scholars, that the "justification logic" basis of science might not be necessary or applicable to organization studies, in danger of sending organization science down a path of misinformation, a point of view supported by Hunt (1994). Instead, we continue searching for successful applications of scientific realist notions to organization science, such as prediction, generalization, and falsification. Our resolution of the dilemma between scientific realism and idiosyncrasy now turns to a discussion of stochastic idiosyncrasies inherent in three kinds of organizational phenomena.

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[1] Eisenhardt (1989) suggests a use of multiple case analysis, which moves inquiry from an inductive discovery use of cases to more of a scientific realist justificatory one. The use of a few sequential natural history sites may offer a basis for prediction, generalization, and falsification, but the power of statistical significance may be difficult, though not impossible, to obtain.

KINDS AND LEVELS OF IDIOSYNCRASY ABSORPTION

To apply the Cohen and Stewart (1994) approach, we need levels of organizational analysis. In their view, each higher level of analysis creates an emergent simplicity out of the random, myriad, microscopic phenomena of the lower level. We focus on process/event sequences, value chain processes, and multicoevolutionary processes. Because each of these exhibits idiosyncrasy and hierarchy, we prefer them to traditional analytical levels such as: individuals, departments, firms, and the environment (Roberts, Hulin, and Rousseau, 1978).

A. THROUGH THE PROCESS/EVENT SEQUENCE SCOPE

Van de Ven (1992) notes that when a process as a black box or category is opened up it appears as a sequence of events. Abbott (1990) states “every process theory argues for patterned sequences of events” (p. 375). Mackenzie (1986: 45) defines a process as “a time dependent sequence of elements governed by a rule called a process law.” In addition he defines processes to have five components (1986: 46):

1. The entities involved in performing the process
2. The elements used to describe the steps in a process
3. The relationships between every pair of these elements
4. The links to other processes, and
5. The resource characteristics of the elements

A process law “specifies the structure of the elements, the relationships between pairs of elements, and the links to other processes” and “a process is always linked to another, and a process is activated by an event” (Mackenzie, 1986: 46). In his view an event “is a process that signals or sets off the transition from one process to another” (1986: 46-47). We consolidate these views in the phrase ***process/event sequence*** (PES), insisting also that events be observable.

Mackenzie’s typology of task PESs contains six hierarchical levels: activity, module, bundle, group, area, and macro-logic (1986: 52-56). Various other typologies of PESs exist in the literature. Sankoff and Kruskal (1983) identify two basic kinds of sequences: discrete (an ordered sample of things) and continuous (but they recognize that continuous is analyzed by conversion to discrete). Abbott (1990) mentions temporal and spatial sequences and notes further that similar methods apply to both. Van de Ven (1992) mentions parallel, divergent and convergent sequences. He also discusses life cycle, teleological, dialectic, and evolutionary change sequences. These process theory approaches direct their discussions of processes toward those that are temporal or developmental, that is, sequential, for example, material-processing workflow sequences (Mackenzie, 1986), innovation processes (Van de Ven and Poole, 1990), or careers (Abbott and Hrycak, 1990). Since Mackenzie’s definition of process events amounts to a “grammar,” it is important to recognize that alternative process grammars have been suggested (Weick, 1979; Barley, 1986; Sandelands, 1987; Salancik and Leblebici, 1988; Pentland and Rueter, 1994).

Mackenzie recognizes that in an organization

> There are multiple events, chains of events, parallel events, exogenous events, and chains of process laws. In fact, an event is itself a special process. Furthermore, there exist hierarchies of events and process laws. There are sequences of events and process laws. The situation is not unlike the problem of having a Chinese puzzle of Chinese puzzles, in which opening one leads to the opening of others (1986: 47).

Later in his book Mackenzie describes processes that may be mutually causally interdependent. In his view, even smallish firms could have thousands of process/event sequences.

Though recognizing the thousands of PESs, and Chinese puzzles inside Chinese puzzles, Mackenzie says, "I prefer deductive, nomological theories based on laws that describe *how* a phenomena occurs" (1986: 272; his italics). As Cohen and Stewart note (1994: 244), reductionists focus on explaining *how*—they try to explain complexity at a higher level by looking for simple laws at lower levels. Mackenzie clearly takes a reductionist approach, but can he find simple process rules to explain all the complexity in organizations?

B. THROUGH THE VALUE CHAIN PROCESS SCOPE

In 1985 Porter introduces his value chain idea (Figure 1). In his view, "any strength or weakness a firm possesses is ultimately a function of its impact on relative cost or differentiation" (1985: 11). His two foundation chapters carry on an elaborate discussion of cost and differentiation in terms of activities comprising the value chain. It has two main components: primary activities and support activities.

Insert Figure 1 about here

Primary activities of the value chain include all activities "involved in the physical creation of the product and its sale and transfer to the buyer as well as aftersale assistance" (1985: 38). These activities generally include the following categories: *Inbound Logistics, Operations, Outbound, Logistics, Marketing and Sales, and Service*. **Support** activities in the value chain "support the primary activities and each other by providing various firmwide functions," including: *Procurement, Technology Development, Human Resource Management, and Firm Infrastructure.* The primary activities of the value chain are those directly involved in generating revenue. These activities produce and transfer a product into a customer's hands in return for which the customer transfers value, as gross revenues, to the firm. Primary value chain elements achieve primacy because a break in this part of the chain means no revenue, whereas a break in the support chain may eventually weaken the firm, but does not stop the revenue stream, at least in the near term.

Attempts to understand how resources internal to the firm act as sustainable sources of competitive advantage are reflected in such labels as the "resource based-view" (Wernerfelt, 1984), "core competence" (Prahalad and Hamel, 1990), "strategic flexibilities" (Sanchez, 1993), and "dynamic capabilities" (Teece, Pisano, and Schuen, 1994). We include all these variants in "RBV." Resources include all of the more permanent tangible and intangible assets tied to a firm (Caves, 1980; Wernerfelt, 1984), including both its strengths and weaknesses. A fundamental tenet of RBV is that differences in firms' performances are tied directly to differences in firms' resources. RBV identifies two conditions leading to rents: 1) scarce resources, and 2) valuable resources.

Scarcity. Barney (1991) suggests resources generating rents must necessarily be unique, inimitable, and nonsubstitutable. Given the possibility of substitution, Mosakowski and McKelvey (1995) argue that both the form and function of resource elements must be unique and difficult to imitate. Only resources whose actual form and function remain ***idiosyncratic*** can generate rents.

Value. Identifying resource value calls for a differentiation between resources that enhance a firm's performance, detract from it, or have little effect. Barney (1991) observes that resources yield rents[2] only as long as they remain suited to their environment. However, events in a firm's rapidly changing environment may render worthless previously valuable resources. Thus value is a function of both environmental and temporal effects. In this view, the link between a firm's internal operations and its environment is the basis for determining the value of internal firm resources.

In Porter's view, activities have value in attaining competitive advantage, if they are distinct or unique, just as in RBV. Instead of using "idiosyncrasy," Porter says, "value activities are the physically and technologically **distinct** activities a firm performs" and "a firm differentiates itself from its competitors when it provides something **unique** that is valuable to buyers beyond simply offering a low price…. Any value activity is a potential source of **uniqueness**" (1985: 38, 120; our emphases). Porter recognizes that even firms producing commodities may have unique activities (1985: 121). Both RBV and Porterian schools of strategy now focus on idiosyncratic firm effects. Following Mosakowski and McKelvey (1995), we subsume all RBV terms, such as "resources," "core competencies," "strategic flexibilities," and "dynamic capabilities," into one term, ***competencies***. We will also treat Porter's "activities" as competencies.

C. THROUGH THE MULTICOEVOLUTIONARY PROCESS SCOPE

Porter (1990, 1991) focuses on coevolution, as the basis of instability in whatever patterns of uniqueness a firm might have in its value chain. Firms in strong coevolutionary relationships push each other to "continuously improve, innovate and upgrade their competitive advantages over time" (1991: 111). With Porter, as with RBV, the coevolutionary, mutually causal relationships between a firm's activities and those of competing firms create a constant force toward change in whatever distinct, unique, or idiosyncratic activities it draws on for competitive advantage.

Coevolution occupies a central position in biological ecology and organization science (Hannan and Freeman, 1977, 1989; Aldrich, 1979; Brittain and Freeman, 1980; McKelvey, 1982; Carroll, 1988; Singh, 1990; Baum, forthcoming). Coevolution means that there are always some

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[2] Economists' term, "rents" refers to supernormal profits, or greater than marginal profits, usually stemming from successful risk-taking, monopoly, or protective entry barriers.

elements of a niche that change as an organizational form evolves. However, some elements of the environment surrounding a specific niche are never subject to manipulation by most organizations or populations, whether consciously, inadvertently, or from blind variation, such as: physical laws, location of major cities, location of national borders, population demographics, dominant culture of a nation or its economic system, and so on. The number of environmental elements open to manipulation varies by organization and population. A niche includes all those environmental elements subject to manipulation. This view[3] forms the basis of coevolution in recent studies at the intrafirm, interfirm, and community levels (Barnett, 1994; Brittain, 1994; Baum and Singh, 1994a; Rosenkopf and Tushman, 1994; and Van de Ven and Garud, 1994).

As applied to organizations, coevolutionary events appear at several levels of analysis:

niche, population, firm, and parts of firms. Coevolutionary links occur horizontally within these levels and also vertically between levels. The first three levels have been touched on by various authors in the Baum and Singh book (1994b), primarily with respect to foundings and failures. Economists have also focused on coevolution at these levels, but primarily in terms of bottom line measures such as price or cost, in describing comovements toward competitive equilibrium.

We take coevolutionary competition one level lower by focusing on horizontal and vertical coevolutionary movements involving individual chain competencies as “parts” of firms. Suppose, for example, that competition between two laptop computer firms dropped down from overall product price to competition in terms of a more specific part of the value chain, such as advertising or battery life. Once coevolution starts between two competing firms on one chain competence, it could spread to other chain competencies. Thus the initial competition over advertising “hype” and improving battery life could later spread to other chain competencies, such as, memory capability, the processing chip, mouse control, kind and size of screen, weight, ease and speed of upgrading, reliability, service, and so on. Competitive improvements may appear on some of these items at a very rapid pace. While the primary chain elements are most obvious, coevolutionary competition could be stiff on support competencies as well. ***Multicoevolutionarity*** refers to situations where firms simultaneously compete on two or more coevolutionary chain competencies.

In this section we have laid the groundwork for vertical idiosyncrasy absorption by focusing on three bases of idiosyncrasy: process/event sequences, value chain processes, and multi-coevolutionary processes. These phenomena range from bottom to top of any firm. We work with four levels in analyzing idiosyncrasy absorption, though there could be others. They are 1) PESs, 2) chain competence elements, 3) chain competencies, and 4) firm multicoevolutionarity.

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[3] Key steps in the development of this view were taken by Hutchinson, 1957; Ehrlich and Raven, 1964; Smith, 1970; Odum, 1971; Feeny, 1975; McKelvey, 1982; Futuyma and Slatkin, 1983; Thompson, 1989; Nelson, 1994; Pianka, 1994.

REDEFINING ORGANIZATION SCIENCE

We redefine organization science in directions more consistent with the epistemology of modern science by focusing on stochastic idiosyncrasy, molecular lower bounds as platforms of scientific explanation, and reductionism, together with Cohen and Stewart's (1994) contextually emergent simplicity via levels of idiosyncrasy absorption. Then we turn to Sommerhoff's (1950) directive correlation concept as a way of revisiting a classic element of general systems theory on the road toward bringing added specificity to the emergent simplicity idea.

D. COMPLEXITY AND SIMPLICITY

1. MOLECULAR LOWER BOUNDS

In a comprehensive review of reductionism, Cohen and Stewart cite the root reductionist assumption: "Complexity at any given level is a consequence of the operation of relatively simple rules one level lower down" (1994: 219). In the reductionist view, sciences are arranged in hierarchical order: mathematics, physics, chemistry, biology, psychology, economics. In a classic article about what scientists actually do, Schwab (1960) points out that there are two kinds of reductionism: atomic reduction and molecular reduction. The Nobel Laureate physicist, Lederman, recently wrote a book titled *The God Particle* (1993). Writing about the basic particles involved in unified field theory, this book somewhat whimsically illustrates the *atomic* reductionist view that all explanations ultimately begin with nuclear particle wave functions. If anyone really believes particle wave functions could explain why Japanese cars are better than American ones, they hide it. For example, Cohen and Stewart show how unwieldy atomic reduction is for explaining the wave function of an entire cat or explaining the orbit of Mars (1994: 269, 281).

Most sciences rather modestly work within a limited range of the total hierarchy. In *molecular* reductionism each science traditionally has a well defined lower cutoff, the ***molecular lower bound***, where they stop trying to explain things and just make some initializing assumptions. Chemists do not explain nuclear particles; they just assume that molecules have various nuclei and electron rings and then they go about their explanations of chemical bonding and so forth. Biologists do not explain the chemistry of nucleic acids; they just assume that nucleic acids consist of various chemical molecules and then they start to work on explaining DNA base-pair sequencing, genes, chromosomes, proteins, cells, and so forth.

The molecular lower bound may be viewed as a ***platform*** consisting of myriad particles about which simplifying assumptions are made. These assumptions are ***instrumental conveniences*** allowing molecular reductionists to develop explanations of higher level phenomena without trying to explain complex individual particle movements. For a given science, explanations deal with complexity *above* the lower bound but not within or below it—some other science takes over at the lower bound, or sometimes a mature science eventually extends its explanatory territory into the lower bound, as in physicists' unified field theory, molecular biology, or physiological psychology. Sociologists worry about being "psychologized"—their way of protecting their lower bound.

These instrumental assumptions are of two fundamental kinds. We will ignore a third variant, **statistical fluctuation** (Brody, 1993), which is really the uniform assumption but with an accommodation for measurement and other random error that might obscure uniformity.

1. **Uniform**. Frequently particles are assumed all alike. All quarks, oxygen molecules, rat DNA molecules, and neurons, for example, are assumed identical. By using the "rational actor assumption" that all individuals attempt to achieve constrained maximization (Hogarth and Reder (1987), economists instrumentally treat all people as identical and then they go about their work of trying to explain the behavior of aggregate economic systems (though each individual's indifference curve might be unique, they are all treated as perfectly rational). Following this logic, process/event sequences for purchasing the best laptop would be assumed uniform across all firms.
2. **Stochastic**. Particles are assumed to behave randomly—there is no underlying uniformity. Boltzmann suggested that physicists should assume all particles in solids like metal or glass vibrate or move randomly. There is no proof of this as yet, they just assume it. Gas particles in a pressure vessel are assumed to have random trajectories on a particle by particle basis. Epidemiologists assume that malaria mosquitoes choose victims randomly, though it is possible that mosquitoes see it differently. Biologists assume that faults in a particular DNA sequence occur randomly, or that cell mutations are random. von Mises terms this **case** probability—"we know, with regard to a particular event, some of the factors which determine its outcome; but there are other determining factors about which we know nothing" (1963: 110). Thus, process/event sequences for purchasing the best laptop would be assumed to exhibit random variation in all firms.

The best way to think about instrumental conveniences is that they are never perfectly true. They are imperfect starting points in an imperfect world. We do not ask you to trade in perfection for imperfection. However, the imperfect approach we suggest seems better than the imperfect approach you are already using, because our assumption is more robust. If one assumes uniformity which turns out not to be true, falsification is clearly apparent. If one assumes stochastic arrivals or idiosyncrasy, the line between randomness and less or no randomness is not so well defined. By making a weaker assumption, the cost, if it is not perfectly true, is less damaging.

Also, it is important to realize that instrumental conveniences are starting places—they are not permanent. In retrospect we know that physicists got a way with the uniformity assumption for a couple of centuries at least, until quantum mechanics came along in the 1920s; then deterministic assumptions gave way to probabilities and statistical mechanics. Even so, for much of physics and engineering, determinism still works effectively (Brody, 1993; Cohen and Stewart, 1994). Economists have also held on to the rational actor assumption for two centuries, even though there is much convincing evidence that it is false (Hogarth and Reder, 1987). However, for aggregate analyses, many economists believe the rational actor assumption will work for many years to come, even if it is false at an individual "particle" level (Blaug, 1980; Lucas, 1987; Kreps, 1990).

2. THE ORGANIZATION SCIENCE MOLECULAR LOWER BOUND

What is the nature of the molecular lower bound for organization science? The traditional bottom level of organizational analysis comprises individuals (Roberts, Hulin, Rousseau, 1978). To date individuals, as "particles" in any given organization, have not been deemed unworthy of explanation and thus have not been placed in the molecular lower bound and instrumentally assumed by organization scientists to exhibit either uniformity or stochastic idiosyncrasy.

Organizational psychologists assume individual behavior in organizations *is* worthy of explanation. Psychologists' "micro O. B." epistemology still seems to stand as the dominant scientific approach for studying most internal organizational behavior. Micro O. B. epistemology implies that the molecular lower bound for organization science is the same as that for psychologists. Thus, the prevailing starting instrumental assumption for studying firms is presumably that the body chemistry of people in firms is assumed to be uniform. Therefore, *any* level of analysis *above* body chemistry is worthy of explanation—no other starting instrumental assumption or molecular lower bound has gained acceptance. Interestingly, population ecologists duck the entire issue by treating *everything* inside firms as particles not worthy of explanation.

Organization science has been misled by its reliance on the psychologists' molecular lower bound. In fact, firms are totally different phenomena from people. They are not just people; they are *aggregates* of people, machines, task processes, groups of various kinds, intragroup processes, interpersonal and intergroup processes, diverse environmental transactions, and so on. It appears *not* in the best interest of organization science to assume individuals are the particles of the molecular lower bound. It is time to draw a line between psychology and organization science.

If not body chemistry or individuals, what then are the organizational "particles?" Decision theorists would likely pick decisions. Information theorists might pick information bits. We side with process theorists. Information bits could well be the particles for decision science and electronic bytes may make good particles for information science—but they are below the organizational lower bound—thus uninteresting to organization scientists. As Mackenzie's (1986) work shows, organizational processes constitute a very micro level of organizational analysis, they are ubiquitous in all firms, and there are thousands of them in most firms. If processes are to be particles, there is still a problem of an apparent hierarchy of processes. Should the lower bound include all processes as particles, or just those at the very bottom of process analysis? Should the tiniest processes be those that are lowest in a firm or shortest in time duration, or indivisible?

As a starting instrumental convenience, let's assume that organization science particles will be the task processes Mackenzie calls *activities*. They are at the bottom of his hierarchy of aggregation. An activity "is a task process for which there are no nonempty subsets of task processes at the level of [organizational] analysis selected" (1986: 52). Also as a starting assumption, we will include task process/event sequences at *all* levels of an organization as particles in the molecular lower bound. Now there is the question as to what assumption to make about individual task PES particles—uniform or stochastic?

What is the best particle assumption for organization science? A couple of lists of example PESs at the particle level are shown in Figure 2. We think the manner in which these kinds of activities are *exactly* carried out from one day to another, or from one person to another, or in one organization or another, is uninteresting to most organization scientists. Specific details about how thousands people on thousands of loading docks decide a pallet is acceptable, or how thousands of people deal with thousands of calls from customers, are levels of complexity organization science seems willing to forego. Possibly they are of interest to those who study factory production, but not to us. These kinds of PESs are what we have in mind as "particles" for organization science.

Insert Figure 2 about here

Now the question is, should we assume they are all uniform or random? Granted, some activities might be identical, such as automated processes controlled by computers—we will ignore these. Could the rest all be uniform? Would we expect all people on all loading docks to inspect pallets exactly the same way or all software response persons to open all calls exactly the same way? Probably not—people, loading docks, product, software, customers, and so on, all differ. It is also clear from the examples above that there are many kinds of PES particles, so PESs are not uniform in this sense either. We think most organization scientists would *not* assume that all PESs are uniform, so we rule out the uniformity assumption.

If PESs are not uniform, can one reasonably assume their differences are random, absent systematic organizational effects that are the legitimate subject of explanation by organizational scientists? Suppose an organization specifically does not attempt to chose what kinds of people are on a loading dock, what kinds of products are there, what the time schedules might be, what the inspection standards might be, and so on. If we take away all those things that managers might want to *manage*, is there any reason to expect that PESs at the level on the lists would not appear random? We think not. In this manner we think PESs at what Mackenzie terms the *activity* level are stochastic particles we can use to construct the organization science molecular lower bound.

One final point needs clarity. Our stochastic idiosyncrasy assumption is a starting point, only that. Lurking in the sea of particle randomness *could* be uniformities that might show up as statistical features. The gas laws initially assumed randomness among the seething gas particles inside the pressure container. Later physicists began to use statistical mechanics to discover features of quantum mechanics governing particle movements inside the container. Now they are using statistical mechanics at the particle level to explain behaviors of solid matter.

3. CONTEXTUALLY EMERGENT SIMPLICITY

The question here is: Are the statistical features emerging from the organizational molecular lower bound created by simple deterministic rules governing particle behavior or are they simplicities created by forces in the level above? Either of these possibilities could be true in firms.

Cohen and Stewart's (1994) review of reductionism takes half of their 446 page book. They do not put this much space into reviewing reductionism to overturn it. They point out that sciences rigorously pursuing reductionism have gained high respectability, made many important findings, and made tremendous contributions to modern society. Cohen and Stewart emphasize that by looking for simple rules, reductionist scientists rely on simplicity to explain the origin of complexity—reductionism answers the question: Where does complexity come from?

Cohen and Stewart observe two problems with this approach. First, complexity at a particular level may be the result of several interacting simple rules, with the effect that reductionism runs a good chance of failing to unbundle the rules. This is like trying to solve a problem having one equation with several unknowns. Second, over the last couple decades those studying chaos have discovered chaotic behavior produces complexity in systems where the complexity had been presumed susceptible to explanation via the simple rule approach. Thus it is often difficult to unbundle chaotic origins of complexity from simple rule origins.

Cohen and Stewart take the second half of their book to explain how ***contextually emergent simplicity*** might offer insights unavailable from reductionism. We will repeat an example they use to make their point (1994: 244-246). Try explaining why herbivores have eyes on the side of their head while carnivores have them on the front. First imagine trying to find simple reductionist rules based on body chemistry, cell physiology, genes, proteins, DNA, RNA, or nucleic acids, with which to explain why eyes would migrate from, say, random placements on herbivore and carnivore heads to the sides or front. Impossible you say? Now try it with natural selection theory. Carnivores can chase herbivores more effectively if eyes are facing forward; herbivores with heads down eating grass can see approaching carnivores sooner if eyes are on the sides of heads. The rest starve or become dinner. Cohen and Stewart point out that natural selection theory is "transparent" (in the computer programmer's sense that a piece of software is transparent if you can use it without knowing how it works). It is also contextual and simple. It works in many walks of life, literally and figuratively: biologists, economists, organization scientists, and epistemologists all use it. One need not know about countless particle level details to apply it, nor even much about how natural selection details work, witness Darwin (1859).

On balance, the Cohen/Stewart contextually emergent simplicity concept is a loose set of perceptions rather than a detailed framework about how such an approach to science might work. They say, "the prime example of [contextually emergent simplicity] is evolution (1994: 418). Elsewhere they say, "***statistical regularities*** are certainly one important and widespread mechanism for emergence" (1994: 233; our emphasis). But they also say, "…many emergent features do not come from statistics" (1994: 233). And, "other kinds of feature can ***crystallize*** out from underlying chaos—numbers, shapes, patterns of repetitive behavior" (our emphasis). These "phenomena that are independent of detailed substructure are *universal*—"nature's theorems" (1994: 238; their emphasis). Cohen and Stewart see emergent simplicities explaining *why*; they see reductionism as explaining *how*. Of their mission, they say, "we are looking for hidden simplicities of a nonreductionist kind and trying to elucidate the contextual mechanisms that produce them" (1994: 246). In this paper, we focus on evolution and also on statistical regularities, what von Mises (1963: 107) terms **class** probability—"we know or assume to know, with regard to the problem concerned, everything about the behavior of a whole class of events or phenomena; but about the actual singular events of phenomena we know nothing but that they are elements of this class."

E. DIRECTIVE CORRELATION ENVELOPES

To crisp up the emergent simplicity idea and better understand how stochastic idiosyncrasy can be translated into emergent simple rules, we draw on Sommerhoff's (1950) concept of directive correlation. In the following subsections we define directive correlation and some derived concepts to further develop the Cohen/Stewart emergent simplicity concept.

1. DIRECTIVE CORRELATION DEFINED

Consider laptop computer manufacturers' possible responses to the publication in 1994 of comparative ratings of laptop 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 laptop capabilities and underlying chain competencies. Consider the responses of four fictitious laptop makers. Prior to the shock, firms *A*, *B*, and *C* competed on high-end "bells-and-whistles"—laptops with color screens, lots of capacity, mouse controls, docking stations, service, up-gradability, etc.; firm *D* competed on efficiency, convenience, and portability primarily abroad—chip speed, low weight, battery life, built-in modem and fax capability, etc. After the shock, firms *A* and *B* continue to direct their attention toward bells-and-whistles, competing on all the chain competencies related to high-end demand, with firm *A* focusing on disk capacity, chip speed, RAM, docking station, service, and desk-top equivalence, and firm *B* focusing on disk capacity, speed, reliability, flexibility, options, up-gradability, software, and service. Firm *C* shifts its attention to the needs of the business traveler for efficient portability and hotel-room use, and firm *D* decides to make a major attempt to enter the U. S. market. Because of these responses, competition between laptop makers *A* and *B* and between *C* and *D* intensifies; firms *A* and *B* also compete directly at the chain level on disk capacity and service, and firms *C* and *D* end up competing directly at the chain level on weight and battery life.

At this point, focus on the key elements in this example: (1) the initiating event is the reporting of the customer survey by *PC World*; (2) the desired outcomes of increased bells-and-whistles or increased efficiency, convenience, and portability, recognizing that continued profitability and growth in their respective laptop classes may or may not be achieved; (3) the responses of laptop makers *A*, *B*, *C*, and *D* in terms of investments in various primary and support chain competencies; and (4) the nature of the constraints and changes in the competitive context. Translating these elements into the terminology that Sommerhoff uses to describe directive correlation, we find that (1) is the ***cœnetic variable*** (CV_{t_0})— the initiating event is the same for all companies; (2) are the hoped-for adaptive results, the ***focal condition*** pairs, (FC_{At_2}, FC_{Bt_2}) and (FC_{Ct_2}, FC_{Dt_2})—pairs because each pair of laptop makers, *A*-*B* and *C*-*D*, aimed at different focal conditions or adaptive change outcomes, with some chain competencies directly competing and others not in direct competition; (3) are the laptop makers different ***responses***, R_{1t_1}, R_{2t_1}, R_{3t_1}, R_{4t_1}—each *R* represents a variety of responses a firm makes in trying to approach its *FC*; and (4) are **environmental constraints** in the competitive context for each laptop maker, E_{1t_1}, E_{2t_1}, E_{3t_1}, E_{4t_1}—each *E* represents a variety of environmental changes and actions by competitors a firm encounters in trying to approach its *FC*.

In Figure 3, we depict the relationships among the four elements. Sommerhoff (1950: 54-55) defines directive correlation as follows (*FC* substituted for *G* in the original; his emphasis):

> 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}.

Insert Figure 3 about here

Sommerhoff's directive correlation analysis shows 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*. 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, or the *R*s and *E*s may be in a mutual causal relationship (Maruyama, 1968), that is, directively correlated.[4] Note also that once the system has started, any E_{t_n} might act as a *CV* of $R_{t_{n+1}}$.and any R_{t_n} might act as a CV of $E_{t_{n+1}}$. We will refer to the foregoing interrelationships of *E*s and *R*s as a ***directive correlation system*** (DC system), contained within a ***directive correlation envelope*** (DC envelope) defined by *CV* and *FC*.

2. THE DC ENVELOPE LEVEL

A given *CV*, and a consequent *FC*, such as increasing disk capacity, form an envelope which contains a number of *R*s and *E*s that emerge as a laptop maker directs this competence toward achieving the *FC*. This *FC* as a specified objective, however, may be adopted by a competitor as an ***intendedly comparable***[5] *FC*, thereby setting up the potential for competitive behavior[6] and the creation of some comparable competitive effects—several firms might all choose to compete on increasing disk capacity. Possibly, any *R* by firm *A* could be adopted as an

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[4] Ashby (1956: 211) observes that if an *FC* is to be held in steady state, given a changing *CV* or *E*, the variety in *R* has to match the variety in *CV* or *E*, which is Ashby's Law of Requisite Variety stated in Sommerhoff's terms.

[5] Intended comparability (elaborated in Mosakowski and McKelvey, 1995) occurs when two competitors adopt the same *FC*s, such as underlying value chain competencies leading to improved disk capacity and service (firms *A* & *B*), or weight and battery life (firms *C* & *D*), even though in each competence the specific processes in each firm remain idiosyncratic.

[6] We do not have space to enter into a discussion of why competitors might chose to compete intensely on some *FC*s and not others. This is clearly an interesting question. We only assume that they do, and carry on the analysis from this point forward.

intendedly comparable *FC* by firm *B* (via mimetic behavior or by chance initiation), and given this, the *R* could in turn become subject to more intense focus as an *FC* by firm *A*, thus leading to coevolution on this competence between firms *A* and *B*.

Given an intendedly comparable *FC*, it follows that coevolving DC envelopes may come to exhibit similar properties across competing firms, as firms observe competing firms' competencies and attempt to improve their competencies relative to them. We will get into much more detail shortly, but for now, think of the envelope properties as attributes of the organizing processes that produce *R*s directed toward attaining the *FC*, given the *CV* and various *E*s. Because of the intendedly comparable coevolutionary effect, the several individual firm envelopes may exhibit a statistical regularity of properties across firms on a given competence. Despite a number of comparable envelope properties, the *R* and *E* contents of envelopes may remain idiosyncratic to each firm. DC envelopes thus cause 1) idiosyncrasy absorption, by bottling particle idiosyncrasies up inside the envelopes as DC systems, and 2) predictable statistical regularities (***SR-distributions***) across firms, which provides the basis for scientific realism. They are ideal devices for explaining how the Cohen/Stewart emergent simplicity process might work in firms to identify simple rules.

3. THE DC SYSTEM LEVEL

As firm *A* attempts to achieve a particular *FC*, such as reducing the weight of its laptops, it produces a set of *R*s in response to the *CV*. These *R*s take place in the context of some *E*s such as technological or market constraints or actions by competitors, or intrafirm constraints, such as personnel capabilities, departmental boundaries, and so on. The *R*s may be at the top management level, or in various lower chain competencies,[7] such as disk configuration, motherboard design, RAM specification, docking station design, service department, etc. Possibly the *FC* might become decomposed into a nested hierarchy of intermediate *FC*s, for example, as the docking station people break the job down into power pack, CD-ROM drive, floppy disk drives, housing, assembly, and so forth, and assign design-improvement goals to each subgroup. Over time any *R* might become a potential *CV* to which other people and departments respond, and any *E* might become a *CV* to which people respond. These *CV*s might be further decomposed into component *R*s, *E*s, and *FC*s. A number of possible nesting levels, involving different decompositions of *CV*s and *FC*s, are shown in Figure 4. Thus nested systems of adaptive processes may appear within the initial envelope defined by the initial *CV* and the initial overall *FC* of improving laptop components. The nested hierarchy of *FC*s sets up a hierarchy of nested DC envelopes, any one of which *may* become intendedly comparable with one or more opposing firms.

Insert Figure 4 about here

Within a particular DC system, adaptive processes tend toward being idiosyncratic to the particular firm or subgroup, by virtue of reasons such as: different backgrounds and personalities

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[7] We realize that laptop makers may buy components from vendors rather than building in-house competencies. In this case, competence for dealing with a vendor substitutes for in-house competence.

of employees, interpersonal similarities and differences, kinds of interdependency paths, emergent culture, spatial relations, coalition dynamics, cognitive biases, kinds of equipment available, other assets, competencies, different abilities to alter competencies, and different PESs—the causes of particle randomness. Within a DC system, the coevolution of *E*s and *R*s could also serve to produce idiosyncratic adaptive processes, as each unique mix of idiosyncrasies interacts over time. Consequently DC envelopes that appear similar across competitors, because of intendedly comparable *FC*s, would enclose quite idiosyncratic adaptive processes.

F. STOCHASTIC IDIOSYNCRASY ABSORPTION

We begin by using the gas law analogy to link emergent simplicity with the DC envelope concept. Then we explain how idiosyncrasy is absorbed at the different levels of analysis. Finally we focus on making the philosophical jump from testing propositions based on the particle uniformity assumption to an approach aimed at predicting statistical distributions.

1. DC ENVELOPE CRYSTALLIZING

One might think DC envelopes are imaginary, but in fact they have analytical substance and form a level of analysis that becomes important in the context of coevolutionary adaptive progression and simplicity crystallization. One way to focus on the nature of DC envelopes is by analogy to the pressure vessel in Boyle's Law. This law[8] holds that P = QT/V (accurate enough for nonphysicists). As mentioned earlier, gas particles inside the vessel are within the molecular lower bound and therefore are assumed to have random behavior. Gas laws are one of the dominant analogies Cohen and Stewart (1994) use in explaining emergent simplicity.

For most practical purposes, the nature of the pressure vessel does not figure in Boyle's Law. But what if one were standing next to it when it exploded? Will the vessel melt when heated? Will it hold a pressure over some length of time? Can one move the vessel? Can the vessel be transparent glass? Flexible like a tire? Long and thin like a pipe? Complicated like one's arteries? Our point with this analogy is that without the vessel Boyle's Law does not work, yet the nature of the vessel is seldom mentioned in many renditions of the equation.

Suppose a set of competing firms try various design approaches toward winning a bid on the following "bid spec:" "Build a pressure vessel capable of maintaining a 100 lb. pressure stream for 10 minutes without having the compressor start up." In this situation we can expect:

1. Gas particle movements are idiosyncratic;
2. Design solutions may be idiosyncratic, depending on how firms balance vessel size, weight, portability, strength of materials, cost of materials and construction, maximum allowed container pressure, and so on;
3. Parameters governing the trade-offs are uniform: more size-more weight; thinner material-less weight; stronger material-less weight; stronger material-higher pressure, and so forth. All the design solutions

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[8] P = pressure; Q = quantity by weight; T = temperature; V = volume.

progress within these parameters, producing idiosyncratic pressure vessels having similar effects: they all translate stochastic gas particle movements into pressure streams exhibiting uniformity & SR-distributions.

For example, in an air pressure stream there are arrival probabilities of molecules of different gases, nitrogen, oxygen, carbon dioxide, and so on, as well as probabilities of molecular trajectories and energy levels; in Boyle's Law pressures are uniformities. By analogy:

1. PES particles inside DC systems are idiosyncratic;

2. DC system organizing solutions, as firms each attempt to achieve the *FC*, are idiosyncratic, depending on trade-offs firms make among various design options;

3. When firms compete in trying to achieve an intendedly comparable *FC*, we hypothesize that DC envelope parameters governing organization design trade-offs have SR-distributions producing idiosyncratic DC envelopes having similar effects: they all translate stochastically idiosyncratic DC system solution approaches (that create idiosyncratically excellent moves toward attaining the *FC*) into behavioral pressure streams exhibiting SR-distributions—illustrated in Figure 5.

Insert Figure 5 about here

This analogy fails us in one respect. Pressure vessel design parameters are already well known and are uniform. Think instead of the process by which one might discover parameters governing successful vessel design. One might study a range of attempted vessel designs to attain the goal (100 lb. pressure stream, etc.). Analogously, leaving idiosyncratic PES particles within the lower bound, organization scientists are interested in discovering:

1. Emergent DC system organizing solutions producing pressure streams of behavioral outcomes having SR-distributions, as firms solve the puzzle of how to respond to the *CV* and progress toward the *FC*.
2. Emergent DC envelope parameters having SR-distributions that appear to govern the interaction of the various elements used in developing organizing solutions to the puzzle of how to progress rapidly and effectively toward the *FC*.

By this reasoning, the DC envelope concept produces two different kinds of SR-distributions that absorb stochastic idiosyncrasies in organizing solutions for *FC* attainment.

Using the gas law analogy, what we term ***Cohen/Stewart simplicity rule-sets*** (hereinafter ***"rule-sets"***) play the role of pressure vessel design parameters governing how firms translate stochastically idiosyncratic particle movements into pressure streams having SR-distributions.

1. Given an intendedly comparable *FC*, a rule-set is defined as a number of "solution parameters" governing trade-offs among organizing choices for a population of firms. A rule-set includes:

    a) A number of parameter SR-distributions governing the configuration of puzzle solution components (competencies, competence elements, PESs) within the DC system.

    b) A number of parameter SR-distributions governing trade-offs among the components themselves.

    c) An outcome SR-distribution governing the behavioral "pressure" stream capable of attaining the *FC*.

2. Variance in parameter SR-distributions reflects the degree to which members of the population achieve idiosyncratic excellence in their pursuit of the *FC*.

3. Variance in parameter SR-distributions also reflects the size and homogeneity of the population.

4. As large populations of firms coevolve toward a "best practice" puzzle solution, it is possible that the rule-sets will approach the assumption of statistical fluctuation around a uniformity. However, since large populations are less likely to achieve homogeneity, this outcome seems unlikely.

What we mean is illustrated in Figure 6. Suppose there are several firms, F_1 to F_n, comprising a population F_a, coevolving toward an intendedly comparable FC_a, such as a laptop design having minimum weight and maximum battery life. Even though the *FC* is the same, each firm develops *FC* attainment solutions and produces its own "idiosyncratically excellent" DC system processes that prove successful in its adaptive progression toward FC_a. The interaction of the various elements used in the organizing solutions of each firm are governed by parameters P_{1Fj} to P_{nFj}. For each parameter P_{iF1} to P_{iFn}, an SR-distribution D_{PiFa}, exists, with mean and variance depending on the particular parameter P_{iFa}, and the nature of the DC system solutions tried by the firms, F_a. Given FC_a, and population F_a, a DC envelope exists containing rule-set$_a$, which consists of the various SR-distributions of the parameters P_i, and envelope designs ED_{F1} to ED_{Fn}.

Insert Figure 6 about here

In our view, research propositions concerning a rule-set would be of the form:

1. Given *FC* conditions *C*, parameters P_{iF} exist in SR-distribution form, across firms F_a, governing the range of allowable solution approaches producing idiosyncratic excellence at the DC system level.
2. Given FC conditions *C*, and DC envelope designs ED_{jFj}, idiosyncratically excellent DC systems exist across firms F_a, producing a behavioral outcome pressure streams O_{aFj}, in SR-distribution form.

2. Levels of Stochastic Idiosyncrasy Absorption

Both DC envelopes and systems *may* occur in any of four analytical levels *L*: 1) PES, 2) value chain competence element, 3) value chain competence, and 4) multicoevolutionary firm, as depicted in Figure 7. At each level, for all firms sharing in an intendedly comparable FC_{aLm} (meaning that they all want coevolutionary superiority in achieving the FC_a), a similar FC_a structure would exist. If there is no intendedly comparable FC_a, or if lower, nested intendedly comparable *FC*s (FC_{aL3} to FC_{aL1}) do not exist, then the respective envelopes and systems would not exist, though there could still be lots of undirected idiosyncratic behavior—it just would not be subject to the idiosyncrasy absorption process. At each level, the DC system is analogous to gas particles and DC envelopes are analogous to pressure vessels. Intendedly comparable *FC*s are most likely at the top (multicoevolutionary firm) level ($L = 4$) and least likely at the lowest (PES) level ($L = 1$).

Insert Figure 7 about here

Given intendedly comparable *FC*s, we point to three interesting phenomena in firms: 1) There are nested levels of stochastic idiosyncrasy—randomness is not limited to just the molecular lower bound—it exudes upward; 2) Coevolutionary processes at each level act to create rule-sets, with the effect that, at each of the upper three levels of analysis we have described, there is an idiosyncrasy absorption selection process; 3) SR-distributions become more pronounced as the level of analysis is raised. Since they are closely intertwined, we devolve these effects into one. This leads to the following view of firms:

1. From the top down, elements at each level of analysis create contextually emergent rule-sets in the level below, following the general principles of natural selection theory, possibly aided by the "educated" variations, selections, and retentions of managers—analogous to Plotkin's (1994) Darwin machines.
2. Starting from the bottom up, there is an increase in the proportion of total particle or component behavior following rule-sets rather than randomness.
3. The result is that stochastic idiosyncrasy is absorbed at each level with relatively more behavior "crystallized" into rule-sets at each higher level.
4. Organization science would be better served if its primary focus was on the causes and consequences of different kinds of rule-sets, not on supposed uniformities of "particles" or averages of particle behavior.
5. Rule-sets appear at least at three hierarchical levels, including: chain element rule-sets; chain rule-sets; and firm rule-sets. PES level rule-sets are within the lower bound and thus excluded at this time.
6. Eventually, as in other sciences, scholars might develop "micro" rule-sets at the particle level within the lower bound. At this time, these should be a low priority for organization scientists.

We now discuss crystallization of example rule-sets at two levels, firm and value chain. Each level may have DC envelopes consisting of parameters for one or more of a number of components comprising the lower level idiosyncratic DC system.

Crystallizing Firm Level Rule-Sets. Suppose for example, a laptop firm adopts the intendedly comparable FC_{wb} (with opposing firms) to strive for laptop design leadership in minimum <u>w</u>eight and maximum <u>b</u>attery operation. Suppose this population includes a number of firms successfully coevolving at the cutting edge of competencies relevant to achieving FC_{wb}. A rule-set$_{wb}$ emerges that governs DC envelope inputs (1a, 1b) and DC system outputs (2a, 2b):

1a. The configuration of <u>competencies</u> assembled in attempting to achieve *FC*wb—the list of competencies is not identical across firms, but the range of variation fits a predictable SR-distribution;

1b. <u>Trade-off</u> ratios among interacting competencies—the parameters governing trade-offs are not exact or identical across firms, but the range of variation fits a predictable SR-distribution;

2a. The behavioral <u>elements</u> comprising the output "pressure" stream achieving FC_{wb}—even though the DC system "contents" are idiosyncratic, the elements emerging will form a predictable SR-distribution.

2b. The <u>attributes</u> of the outcome stream—the outcome streams are not identical across firms but the range of variation of some, though not necessarily all, characteristics fits a predictable SR-distribution.

The SR-distributions contain four embedded probabilities:

1. That the outcome pressure stream effectively attains the *FC*;
2. That each competence is effectively designed and pursued;
3. That the configuration of competencies is correct;
4. That the trade-offs are correctly understood.

Our hypothesis is that the competitive pressure of coevolutionarally attaining the *FC* drives each probability in the direction of certainty, though it is never achieved. Nevertheless, the result is predictable SR-distributions because of the intendedly comparable *FC* effect.

By way of a more specific example, and ignoring the possibility of nested *FC*s, what are some possible DC envelope parameters $P_{S\mathrm{wb}}$, that might govern effective configurations of *support*

competencies in idiosyncratic DC systems designed to produce successful adaptive progression toward FC_{wb}? We can specify parameter categories that might apply, but not the specific parameters themselves. Possible support chain competencies are shown in Figure 8a:

Insert Figure 8 about here.

A hypothetical rule-set$_{\mathrm{wb}}$ might say: "For laptop FC_{wb}, a DC envelope exists having SR-distributions $D_{\mathrm{c,p,e,a}}$ describing: 1) Competencies 1-7 and 9-10 as the required "parts" configuration (perhaps #8 is less critical for FC_{wb}); 2) Parameters governing trade-offs 2 vs. 9, 4 vs. 5, 6 vs. 7, and 6 vs. 9, and so on, as required to guide the firms' solution approaches, with optimal levels required on the other competencies; 3) Elements comprising the pressure stream of DC system output behavior O_{wb} required to achieve FC_{wb}; 4) Attributes of the outcome stream O_{wb}." Admittedly, our example, FC_{wb}, has a narrow focus and small population and thus may be scientifically uninteresting. However, classification research might show that FC_{wb} is not unlike many other *FC*s in laptops and also that laptop *FC*s such as FC_{wb} are not unlike *FC*s in many coevolving populations in microelectronics, and so on. The foregoing is an example of a rule-set crystallization at the multicoevolutionary firm level. These emergent simplicities help us understand what transpires at the value chain competence level. We need not know the details about what happens inside the lower level DC systems.

Crystallizing Chain Level Rule-Sets. We now drop down one level, from firm to value chain competence, to consider SR-distributions pertaining to elements making up a particular value chain competence. It is possible that rule-sets would emerge within some chains, while idiosyncrasy might remain unresolved in others, depending on whether nested *FC*s exist. Where rule-sets emerge, they would consist of SR-distributions describing various competencies, trade-offs, and outcome elements as discussed above. Suppose, for example a population of firms began to compete and coevolve around a nested *FC* pertaining to their incentive systems. As before, we only can specify broad parameter categories that might apply, but not the specific parameters themselves. For the incentive system "part," we might specify trade-offs among such elements as those suggested by Pfeffer (1995) (shown in Figure 8b).

For example (only an example!) a hypothetical rule-set might say: "For the incentive system competence, $Comp_{\mathrm{I}}$, under laptop FC_{wbI}, a DC envelope exists having SR-distributions $D_{\mathrm{c,p,e,a}}$ describing: 1) Competence elements 1-6, and 8-10, as the required "parts" configuration (perhaps #s 7, & 11-13 are less critical for FC_{wb}); 2) Parameters governing trade-offs 3 vs. 1; 3 vs. 5; 3 vs. 7; 3 vs. 13; 4 vs. 11; 9 vs. 10, and so on, as required to guide the firms' solution approaches, with optimal levels required on the other competence elements; 3) Elements comprising the pressure stream of DC system output behavior O_{wbI} required to achieve FC_{wb}; 4)

Attributes of the outcome stream O_{wbI}." The exact mix of any of these could be idiosyncratic. For example, each firm might have different wage rates and employee security, but (we hypothesize) they follow the trade-off parameters consistently—as 1 goes down 3 goes up, and so on. The foregoing is an example of crystallization within a value chain competence. There could be rule-sets at the value chain element level within all production level value chains and other primary and support chains as well.

3. Stating Propositions in Terms of D-S Logic

Squirming uncomfortably under positivism-evolved-into-scientific realism, most organizational scientists start from an underlying particle assumption of *uniformity*, modified to *statistical fluctuation* to accommodate measurement and other random error. This approach fits under Hempel's (1965) D-N model of explanation and its deterministic level of predictability:

> ***Deductive-Nomological (D-N) Model.*** In this model, conditions are identified, applicable theories (laws) are applied, predictions made, and then tested. To the extent that results are corroborated (positivism translated to scientific realism), and the theory is shown to be true, existence of the conditions always leads to the result: If conditions *C* exist, and covering laws *L* apply, *C* always causes *R*. This model is falsifiable.

Since the uniformity assumption clearly does not hold for organizations, D-N logic has proved a fruitless venture, leading many scholars to conclude that the D-N model is irrelevant to organizational science (Lincoln, 1985; Daft and Lewin, 1990; Mahoney, 1993; Van Maanan, 1993; Perrow, 1994). Instead, social scientists rely on what Salmon calls "statistical relevance:"

> ***Statistical-Relevance (S-R) Model.*** In this model "an explanation is an assembly of facts statistically relevant to the explanandum, regardless of the degree of probability that results (Salmon 1971: 11; italics omitted). Thus, starting with conditions *C*, *E* has been found at a probability of occurrence slightly higher than chance. Typically some factor is claimed to be a cause, or at least related, because a minimum probability condition is met. This can be as high as $p = .05$, which for a large sample can mean a minuscule amount of explained variance. Since the predicted pattern is barely present, most of the variance in most studies suggests the proposition is false (yet social scientists are accustomed to concluding in favor of corroboration). The proposition is thus unfalsifiable since the probability of expecting the effect *not* to happen on an individual case-by-case basis is far greater than the probability of expecting it *to* happen.

This model is clearly popular in organization science—just look at almost any empirical journal article. The use of this model ignores *O. idio.*, and failure to cure *O. idio.* leads to *S. multi*.

Our cure starts with the underlying *stochastic idiosyncrasy* assumption at the molecular lower bound. We suggest three levels of analysis (there could be more) above the lower bound that absorb idiosyncrasy by creating SR-distributions. By focusing on stochastic idiosyncrasy we steer organizational science toward Hempel's deductive-statistical model of prediction:

> ***Deductive-Statistical (D-S) Model.*** This model is the same as the D-N model, except that what is predicted is not an event but rather a statistical regularity, or probabilistic distribution of events. It parallels von Mises' (1963) *class* probability. In nuclear physics, for example it has been shown that radioactive molecules (of any kind) do not all decay at exactly the same rate. But the half-life of any quantity of, say, plutonium is predictably the same, even though the particle emissions from radionuclides are random events. That is, the mean and variance of the distribution of the escape of alpha and beta particles and

gamma rays is always the same. The organizational learning curve is of the same kind. Thus, if conditions *C* exist, and covering laws *L* apply, *C* causes SR-distribution *D*. This model is falsifiable.

CONCLUSION

Summary. We began this paper by noting that a fundamental dilemma exists for organization science: Scientific realist methods do not apply to idiosyncratic organizational phenomena. We then identify three sources of idiosyncrasy in firms: process/event sequences, value chain processes, and multicoevolutionary firm processes, that occur at various levels throughout firms. We redefine organization science by the use of Cohen and Stewart's (1994) contextually emergent simplicity approach as an alternative to reductionists' search for "simple rules." We add specificity to the Cohen/Stewart approach by elaborating Sommerhoff's (1950) directive correlation concept to include directive correlation DC envelopes and DC systems. Our argument suggests that for any given level of analysis among a population of coevolving firms trying to attain a similar focal condition (target), there are two kinds of "idiosyncrasy absorption" 1) rule-sets governing organizing solutions, and 2) and pressure streams of behavioral outcome events directed toward the attainment of the target. The results of idiosyncrasy absorption are statistical regularities conforming to Hempel's (1965) "deductive-statistical" model of explanation.

Idiosyncrasy *and* Scientific Realism. Trying to resolve the idiosyncrasy/scientific realism dilemma calls for heroic solutions. The path toward "simple rules" is not necessarily simple. There are confusing kinds of idiosyncrasy discussed, different levels of analysis, a very new idea from biology and mathematics via Cohen and Stewart, a very old idea from Sommerhoff, and we have tried to introduce some specificity in terms of additional concepts. In trying to be clear we may have indeed become less accessible. Nevertheless, our argument is a critically important one for organization science. *There is scientific life with idiosyncrasy*. We should stop looking for soft, fuzzy, unpredictable, ungeneralizable, and unfalsifiable alternatives to scientific realism. The warm comfort of case analysis is no substitute for rigorous scientific analysis under the dictates of scientific realism, even for a science focused on competitive coevolution (Peters, 1991).

The Lower Bound. Organization science, as the study of organizational aggregates, has been "psychologized" virtually to death. Since organizational psychologists seem to have dominated the field first, their definition of the molecular lower bound also dominates. We call for a redefinition of the lower bound from one defined by psychologists to one that will work for organization science. We argue that the "particles" of the lower bound "platform" consist of process/event sequences and that these fit the underlying *stochastic* particle assumption **not** the *uniform* assumption. The stochastic particle assumption is more robust than the uniformity assumption and is more in keeping with the idiosyncratic nature of most organizational phenomena.

Scientific Life Cycle. By most reckoning, organization science is not yet a science. By trying too hard to look like a modern mature science—like physics, chemistry, or biology—we have shot ourselves in the "respectability and fruitful outcome" foot. Kids are told not to throw curve balls, for fear of injury. Pianists are told not to try to play Beethoven's *Emperor Concerto* before they have mastered scales and simpler works. As with children, sciences seem to have discernible life cycle stages. Let's consider three stages: 1) natural history, 2) deterministic, and 3) probabilistic micro-analytic. Physics had 200 years of determinism in which to make incredible findings and gain world-wide respectability *before* they moved into the probabilistic micro-analysis of nuclear particles and the search for unified field theory. Biology had 200 years of natural history and evolutionary theory *before* they moved into the probabilistic micro-analysis of molecular, DNA, RNA, and cell "particles" in the search for life's origin and replication processes. Economists have had 200 years of uniformity in the rational actor assumption as the platform for analysis of aggregate economic behavior, and most still show little interest in abandoning the uniformity assumption (Hogarth and Reder, 1987).

Organizational science is most charitably viewed as in the latter phase of its natural history stage. Many published studies are best characterized as, "See what I found out there and isn't it interesting!" They are similar to *National Geographic* stories and nature films that characterize "popular" science conducted at the fringe of modern biological science. They are a vestige of the past compared to the modern biological science of MRI brain scans, RNA "trucks," cell physiology, DNA sequencing, and protein synthesis. Organization science natural history ranges from "thick" ethnographic descriptions and historical presentations to questionnaire and case studies.

An alternative view of organization science might reasonably suggest 50% of research time should go into simulations and more formal models, with the other 50% of the time going into empirical tests (and discovery) of premises driven by the scientific goal of validating the models, as is characteristic of physics and biology. In this sense, for example, organization science has too much theoretically *unguided* empirical work and economics has too much empirically *untested* formal mathematical work (Boland, 1989). Organization scientists should focus on simulation and more formal modeling approaches, but without de-emphasizing empirical testing. Specifically, we advocate two fundamentally important new directions for organization science.

Particle Models. For modeling, spin-glass and other particle models (Mezard, Parisi, and Vivasoro, 1987) are ubiquitous in physics (Aarts, and Korst, 1989) and are now used as the basis of evolutionary genetic modeling (Kauffman, 1993), neural network analysis (Geszti, 1990), with some spill-over into sociology (Weidlich, and Haag, 1985) and economics (Friedman and Aoki, 1992). These models rest on the stochastic particle movement assumption. Kauffman (1993) uses a variant of these models to study the relative effects of complexity and natural selection on evolving entities; a translation of Kauffman's approach to strategy is suggested by McKelvey (1995a). A longer run view of our contribution is that we set the stage for moving past the natural history phase toward the more formal modeling stage by setting up stochastic particles as the molecular lower bound platform for organization science.

Deductive-Statistical Logic. The overall lesson from our analysis is that organization scientists should stop stating theoretical propositions phrased in terms of the D-N model, as in:

> If conditions *C* exist, and covering laws *L* apply, *C* always causes *R*.

We should stop hoping for empirical results in the form of:

> Starting with conditions *C*, *E* has been found, though somewhat clouded by statistical fluctuations due to measurement and other random error.

We should fooling ourselves into believing that we can base justification logic on results no better than those provided by the commonly accepted S-R model, which are of the form:

> Starting with conditions *C*, *E* has been found at a probability of occurrence slightly higher than chance, with minimal variance explained.

Organization scientists *should* adopt the following D-S propositional form:

> If conditions *C* exist, and covering laws *L* apply, *C* causes SR-distribution *D*.

Organization scientists should stop trying to build a science on the assumption of *uniform* particles in the molecular lower bound that simply are not there. Failing to accomplish this, is not, however, the end of our scientific world and should not be cause for settling for warm fuzzy case studies. In fact, switching to the *stochastic* particle assumption would do more to put organization science on a strong foundation than any other single thing we could do. In order to make better forward progress toward more believable and useful theories and results, our message is rather strongly that we can create a solid and respected organization science only by building on a stochastic molecular lower bound and focusing predictions primarily on SR-distributions.

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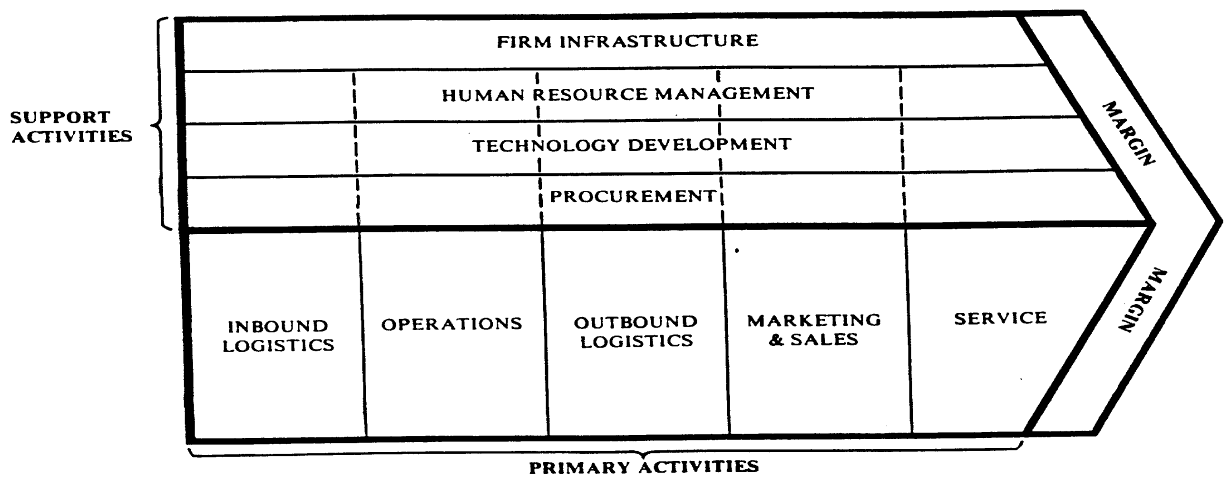
FIGURE 1

Porter's Generic Value Chain



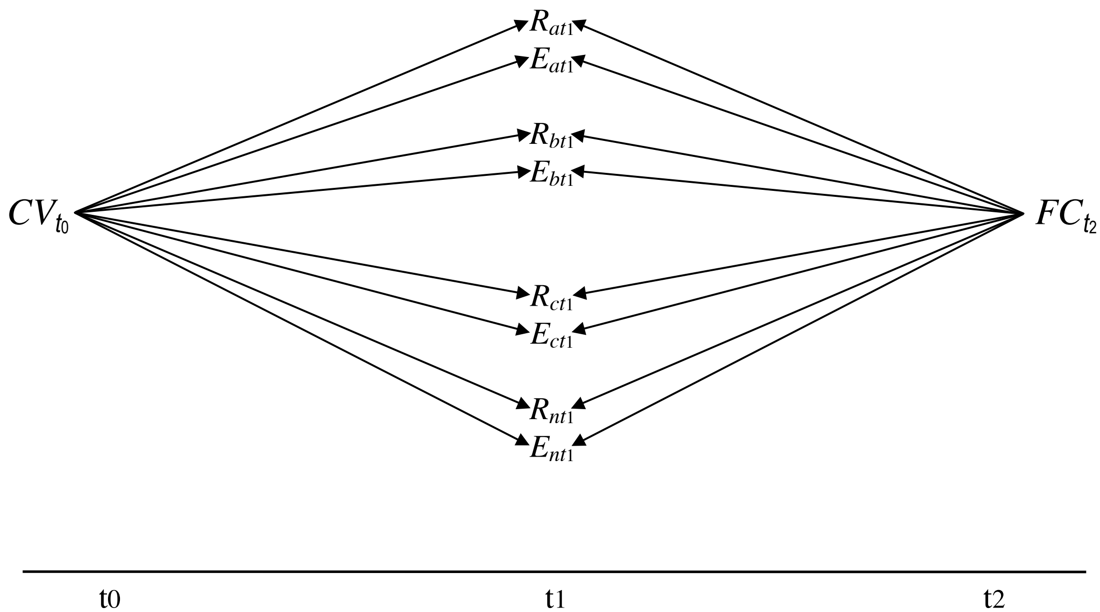
Reproduced from Porter (1985: 37)

Figure 2

Lists of Example PESs at the Particle Level

Mackenzie (1986: 52):	Pentland and Rueter (1994)
Ensure receiver has freight bill, packing list...	Open the call
Unload freight cars, pile product properly on pallets	Work on the call
Inspect for damaged or bad product	Declare the problem inactive
Count product received and verify against freight bill	Defer the problem
Approve receipt if undamaged, correct count…	Fix given to customer
Refuse receipt if damaged product	Explain reason for closing
Document and pallet exchange	Transfer responsibility
Place slot tag on pallets	(partial list)

Figure 3
Directive Correlation Space[1]



[1] Adapted from Sommerhoff (1950): Figure 3 (p. 53) and Figure 4 (p. 60)

Figure 4

Decomposition of a DC Envelope

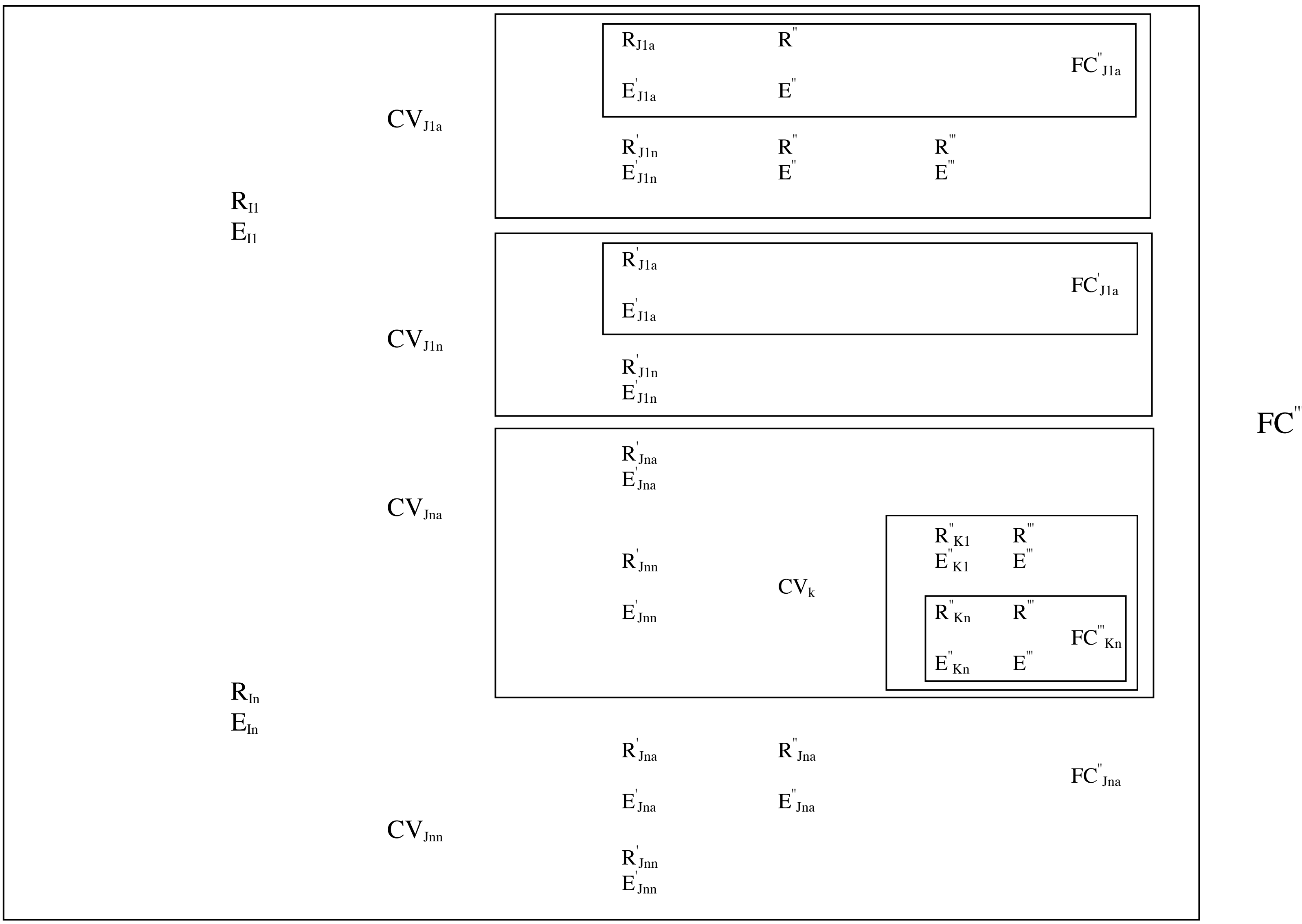


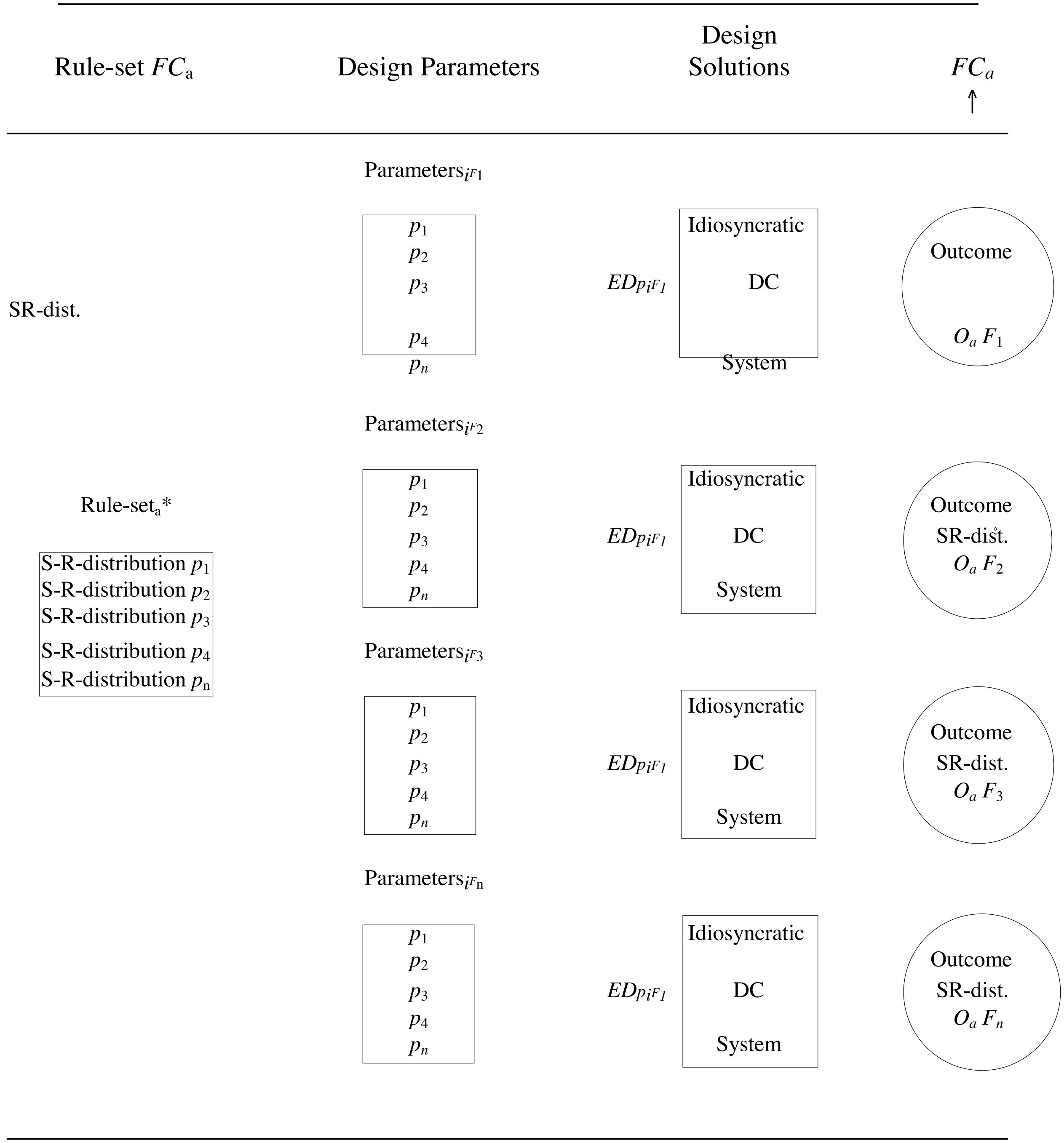
FIGURE 5

Relation of DC Envelopes and Systems to Idiosyncrasy Absorption

Analytical Concepts		**Phenomena**	
		Firm	Pressure Vessel
DC Envelope	Rule-set parameters	SR-distributions	Design Parameters
	Different DC envelope designs	Idiosyncrasy	Vessel Designs
DC System	Puzzle solution approaches	Idiosyncrasy	Gas Particles
	Behavioral outcome pressure streams	SR-distributions	Pressure Stream

FIGURE 6

Relation Between Rule-sets, Parameters, SR-distributions, and DC Envelopes



* Rules-sets include:
1) SR-distributions---presence of parameters
2) SR-distributions---parameter interactions
3) SR-distributions---outcome behavioral elements
4) SR-distributions---outcome pressure stream attributes

↑ CV_a

FIGURE 7

Levels of DC Envelopes and DC Systems

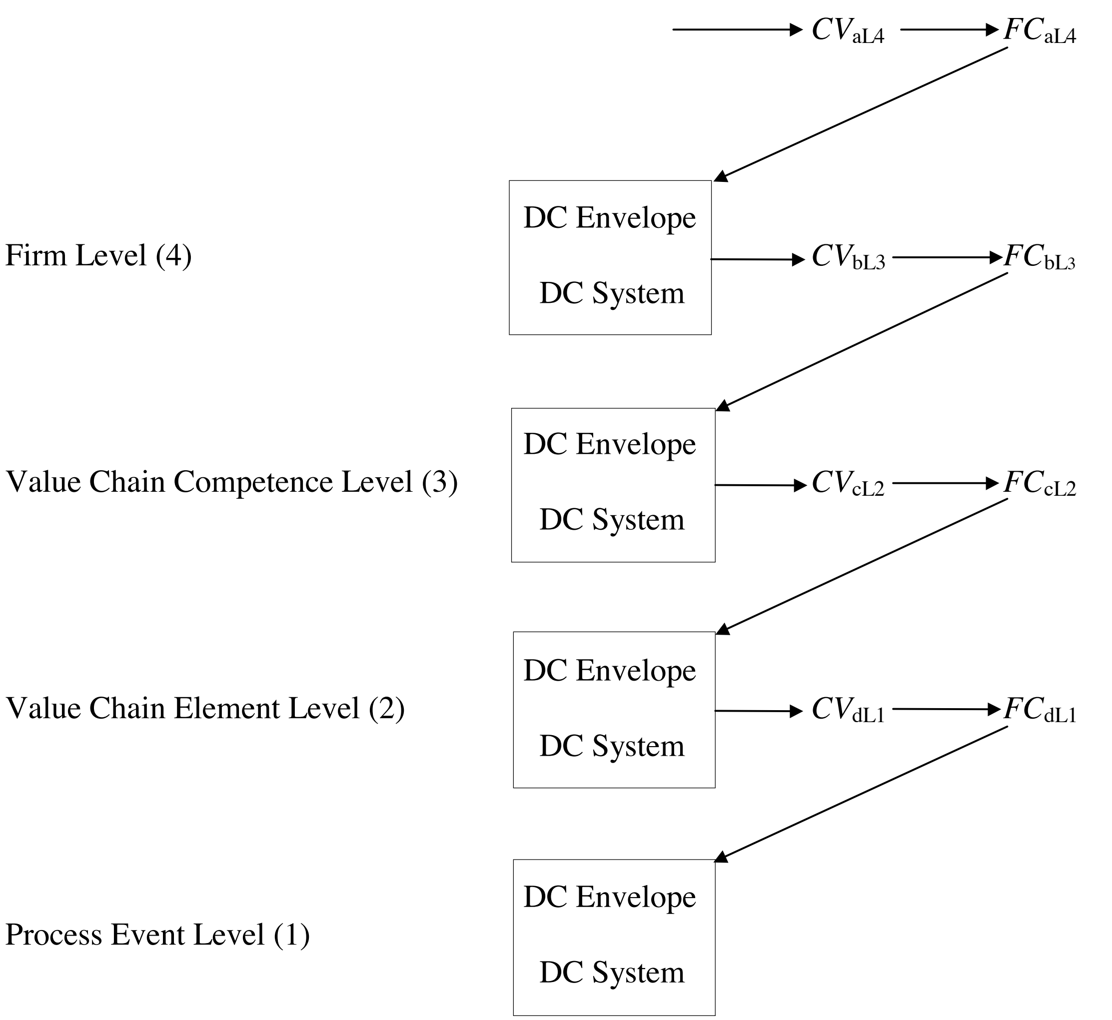


Figure 8a

List of Possible Support Value Chain Competencies

1. Personnel
2. Incentive system
3. Organizational learning
4. State-of-the-art expertise/specialization
5. Integration
6. Governance
7. Culture
8. *FC* nesting
9. Change and adaptation
10. Idiosyncratic resource protection

Figure 8b

List of Possible Incentive System Chain Elements*

1. Employment security
2. Selectivity in recruiting
3. High wages
4. Incentive pay
5. Employee ownership
6. Information sharing
7. Participation and empowerment
8. Self managed teams
9. Training and skill development
10. Cross-utilization and training
11. Symbolic egalitarianism
12. Wage compression
13. Promotion from within

*From Pfeffer (1995)