

COEVOLUTION AS A RESEARCH FRAMEWORK FOR ORGANIZATIONS AND THE NATURAL ENVIRONMENT

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Coevolution is an established research framework in the biological and evolutionary sciences, and though a new entrant to organization studies, it holds potential to transform the field (Lewin et al., 2003). Its fundamental premise is that entities or organizations evolve in relation to their environments while at the same time these environments evolve in relation to them. This paper argues that a coevolutionary approach is particularly well suited for research on organizations and the natural environment (O&NE), and that O&NE scholars may make significant contributions to organization theory from this perspective. However, this potential depends upon developing and maintaining a clear distinction between coevolution as a verb, or broad logic (a.k.a. macro coevolution), and coevolution as a noun, or specific mechanism (a.k.a. micro coevolution). In building these arguments the paper develops a definition and research framework for coevolutionary research and discusses theoretical and practical implications for O&NE.

Keywords: *coevolution; environmentalism; organizations and the natural environment (O&NE); complexity; ecological organization theory*

Coevolution refers to the simultaneous evolution of entities and their environments, whether these entities be organisms or organizations (Baum & Singh, 1994). The term was first coined by Ehrlich and Raven (1964) in their groundbreaking paper tracing the mutual genetic evolution of butterflies and associated plant species. It encompasses the twin notions of interdependency and mutual adaptation, with the idea that species or organizations evolve in relation to their environments, while at the same time these environments evolve in relation to them. The concept has grown significantly in the biological sciences and has also spread across a number of disciplines, including genetics, linguistics, computer modeling, and psychoanalysis, among others. Sophisticated research approaches have been developed, drawing from complexity science, emergence, computational organization theory, and population ecology (Lewin & Volberda, 2003). In organization studies, it is still a new entrant, but work applying the coevolution construct has been garnering increasing attention in recent years.

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A coevolutionary research approach can advance the field of organization theory significantly (Lewin & Volberda, 2003), but this article argues that it is especially well suited for research on organizations and the natural environment (O&NE). In developing this argument, the article draws from scholarship in the biological sciences and builds a research framework for organizational and O&NE scholarship. Theoretically, the concept is situated at the nexus of open systems theory, evolutionary organization theories, complexity theory, and the current eco-social-historical moment. Coevolution is formally defined and a distinction is made between coevolution as a verb, or broad logic, and coevolution as a noun, or specific mechanism. Numerous applications and exemplars are discussed from both organizational and O&NE literatures. The key point is made that O&NE may be the “natural home” for the emerging genre of coevolution research, and O&NE researchers may make lasting contributions to organization studies as a whole from this perspective. The article proceeds in three sections: the conceptual origin and definition of coevolution, a coevolutionary framework for organizational research, and applications and development in O&NE.

CONCEPTUAL ORIGINS AND DEFINITION

This section of the article addresses the origin and definition of coevolution in the biological sciences, including debates surrounding its development and its adaptation in organization theory.

Early Work in the Biological Sciences

The term *coevolution* first made its appearance in Ehrlich and Raven’s (1964) paper describing reciprocal evolutionary relationships in population biology. “Butterflies and Plants: A Study in Coevolution” reported on extensive studies in which the researchers traced patterns of association among particular combinations of butterflies and food plants. They found that species-specific biochemical plant substances attracted or repelled specific, often singular, butterfly species, thus demonstrating that interspecific combinations of organisms “evolved in part in response to one another” (p. 604). Ehrlich and Raven argued that too little attention had been previously focused on reciprocal interspecific evolution in their field and concluded that evolution in tandem was nature’s primary mechanism for generating the vast organic diversity on earth. The latter point has been debated (Futuyama & Slatkin, 1983), but certainly not in doubt was this “news of difference” that instigated a powerful new research stream.

Interest in coevolution grew exponentially, and in the 1980s, it was identified as a major research framework in the biological sciences (Futuyama & Slatkin, 1983). The concept spread quickly and was applied to human and organizational systems as well. For example, van den Bergh and Stagl (2003) credit Norgaard (1984, 1994) as the first to explicitly apply coevolution to socioeconomic contexts. A biologist by training, Norgaard studied the mutual influence processes among pests, pesticides, the institutional regulation of pesticide use, and the cultural valuing of the use of pesticides as a coevolving system, arguing that the five subsystems of knowledge, values, organization, technology, and natural environment are all permanently affected by the selection conditions provided by the others, as they themselves evolve. Feldman and Laland (1996) suggest that the classic nature-nurture debate is naïve in light of recently available models and methods, and that

Table 1: Relative Growth Trajectories of Coevolution-Related Papers in Biological and Management Journals, 1960-2000

| | <i>Biological Sciences^a</i> | <i>Management Sciences^b</i> |
|------------------------|----------------------------------------|----------------------------------------|
| 1960s | 5 | 0 |
| 1970s | 48 | 0 |
| 1980s | 155 | 2 |
| 1990s | 340 | 34 |
| 2000-2006 ^c | 304 | 52 |

a. *Evolution* journal

b. Collection of management journals in continual publication at least since 1960 (*Academy of Management Journal*, *Administrative Science Quarterly*, *American Economic Review*, *Business History Review*, *International Economic Review*, *Journal of Business*, *Journal of Marketing*, *Management Science*).

c. Based on projections of data available in JSTOR and ABI INFORM.

human genetic and cultural evolution are better understood as nature-nurture coevolution. Similarly, van den Bergh and Stagl (2003) argue that to be complete, institutional theories of change must incorporate the social evolution of individual and group behavior. The concept has also been applied to human development, for example, in early work on personal computing that led to the idea of “bootstrapping.” Here, it was hoped that “computers would be able to perform as powerful prostheses, coevolving with their users to enable new modes of creative thought, communication, and collaboration” (Bardini, 2000, p. 143). In academe, a recent study demonstrated a “reciprocity effect” between higher student grades in the latter part of a semester and corresponding increases in student evaluations of their instructor (Clayson, Frost, & Sheffet, 2006) that remained robust even after student performance, demographics, and major, and instructor gender and general leniency were controlled for. This “reciprocity” could be interpreted as a coevolutionary effect, with the positive connotations that students rewarded in kind their professor’s extra attention in the second half of the class, or from the cynical viewpoint that good evaluations can be “bought” by grade inflation.

Table 1 provides evidence of the growth trajectories of the coevolution concept in the literatures of biology and business administration. It was produced by searching JSTOR, an online archival database of journal articles, for articles containing the word *coevolution* from 1960 to the present. The first column shows that interest in the concept in evolutionary biology was hardly more than a trickle in the 1960s and 1970s but became a flood in the 1980s and since. The second column shows no articles in the management journals searched during the 1960s and 1970s but a similar type of expansion pattern in the 1980s, 1990s, and continuing today. Thus, there may be a parallel coevolution revolution in organization studies at this time, with a 20-year lag time behind the concomitant phenomenon in biology. In short, the notion that organizations change in relation to their environments while at the same time environments change in relation to organizations is entering the organizational literature but is, at this time, an emergent, relatively unknown phenomenon.

Defining Coevolution

To define coevolution in a meaningful way for organization studies and O&NE research, the formal definition from biology is first discussed and then

subsequently applied to organizations. Coevolution is synonymous with “mutualistic evolution” (Van Valen, 1983, p. 2), the adaptive response of one species to genetic change in another species, which itself becomes genetic. Its key feature is that the selective factor that “stimulates evolution in one species is itself responsive to that evolution” (Futuyama & Slatkin, 1983, p. 6). Thus, coevolution is reciprocal genetic change in unlike, interacting species (Thompson, 1994). Its fundamental criteria are specificity, that the evolution of one entity is due to the other; reciprocity, that both entities coevolve; and simultaneity, that both entities coevolve concurrently (Futuyama & Slatkin, 1983).

These three fundamental criteria distinguish coevolution from several other interspecific bioevolutionary mechanisms. For example, an interaction denotes a change in one but not both of the interacting species (Van Valen, 1983), coadaptation is a behavioral change that is not genetically fixed (Slatkin, 1983), mimicry involves convergence of the mimic with the model while the model remains unchanged (Futuyama & Slatkin, 1983), symbiosis is the close living association of two species that may or may not be beneficial, and parasitism and predation involve one species from which a second species draws sustenance or takes prey. It is important to note that many of these bioadaptive relationships may develop in a coevolutionary manner—predator-prey interactions, for instance (Freeland & Boulton, 1992)—but coevolution refers specifically to the longitudinal process of genetic fixation and replication, and not to the predator-prey interaction itself. Thus, any of these adaptive mechanisms may be seen in cross-sectional observation, but coevolution requires longitudinal analysis of some kind in order to document its mutual genetic replication. Coevolution is the only one of these mechanisms that involves permanent, genetic change in both species.

Although it is generally agreed that the specific criteria of specificity, reciprocity, and simultaneity constitute the restrictive definition of biological coevolution, consensus is lacking as to whether all three conditions must necessarily be met (Nitecki, 1983). For instance, relaxing the conditions of specificity and simultaneity results in what some have termed diffuse coevolution, the broad adaptation of groups of species to changing features of the biotic environment. An example of diffuse coevolution is the evolution of immune systems in all vertebrates as a defense against numerous hostile agents (Levin, 1983). Many authors prefer the more restrictive definition, however, noting that coevolution defined too broadly simply becomes evolution.

In addition to the three conditions discussed above, three additional, implicit aspects of biological coevolution are important to mention in regards to its transfer to organizational research. First, coevolution is a boundary-crossing phenomenon, meaning that it involves interspecific changes. This suggests that coevolution in organizations involves multileveled and boundary-crossing interrelationships. Second, it arises organically—quite literally so in biology—suggesting that organizational coevolutionary phenomena are adaptive and responsive rather than part of a deliberate (Mintzberg & Waters, 1985) or induced (Burgelman, 1991) strategy. Finally, as discussed above, coevolution involves genetic fixation and replication in both species, suggesting that there must be some mechanism that ensures permanent change when the concept is applied to organizations. Together, these six characteristics delimit the scope of organizational coevolution and distinguish it from other types of evolutionary and organizational change.

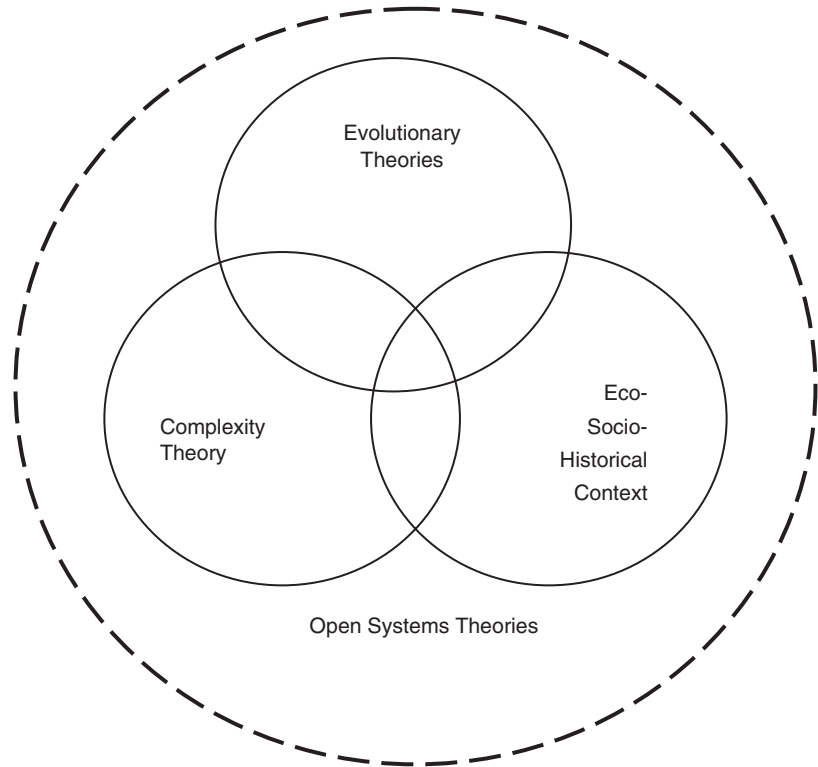


FIGURE 1: Theoretical Location of Coevolution in Organization Studies

The next section of the article delves into coevolution research in organization studies. A conceptual framework is developed and several exemplars are discussed. The final section of the article builds on this framework to develop a number of implications for O&NE research.

COEVOLUTION IN ORGANIZATION STUDIES

Despite its emergent status, the concept of coevolution has garnered great enthusiasm in organization studies to date. Some scholars have argued that it will lead to fundamental changes in our understanding of organizations (White, Marin, Brazeal, & Friedman, 1997) and significant advances for the field (Lewin & Volberda, 2003, p. 586). To evaluate these claims and whether coevolution is just a fad or more lasting “news of difference,” this section of the article considers several theoretical perspectives and exemplars of organizational coevolution. A framework is developed that situates coevolution at the conceptual nexus of open systems theory, evolutionary organization theories, complexity theory, and in relation to a particular eco-social-historical context. Figure 1 depicts this theoretical location as the central overlapping region of the three circles representing these conceptual areas, as described below.

Systems Theory

Reed (1996) has usefully identified a progression in systems perspectives in organization theory. The earliest approach was the view that organizations are autonomous, fully rational systems. Operating independent of their environments, they rationally impose structures to divide and distribute resources in the most efficient possible ways. This view was concurrent with the solidification of industrial capitalism in the United States and included Weber (1946), Taylor (1914), and Fayol (1949) among its leading theorists. In this genre, Newtonian scientific principles and hierarchical control could presumably resolve all problems of distributional and social equity.

A second view of systems emerged in the increasingly uncertain times that led up to World War II and contemporaneously with general systems theory in biology and physics (Bertalanffy, 1950, 1968). Reed (1996) refers to this as an understanding of organizations as "intermediate social systems" (p. 37), a holistic understanding of systems as constituted by interdependent relationships among interacting activities or parts. Research focused on the nature of relationships within and between systems, and although rationalism and top management control remained dominant assumptions, there was greater concern with social welfare than there had been under scientific management. For instance, Parson's (1951) structural/systems school and the human relations perspective (Mayo, 1945; Roethlisberger & Dickson, 1939) both postulated that individual satisfaction *and* technical efficiency could be maximized by smoothly integrating individuals into organizations. Contingency theory (see Donaldson, 1996, for a review) and structural functionalism (Thompson, 1967) later grew from this tradition and still dominate much of mainstream management today.

These different views of systems did not supplant one another in linear fashion but as waves of overlapping theories or prescriptive ideologies. A third movement was identified by Scott (1992) as open systems theory in a progression he viewed as developing from rational to natural to open systems. The progression indicates a movement toward more organic and socially responsive views of systems and a growing openness in conceptions of the interactions across organizational boundaries. A fundamental premise in this approach is that organizations fundamentally depend on their environments for the materials, information, and energy they need to function, and that a mutually beneficial flow proceeds in both directions.

Where does coevolution fit in this broad schema of systems theories? Lewin and Volberda (2003) refer to the context of coevolution as the "organization-environment system," a concept that extends systems theory from closed to open to superorganizational, and the level of analysis shifts from intraorganizational to extraorganizational to supraorganizational. With each successive wave of systems theory, therefore, the point of observation recedes, the size of the system that can be analyzed increases, and the possibilities for observing and interrelating phenomena or factors at multiple levels of analysis multiplies. From biology, we know that coevolution requires large, complex ecosystems and extended evolutionary time scales, that the complexity of interspecific interactions is exponential, and that stochastic events predominate under such conditions (Levin, 1983). By analogy, then, organizational coevolution is situated in an open systems framework that permits analysis of multilevel perspectives and spontaneous variation in interacting entities over extended time periods (Starik & Rands, 1995).

More will be said about coevolution research methods later in the article; at this juncture, it is sufficient to recognize that open systems theory is both the backdrop and the springboard of conceptual frameworks for coevolution.

An empirical example is found in Van de Ven and Garud's (1994) study of coevolution in the medical field. In tracking the development of the relationship between a technological innovation—a cochlear ear implant device—and the industry that grew up around it, these researchers demonstrated that neither discrete technical variation nor the process of its institutionalization led to the ultimate technical-institutional configuration that emerged. Instead, “the very technical advancements and institutional rules initially created to facilitate industry emergence subsequently became inertial forces that hindered later technical developments” (p. 443). Entities at three levels interacted over time to produce the eventual arrangement; the engineers' innovations, the organizations in which development and production took place, and the extraorganizational environment consisting of manufacturers, distributors, and customers. Without an open systems approach and an extraorganizational perspective, the analysis of this case would not have been possible.

Ecological Organization Theory

Evolutionary organization theories are next considered in regards to coevolution, and given its bioevolutionary origin, one might expect coevolution to be highly compatible with this perspective. For example, enhanced fitness of the coevolving species to survive in their community is the purpose of coevolution in biology (Van Valen, 1983), whereas organizational coevolution increases the organizations' fitness to cope with their environment (Clippinger, 1999). The parameters of organizational coevolution also resemble those of its biological counterpart: For Baum & Singh (1994) these are feedback, interdependence, and mutual or circular causality, whereas Lewin & Volberda (2003) cite multilevel embeddedness, multidirectional causality, nonlinearity, positive feedback, and path and history dependence as fundamental. Coevolution spans all levels of analysis and has been applied in the evolution of industries (Malerba, 2006), new organizations (Inkpen & Currall, 2004), new organizational forms (Lewin, Long, & Carroll, 1999), and new forms of adaptation (Lewin & Volberda, 2003). For example, Inkpen and Currall argued that trust, control, and learning become coevolutionary phenomena in joint ventures and alliances. Building on Koza and Lewin's (1998) argument that trust is a dynamic concept that should not be treated as a “static causal variable” in an evolving alliance, they develop a number of propositions about levels of trust and concomitant control systems as parent organizations develop their relationship, that is, learn. Three factors make the learning relationship coevolutionary rather than evolutionary: The tangible nature of the change, that is, its replication in the new organization's structure; its nonlinear, path-dependent, and unpredictable course; and the fact that coevolved trust and control in turn affect the future of the alliance and the partners themselves. Various scenarios are possible and cannot be predicted in advance.

In the fields of evolution and organizational change, coevolution has been advanced as a potential resolution to the long-standing selection-adaptation debates. Lewin and Volberda (2003) point out that population ecology studies privilege uncontrollable environmental forces and the external selection of unfit organizations, whereas strategic studies assume that managers are capable of

influencing internal fitness and survival. This disjuncture in levels of analysis is largely what makes the adaptation-selection debates intractable. In contrast, coevolution focuses on the interactions between organizations and their environments and the consequences of these interactions for the dynamics of the organization-environment systems:

The study of coevolution fundamentally is a feedback approach to the study of organization-environment relations . . . it forces a different view than is usually adopted. Coevolution assumes that changes may occur in all interacting populations or organizations, permitting change to be driven by both direct interactions and feedback from the rest of the system. (Baum & Singh, 1994, p. 380)

The key point is that organizations are defined by both idiosyncratic intent *and* systematic regularities, both of which materially affect organizational outcomes (McKelvey, 1997).

Three important points emerge from this discussion of coevolution as a conceptual bridge across the adaptation-selection divide. First, the inclusion of managerial intent and system regularities in one model means that disparate theoretical perspectives may be combined or juxtaposed in one treatment. Theories that take a selectionist perspective include population ecology (Aldrich, 1979; Hannan & Freeman, 1977), institutional theory (DiMaggio & Powell, 1983), and evolutionary economics (Nelson & Winter, 1982), whereas the adaptationist approach is favored in dynamic capability theory (Teece, Pisano, & Shuen, 1997), interpretive views of strategy (Daft & Weick, 1988; Dutton, Ashford, O'Neill, & Lawrence, 2001), learning theories (Levitt & March, 1988), and strategic choice theory (Child, 1972). Even as coevolution research has combined these theoretical traditions, however, it also leaves each one intact (Lewin & Volberda, 2003, p. 570), because coevolutionary logic incorporates different lines of research under new assumptions and models rather than extending any one theory into a different arena.

Second, organizational coevolution differs from biological coevolution in that it has been adapted to incorporate human meaning-making processes. Malerba (2006) notes that coevolution may involve interactions in knowledge, learning, demand, actor characteristics and behavior, strategy, and tactics. Despite the compatibility between biological and organizational evolution theories, therefore, organizational coevolution must necessarily differ from its biological counterpart because biological models have no clear analogue for human reasoning and communication capabilities. Specifically, since human learning processes occur more rapidly than genetic change in biological contexts, the appearance of anomalous organization-related "hybrids," such as new organizational forms (e.g., Lewin et al., 1999), is more frequent and more varied than new speciation in biology.

Third, traditional distinctions between micro- and macrolevels tend to blur and lose meaning in coevolution research. Because coevolutionary systems are characterized by interdependence, circular causality, and iterative feedback, and changes in any one variable may be caused endogenously by changes in others (Baum & Singh, 1994, p. 399), the microlevel activities of situated actors are frequently analyzed in terms of macrolevel community effects, and vice versa.

A study of the PC industry demonstrates the bridging of selective and adaptive forces in organizational coevolution. Henderson and Stern (2004) analyzed the interactions between firms and their internal development projects from 1975

to 1994, asking whether internal and external selection processes might be mutually influential over time. They operationalized the internal adaptationist perspective as the variation, selection, and retention process (Aldrich, 1979) of bottom-up, emergent change (Mintzberg, 1978) in which frontline managers act as internal entrepreneurs by proposing strategic initiatives that are championed upwards by middle managers. The external selection approach was represented by the classic population ecology view that the firm is largely a monolithic entity constrained by its founding imprint, unable to adapt beyond a limited repertoire of strategic responses (Hannan & Freeman, 1977). Empirical analysis of 736 firms and 6,727 products found that internal and external selection did in fact coevolve, in this case, through managers' learning processes. Further, this learning became embedded in the firms' routinized capabilities for developing future products. They refer to a "coevolutionary loop" that bridged internal and external selection, where competitive pressures induce technological innovation, followed by internal selection and a revised cycle of new innovation. In Henderson and Stern's (2004) view, "synthesizing theories of internal and external selection is vital" (p. 69) because internal and external selection approaches alone fail to account for large parts of the complex multilevel interrelationships that take place in joint ventures.

The added value of a coevolutionary approach is not limited to issues of selection and adaptation, however. For example, the "paradox of embedded agency" (Seo & Creed, 2002) has been coined in reference to the question of how embedded, fully socialized actors are empowered to envision and promote substantive change from within an institutionalized system. Two responses to this conundrum are institutional entrepreneurship (Dacin, Goldstein, & Scott, 2002) and strategizing from the middle (Floyd & Wooldridge, 2000). Both are grounded in intra-organizational ecology (Burgelman, 1991; Lovas & Ghoshal, 2000), a framework that views strategy as only partially dictated from the top, the remainder emerging organically from within an organization. For instance, Greenwood and Suddaby (2006) demonstrated that institutional entrepreneurship was in play in the coevolution of new organizational forms in the big five accounting firms, and Floyd and Wooldridge (1997) showed that middle managers' strategic influence activities do indeed impact organizational performance in a study of 259 managers in 25 firms in various industries. Thus, embedded entrepreneurs and/or networks involving midlevel managers may be seen as a coevolutionary mechanism of sorts: By interpreting perceived events, adding meaning, and developing and championing new projects, some of which become ratified as revised strategic initiatives, they become the mechanism of "genetic fixing" in the coevolution of organizations and their environments.

A second application of a coevolutionary research framework is emerging in response to calls for firm interfirm collaboration in complex, densely populated "business ecosystems" (Moore, 1993). For example, Pasquero's (1991) study of interorganizational collaboration to improve environmental protection in Canada showed that supraorganizational collaboration is a viable approach to large-scale environmental problems. Moreover, the success of such projects depends on microlevel innovations such as multiparty roundtables to improve mutual commitment to shared problem solving.

The foregoing discussion has argued that coevolution is a powerful research framework in an expanded conceptualization of evolutionary theories of organization. More than a mere remake of evolution in a new suit of clothes, coevolution

brings a powerful new logic and distinctive analytical tools to the longitudinal, multileveled study of organizations. It breathes new life into ecological organization theories by supplanting “evolutionary positivism” with a shift toward process-based thinking and an expanded awareness of the mutual influence of actors and institutions (Hatch & Yanow, 2003). In this light, McKelvey’s (1997) enthusiasm for the emerging coevolution revolution becomes clear: “Organizational evolutionists and ecologists may have spent the last two decades studying the tip of the iceberg, leaving the more telling story of firm coevolution underdeveloped” (p. 359).

To this point, the article has developed the theoretical underpinnings of coevolution in systems and evolutionary lines of research. Before completing the analysis by turning to complexity theory and coevolution, an equally important issue is addressed, that regarding the timing of its emergence in current eco-social-historical contexts.

Social-Historical-Ecological Context

Coevolutionary logic is not new to organization science. Lewin and Volberda (2003) note, for example, that Weber (1946) argued that bureaucratic organizations emerged in a coevolutionary relationship with the ushering in of the industrial age, just as Chandler (1962) tied the M-form of organizing with the development of more rapid transportation and communication in industrialized societies (p. 579). An important question follows upon the observation that organization scholars have recognized coevolutionary processes since the beginnings of the field. Why now?

This question may be approached from two directions, an organization studies perspective and the perspective of community ecology. On one hand, organizational coevolution research may be arising now in association with rapidly increasing environmental and market dynamism. For example, Bardini (2000) made a strong case that the emergence of artificial intelligence and personal computing were coevolutionary developments with the increasingly complex economic landscape and acceleration of productivity after World War II. *Turbulence* (Emery & Trist, 1965) and *hypercompetition* (D’Aveni & Gunther, 1994) are other terms for this broadly recognized rise in systemic disruption in recent decades, and it is precisely within this context that Baum and Singh (1994) claim a coevolutionary framework is most valuable. Positivist reasoning, linear models, and dependent and independent variables are inadequate in complex and dynamic environments because cause and effect may not be so easily separated: Changes in any one variable may be caused endogenously by changes in others. By definition, coevolution is concerned with changes and feedback at differing levels of analysis as they affect and are affected by changes in focal variables (p. 381) and therefore is a more appropriate research framework in high-velocity environments.

The science of ecology lends another perspective to the “why now” question, that of population dynamics. Rates of change in a population are known to depend on its relative size in relation to its environment (Odum, 1963). Specifically, as a population approaches the environmental carrying capacity—the capability of the environment to support its existence—its rate of growth is affected, mathematically, in a negative direction. The external environment exerts pressures on the population in the form of various kinds of feedback, which in turn affects its growth. In other words, where there are no perceived limiting factors on

a population's growth, the quantity and relevance of external feedback are less important to individual members than they are when there is a high level of competition for environmental resources. Coevolution, which is a feedback approach to the study of organizations (Baum & Singh, 1994), may therefore be more relevant and prominent today precisely as an indication that the carrying capacities of external environments of all kinds—in markets and also in the natural environment (which, of course, is the market for “raw materials”)—are being approached.

An important site of interaction between this increased systemic turbulence and approaching limits of carrying capacity is in the stressed ecosystems of developing economies. Research and theory development are taking place in such settings that address O&NE calls to integrate economic and ecological priorities (Foster & Mellor, 1997; Gladwin, Kennelly, & Krause, 1995; Orsato & Clegg, 2005), but much of it has been done outside the O&NE literature. For example, Conrad and Salas (1993) studied the econo-environmental tension involving local residents in a critical environmental habitat and the fragile butterfly population that depends on this same environment for its survival. The upland oyamel fir forests of Mexico are the exclusive overwintering site and breeding grounds of the northeastern North American Monarch and are protected by a national park, but they are also a critical revenue source for the local population that has traditionally logged there. Uncontrolled logging degrades the forest and threatens its integrity for monarch survival and reproduction, but no logging at all invites illegal activity and threatens human livelihoods. Conrad and Salas (1993) argued that mechanistic models are inappropriate for problems such as these, and instead developed a mathematical model that could account for the option value of reversible actions. Specifically, they postulated a coevolutionary approach that defined coevolution as “a set of feasible economic activities that results in ‘acceptable’ trajectories of both net revenue and biodiversity” (p. 405), that is, a level of logging activity that would not degrade the stability of the forest canopy density. Using the most accurate values available for present value of logging and the concomitant effects on forest density at different levels of harvesting, they defined a “tradeoff frontier” on which they located a point of maximum allowable harvesting and minimally acceptable biodiversity for this particular situation.

Summarizing the organizational and evolutionary arguments above, systemic turbulence and a sharp upswing in contact, complexity, and feedback among multileveled organizational entities are conditions under which mutualistic adaptations of all kinds, including coevolution, increase in frequency. Coevolution research frameworks may be adopted in such contexts and adapted to include economic and environmental parameters in a predictive model of hypothetical courses of action. Two things are noted about this approach, the level of detail that is necessary for scenario modeling to be a worthwhile activity and the equal valuing and trading off of economic (maximizing revenue) and ecological (promoting biodiversity) priorities. One other point is important to make before moving on to complexity theory and coevolution. This is that the unique bioadaptive mechanism of coevolution has an added value that benefits the system as a whole, in that it exerts a stabilizing influence on environmental turbulence. Freeland and Boulton (1992) demonstrated, for instance, that coevolved food web combinations in tropical rain forests are a source of stability and longevity for the ecosystem as a whole and also exert a recalibrating influence toward system equilibrium. Thus, if coevolution is a force toward order and stability in complex ecological

systems, it may be accomplishing a similar type of function in organizational fields. Thus, another answer to the “why now” question is precisely in the structured, ongoing relationships that coevolution may bring in intensely competitive markets.

Complexity Theory and Coevolution

Developing in tandem with coevolution in biology was a broader change in all of scientific inquiry in the late 20th century. Beginning in the 1980s, the principles of complexity theory and complex adaptive systems have slowly migrated and revolutionized many fields of research, gradually supplanting Newtonian, deterministic epistemologies with the principles of self-organization (Kauffman, 1993; Longair, 1997). The central principles of self-organization are the interconnection of all things in ever-expanding layers of nested wholes (White et al., 1997) and the capacities of self-transcendence and spontaneous self-organization (Nishiguchi, 2001). Complex adaptive systems (CAS) is one name for the large, interconnected systems characterized by these principles, and complexity theory describes in more detail what is known about them to date. Examples of CAS are all large ecosystems, the human body, and the human brain (Nishiguchi, 2001). The principles of self-organizing systems originate in, but clearly transcend, open systems theory; thus, complexity theory is the final building block of Figure 1 that locates coevolution in theories of organization and management.

Numerous descriptive typologies of CAS exist, including Macready and Meyer's (1999) useful framework in which self-organization, recombination, and coevolution identify the characteristics of CAS. Self-organization refers to the way in which the system's elements seem to independently arrange themselves with no apparent design or management being enacted. In human systems, for instance, the worldwide web operates in this fashion. Recombination means that such complex systems are continually reorganizing themselves, “flourishing in a boundary between rigidity and randomness” (Pascale, 1999, p. 85), whether as a molecular-level system, a network of species, or a field of corporations. *Coevolution* is a more specified term that describes the operations of recombination at the site where it takes place. Specifically, the environment selects for fitness, but the environment also changes with each species' evolution. Thus, the species and the environment endlessly affect one another, and “this cycle of action and reaction is a continuous shaping and selecting in the search for stability and fitness” (Macready & Meyer, 1999, p. 189).

In organization studies, Nonaka and Nishiguchi (2001) have explored knowledge creation in organizations as a complex adaptive system involving three types of elements; the fixing of new knowledge itself, the organization's technological capacities, and the relational configurations among members and involved stakeholders. In their view, knowledge has unique properties as an asset: It can be possessed but not hoarded, it is a common good that belongs to all, it is an intangible asset, and it is diverse in content but similar in operation. They argued that knowledge creation could not be managed through top-down control systems and traditional types of incentive systems; rather, it thrives best in “caring” and “trustful” environments (p. 4).

A fourth characteristic of complex adaptive systems is the arising and later subsiding of vortexes of maximum creativity that have been termed the “edge of

chaos” (Langton, 1992) and the “sweet spot” (Clippinger, 1999, p. 9). Palombo (1999) writes that the edge of chaos marks the phase transition between order and chaos, where new entities appear in great profusion. “The edge of chaos is where the action is. Complicated structures poised between order and chaos are generated at the phase transition” (p. 102). In short, the edge of chaos is the site at which coevolution takes place and is a very potent concept in revised approaches to management. It has been heralded as “the new mindset” (Macready & Meyer, 1999) and “next big idea” (Pascale, 1999) in management, for example, by Pascale, who argues that a complexity approach will provide a uniting framework for the prolific and currently disparate theories of strategic management. Specifically, it will help organizations and managers “to dramatically improve the hit rate of strategic initiatives and attain the level of renewal necessary for successful execution” (p. 84). Strategic initiatives, in this view, are sites of knowledge fixation, the locus of the human and organizational analogue to genetic fixing in biological coevolution.

SUMMARY

The preceding discussions have argued that coevolution is an emerging research framework that is only beginning to make its presence felt in organization studies. The concept was first defined in its field of origin, evolutionary biology, and subsequently applied to organizational phenomena. A conceptual approach was developed that situates coevolution at the nexus of evolutionary theory, complexity theory, and open systems theory, as well as in current cultural-historical-economic contexts (see Figure 1). Scholarship relating to each of these areas was drawn from to develop an overarching coevolution research framework.

Table 2 presents the six key characteristics of coevolution as defined in evolutionary biology and applies them to an organizational research approach through the framework developed above. Coevolution is a phenomenon, rather than a theory, and has been distinguished in biological terms by its specificity, reciprocity, and simultaneity. Ehrlich and Raven (1964), for example, were the first to show that unlike species—butterflies and plants, in their research—had evolved over time in relation and response to one another. In organizational terms, these fundamental criteria mean that coevolution involves identifiable elements of a self-organizing system that change permanently through interacting and recombining at the “edge of chaos” (Langton, 1992). Genetic fixing refers to permanent speciation in biology, and in organizations it means that a mechanism of permanent change must be identified. For example, Henderson and Stern’s (2004) research showed new strategic capabilities to be the mechanism of permanency in the PC industry, whereas Lewin et al. (1999) explored new organizational forms in this light. The boundary-crossing aspect of coevolution refers to its cross-species aspect in biology, but in organizations it suggests a multilevel, multitheory, multimethod approach to research. Incongruous as this may sound, it makes sense in the context of complexity theory and its complete remake of Newtonian research assumptions. Traditional divisions of convenience separating silos of management departments, such as strategy and organizational behavior, simply fall apart when viewed through the lens of complex adaptive systems. Finally, the organic nature of biological coevolution translates into an adaptive and emergent approach to management: Rather than top-down planning and control, coevolution-focused management involves bottom-up, organic change in

Table 2: Defining Characteristics of Coevolution in Biology and Organizations

| <i>Characteristic</i> | <i>Biological Coevolution</i> | <i>Organizational Coevolution</i> |
|-----------------------|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| Specificity | Precise site and entities of interaction are clear. Distinguishes strict coevolution from diffuse coevolution. | Local, sector specific, and path dependent. The locus of coevolution is "the edge of chaos." |
| Reciprocity | Both entities are changed. Distinguishes coevolution from interaction and mimicry. | Multiple organizational elements are permanently changed, often at different levels of analysis. |
| Simultaneity | Both entities are affected at the same time. | Change is mutual, in relation or response to other elements in a complex adaptive system. |
| Genetic fixing | Change is permanent and replicated automatically. Distinguishes coevolution from coadaptation. | Structural or other permanent form of replication. The mechanism of fixation, or permanency, is identifiable. |
| Boundary crossing | Involves two unlike, interacting species. | Multilevel, multitheory, multimethod approach to research. Breaks down Newtonian research silos and cause-and-effect assumptions. |
| Organically derived | Emergent and responsive, the outcomes of self-organization are unknowable in advance. | Adaptive and emergent. Unplanned and unpredictable, derived at the edge of chaos. Distinguishes coevolution from intended or induced strategy. |

response to changing conditions in the marketplace. The final section of this article applies this coevolution research framework for O&NE research, education, and practice.

IMPLICATIONS OF COEVOLUTION FOR O&NE

Coevolution is an exciting and emerging framework for organizational research, and is only just beginning its rise in organization studies. This final section of the article extends this argument into the realm of O&NE and attempts to stress two important points. First, O&NE is an ideal setting for coevolutionary approaches; indeed, it could be argued that O&NE is its "natural home" in the organization sciences. Second, understandings of both O&NE-related topics and coevolution research itself may be deepened and clarified through their mutual development. Specifically, several unresolved issues have been raised in regards to organizational coevolution, including the scope of coevolutionary research, the meaning of "genetic fixing" in organizational contexts, and the breadth of its applicability, that may be profitably explored through the O&NE lens. The following discussion develops these issues and opportunities in several sections; models, methodologies, research applications, and implications for policy, practice, and education.

Incorporating Coevolution in O&NE Research Models

A first step in applying a coevolution research framework to O&NE is to incorporate coevolution into its conceptual models of organizations and management.

This is a natural step to make in the case of O&NE because coevolution is a biologically founded theory, and O&NE scholars have long argued that theories of organization must relinquish the artificial separation from the natural world that began with closed systems approaches and still lingers today. For instance, in his oft-cited paper, "Castrated Environment: Greening Organization Studies," Shrivastava (1994) argues that "at this point in history organizational research cannot pretend that the natural environment is peripheral to understanding organizations. Nor can OS ignore the effects of organizational decisions on nature" (p. 705). Shrivastava's logic is coevolutionary in that it alludes to a mutual influence between organizations and the natural environment that must be recognized and incorporated in all aspects of research. This would bring the systems view of organization theory to full circle in that it entails a progression from closed, to open, to complex, to complex *and* biospheric systems. Indeed, if management were to be reconceived as an intricate and sensitive dance in the complex adaptive system that comprises managers, all stakeholders, and the natural systems that support them, then the vision of Shrivastava and many others would have reached fruition. Unfortunately, however, that goal remains a long way off, as suggested for example by the fact that the ONE Interest Group of the Academy of Management has 537 members, or just 3.2% of the total membership roster. The group's size has grown every year since its beginnings in 1994, but its acceptance by the wider academy—and by inference the acknowledgement of its value to organization studies—is yet to be realized.

General arguments for building more inclusive models of organizational research are not new; indeed, they only make good common sense. Therefore, the question remains, what can a coevolution research framework add to this discussion? What does coevolution add beyond either a sophisticated evolutionary approach and/or a complexity theoretical perspective? There is a good answer to this question, and it lies with a return to the previous section where the broader framework for understanding coevolution in organization studies was developed. There, coevolution was described as both a general logic and as a specific adaptive mechanism, and the unresolved issue was also raised as to whether "diffuse coevolution," which relaxes the conditions of specificity and simultaneity, is really coevolution at all or whether defining it as such will render it meaningless, simply a remake of evolution proper. The original question may be reframed, in other words, as whether or not coevolutionary logic, in the broad sense, is the same thing as coevolution as described and delineated in the past 20 years. The literature is inconclusive in this regard, and therefore a clarification from the O&NE quarter can make a valuable contribution to all of organization theory.

Debates as to the scope of coevolution permeated the biological literature in the 1980s, which was 20 years or so after the concept was introduced. A 1980 essay in the premier journal *Evolution*, for example, points out that "the obvious commonplace nature" of coevolutionary types of adaptations in evolutionary history has led to "misleading" and overstated uses of the term. Janzen's (1980) call for "more careful attention" to the use of the concept, specifically that it be removed from synonymy of usage with other adaptive mechanisms such as symbiosis, interaction, and parasitism (p. 611), is a point well taken. True to the 20-year time lag between biological and organizational introduction of coevolution, similar bifurcation is emerging now in organization studies. McKelvey's (1997) framework, for example, consists of micro- and macrolevels of coevolution, which conveniently extends traditional distinctions between intrafirm and interfirm

topics. Yet, how much value do separations of micro from macro actually have in a complex world where everything evolves with everything else? This point is made by Malerba (2006), whose powerful argument goes to the heart of the issue:

The challenge for research here is to go to a much finer analysis at both empirical and theoretical levels, and to move from the statement that everything is coevolving with everything else to the identification of what is coevolving with what, how intense this process is, and whether indeed there is a bi-direction of causality. (p. 18)

In short, the challenge for organizational researchers is to more fully clarify the meaning of the strict definition of coevolution in organizational terms.

One approach to this challenge has two different aspects. The first is to separate coevolutionary logic from coevolutionary mechanisms, or coevolution as a verb from coevolution as a noun, or macro- from microcoevolution. The second is to retain both as different and differentially valuable. Coevolutionary logic, or “macro” coevolution, involves a reconceptualization of broad thought processes and theoretical models but is different from coevolution proper. Coevolution proper, a.k.a. “micro” coevolution, must satisfy the six criteria presented in Table 2. There must be an identifiable motive, mechanism, and means of replication before a particular phenomenon is termed coevolution. Stead and Stead (2004) have provided an excellent model for coevolutionary logic in O&NE theory in their revision of strategic management as *sustainable* strategic management. They refer specifically to coevolutionary logic as a “basic assumption that the firm has a symbiotic, coevolving relationship with the greater society and ecosystem” (p. 73).

Figure 2 builds on Stead and Stead’s (2004) framework, and also on Figure 1, to situate coevolutionary logic and coevolutionary mechanisms in a model of organizational analysis. The outer boundary of Figure 1 was organizational analysis itself, but in Figure 2 that boundary is eclipsed by a second circle representing the biosphere, thereby signifying that organizations are in fact enclosed within and dependent on the natural environment for their existence and survival. Figure 2 also shows one location for research developing the concept of coevolutionary logic, figuratively crossing the conceptual boundary between organizational and natural worlds. A separate location is shown for research that delineates coevolutionary mechanisms, one that draws from evolutionary and complexity theory and from current issues and contexts and is figuratively situated in the micro niche at the center of the figure. Figure 2 suggests that coevolutionary logic is the necessary but not sufficient context for discussions of coevolutionary mechanisms. In other words, without the general premise that organizational life exists within and depends on the natural environment, it is nonsensical to consider specific ways in which a bidirectional influence takes place between the two. By the same token, extending coevolutionary logics into new domains will expand the possibilities for delineating explicit coevolutionary mechanisms. Logic and mechanisms are intimately connected, but this article stresses that coevolutionary logic alone will add nothing to current organizational or O&NE theory and practice. The different aspects of O&NE coevolutionary research will be discussed in detail below, but one example of this second research arena is Fussler’s (1996) textbook advocating “eco-innovation” as a breakthrough approach to discrete technical innovation that combines both science *and* sustainability.

In summing up this section of the article, coevolution *is* in fact a cutting edge research approach that is ideally situated in O&NE literature, but realizing its

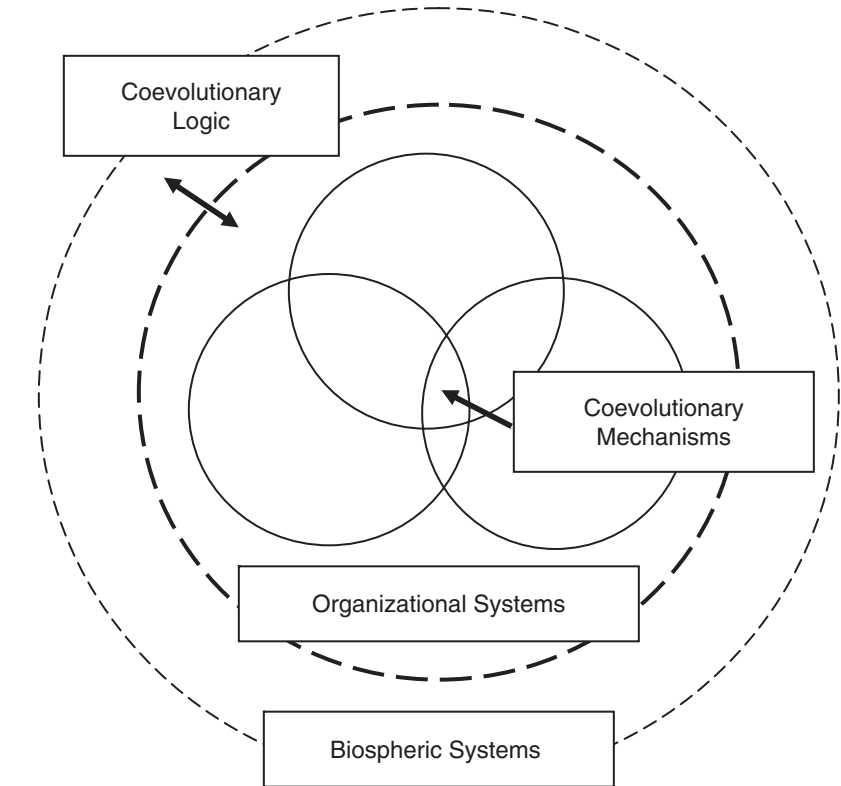


FIGURE 2: Organizational and Biospheric Coevolutionary Modeling

potential depends on maintaining a clear distinction between coevolutionary logic and coevolutionary mechanisms, and reserving the concept of “coevolution” proper to specific coevolutionary mechanisms. If this boundary can be maintained, an approach that is currently in its infancy can become a lightning rod to a more inclusive understanding of organization theory as a whole.

Research Methodologies

Methodologies for organizational coevolutionary research are complex and multifaceted, and unfortunately not as well developed as its conceptual aspects (Lewin & Volberda, 2003), which is to say that they are hinted at and hypothesized but hardly exist in practice. This is again an opportunity for O&NE scholars, one that may be addressed in two ways. The first draws from McKelvey’s (1997) helpful vision for a “quasi-natural organization science” focused on the intersection of intentionally and naturally occurring phenomena (p. 353). In O&NE terms, this suggests a highly specified focus on the quintessential coevolutionary moment where environmental priorities are translated into organizational praxis. That is, coevolutionary O&NE research must somehow capture the idiosyncratic motivation for “going green,” the tangible mechanism by which this is accomplished, and the means of its replication or permanency in the organization’s practice. Many

times, but not always, this may necessitate combining quantitative and qualitative analysis. For example, King and Lenox (2002) showed that profit-maximizing managers (motive) could reduce the cost of waste disposal in chemical plants (mechanism) more by upstream process improvement methods (means of replication) than by end-of-pipe solutions, and Ramus and Steger (2000) showed that supervisory support behaviors (mechanism) in environmentally oriented firms (motive) were associated with greater instance of employee eco-initiatives, which in turn lead to a greater flow of potentially viable strategic initiatives (means of replication). These examples are quite different, but together they suggest that coevolutionary logic is already well established in O&NE research. Coevolution in O&NE may develop further by continuing to develop cross-disciplinary, multi-method approaches to relevant problems and topics.

The second means of capitalizing on the opportunity presented by coevolution research in O&NE involves drawing from scholarship in other fields in order to bootstrap O&NE methodologies to state-of-the-art levels. In effect, this amounts to enlarging the arsenal of O&NE methods to include those of other domains of organizational studies and the evolutionary sciences. For example, biological coevolution methods include mathematical modeling, laboratory replications, fossil analysis, and tracking patterns of morphology, behavior, and geographical distribution (Futuyama & Slatkin, 1983), and come from the fields of botany, zoology, paleontology, anthropology, genetics, and epidemiology (Nitecki, 1983; Thompson, 1982). This extreme breadth of approach is translated for organizational researchers as the use of longitudinal time frames; path dependence; multidirectional causality; simultaneous, lagged, and nested effects; and inclusion of historical and contextual information (Elfring & Volberda, 2001), as well as the use of extensive archival data sets to combine analytical time-dependent models with contextual qualitative insights (Lewin & Koza, 2001). The literatures of community ecology, resource economics, sustainable development, and evolutionary biology, to name just a few, are also rich sources of methodological exemplars and research topics, for example, Conrad and Salas' (1993) modeling of equitable harvest levels in a stressed ecosystem, discussed earlier.

In sum, the exciting potential for O&NE scholarship to make a significant contribution to organization studies (and beyond) lies precisely in the opportunity to go beyond the logical coevolutionary premise that everything evolves in relation to everything else (Malerba, 2006) and drill deep down into the edge of chaos, the sweet spot of maximum generativity, where organizational actors make the critical turn and re-envision their purpose as sustainability first and profitability second. Specifically, how does this happen? Why does this happen? When it does happen, how is it actualized, measured, and replicated? What keeps it from happening more? The answers lie in melding idiosyncratic processes of meaning-making and interpersonal communication with quantitative outcome and performance measurement. The applications of this basic premise are unlimited. A great deal of excellent O&NE work has already achieved valuable insight into the technical problems and solutions of win-win strategic environmental management (Rothenberg, 2005), but at this juncture, the challenge is to investigate how "softer" aspects of management, such as values, identity, and bottom up networking, coevolve with such technical solutions. This project has already begun, for example, in O&NE-focused institutional (Marshall, Cordano, & Silverman, 2005), political (Henderson & Stern, 2004; Jermier, Forbes, Benn, & Orsato, 2006), attitudinal (Bansal, 2003), and process (Winn & Angell, 2000)

approaches to environmentalism. Framing these streams in coevolutionary terms can unite them under a common banner, reduce any loner or maverick connotations, and provide them with a great deal of source material. In this way, their win-win potential gets a methodological and ideological boost.

Applications of Coevolution in O&NE Research

O&NE literature includes a diverse body of research and empirical settings, some well developed and others just emerging. Numerous additional possibilities await exploration. This final section of the article reviews some of these applications and potential applications in the light of the coevolutionary framework developed earlier. The discussion is organized around three themes; broad research domains, applications of coevolutionary logic, and managing organizational coevolution.

Perhaps the most well-developed vein of O&NE research has to do with improving environmental performance in the manufacturing industries of developed economies. The bias toward outcome and performance studies is related to the exigencies of getting published, of course, as well as to the heavy weighting on industrialized settings in both North American and European management journals, and to the fact that industrial economies are by far the greatest source of environmental degradation. Nonetheless, there is a hidden myopia in this focus and tremendous opportunity in other directions. In developing economies, for example, there are great and growing pressures on remaining large tracts of undeveloped land from local populations who are typically poor, rural, and whose lifestyle involves harvesting natural resources within these tracts. Indeed, a recent issue of the journal of the Nature Conservancy, an international conservation organization, frontlines the “poverty/conservation equation,” where it is noted that growing global concern over poverty has increased pressure on conservationists to find win-win solutions for preserving lands rich in biodiversity without ignoring the plight of poor neighbors (Lloyd, 2006, p. 24). These are organizational issues, and a coevolutionary research perspective could explore ways in which coevolutionary logic could be applied to develop concrete coevolutionary mechanisms for maximizing both environmental preservation and local economic integrity. A related area of inquiry has to do with developing sustainable agricultural practices (Norgaard, 1984) in both developed and developing economies. Once again, this research area has been developed in nonorganizational literatures, but it involves organizational issues that merit O&NE attention.

Much of the preceding discussion has privileged coevolutionary mechanisms as the proper locus of coevolution research, but additional attention to novel explorations of coevolutionary logic can broaden the entire discussion. For example, a literature on educating for sustainability is growing quickly in the academy, some of it advocating the cultivation of an environmental sensibility in students who may be overaccustomed to and unaware of their exclusive business perspective (Bradbury, 2003). This stream implicitly raises the intriguing question of whether there is a metaphysical aspect or “process of mindful interaction” behind the efforts of O&NE researchers and conservation allies. Specifically, is it possible that human environmental preservationism is a recalibration mechanism inherent in the Gaia hypothesis, the idea that “the biota, the sum of all living organisms, interacts actively with its environment so as to maintain the environment at values of its own ‘choosing’” (Lovelock, 1973/2000, p. 6)? With

natural ecosystems so extensively disrupted today, perhaps we are unconsciously moved to act as Gaia's agents in attempting to restore some measure of balance. More down to earth, another potential locus for research involving coevolutionary logic lies in further development of environmental management that explicitly awards stakeholder status to the natural environment (Starik, 1995). For example, many cities have made serious commitments to making the environment a priority stakeholder ("Mayors of the World," 2005b) to achieve, for instance, the goal of zero waste emissions by 2040 ("Green Star Cities," 2005a). In sum, the thrust of this approach is an initial expansion of coevolutionary logic into new domains, and the subsequent exploration of specific coevolutionary mechanisms that stem from such an expansion.

A final arena of O&NE coevolution research involves practices of managing for sustainability that involve both coevolutionary logic and mechanisms. Berry and Rondinelli's (1998) manifesto, for instance, articulates the argument for proactive, decentralized approaches to improving environmental (and organizational) performance. Many scholars have taken up this topic and developed literatures of proactive environmental strategy (Aragon-Correa & Sharma, 2003), dynamic capability development in complex systems (Elfring & Volberda, 2001), and middle managers as strategic agents (Floyd & Wooldridge, 2000). Each of these areas involves coevolutionary mechanisms that iterate environmental intentions in explicit organizational contexts, and all can benefit from serious consideration of coevolution as framing lens and empirical strategy. Herein lies potentially the most exciting contribution that O&NE coevolution research can make to the organizational literature, that of developing new answers to the core research question of how and why human beings organize.

Implications for Practice, Policy, and Education

In addition to the research arena, coevolution has several interesting implications for practice, policy, and education. A few possibilities are offered below, and practitioners and educators are invited to expand them into other arenas. First, one of the critical criteria defining coevolution is the presence of "genetic fixing" (in biological terms), or an identifiable mechanism indicating permanency in the bidirectional influence of natural environment and organizational activity (see Table 2). In terms of practice, this raises the question of what constitutes the difference between organizational coadaptation, which is not permanent, and actual coevolution, or permanent change in the organization's strategy, identity, or policy. Greenwashing (Laufer, 2003)—the professed allegiance to green philosophies without an underlying intention of following through—and green marketing without concomitant commitment to ongoing sustainability research and development are a case in point. Both are examples of adaptation without permanency, whereas true coevolution involves a permanent change in the organization's orientation. Identifying and subsequently reinforcing the mechanism(s) by which permanency takes place involves reflection and action in practice, education, and policy making.

A second, related arena of practice lies in applying the definitional criterion of coevolution as a boundary-crossing, multilevel, and multimethod phenomenon to practice. For example, it was argued earlier that values and identity may be relevant coevolutionary mechanisms in the case of organizations and the natural environment. That is, changes in intrapersonal identity and identification can

affect routinized organizational practices. This suggests that attending to members' value systems and identifications may be one way of improving the likelihood that an organization will productively coevolve with the natural environment. Providing environmentally educational forums is one possible way to raise members' awareness and the possibility that they will contribute green ideas that could develop into new initiatives. Similarly, because research has shown that environmentalism in members' family and friends increases the likelihood of their making proenvironmental decisions (Flannery & May, 2000), involving the social networks of members and managers may in turn enhance the influence of environmental priorities in the organization's development.

A third area for practicing managers and educators relates to the sixth definitional criterion for coevolution, that it is unplanned and emergent rather than induced from above (see Table 2). Although top management intent and commitment are needed (Russo & Fouts, 1997), coevolution itself is more synonymous with the realization of that intention at lower levels of the organization. Therefore, enabling and empowering middle managers to make proenvironmental decisions, to encourage their subordinates to contribute environmental initiatives, and to network across functional boundaries around environmental concerns are just some of the ways in which managers may expand the interpenetration of environmental and organizational influence. Relatedly, educators may consider exposing students to concepts of ecorenal (Russo & Fouts, 1997) and strategic management from middle managers' perspectives (Floyd & Wooldridge, 2000) as a way of teaching to these possibilities.

A final concern has to do with interpreting the meaning of "bidirectional influence" as a definitional criterion for coevolution. This reciprocity criterion means that both entities, the organization and the environment, must be changed for a phenomenon to be considered true coevolution. There are two concerns here. The first relates to what is meant by permanent change for the environment; after all, isn't that what the environmental movement is trying to avoid, irredeemable degradation of the natural environment? The answer to this rhetorical question is a resounding affirmative, of course, but the apparent contradiction may be resolved by redefining "permanent change" as the restoration of environmental balance, removal of a degrading influence, or reestablishing the conditions for an endangered habitat to reconstitute itself. More to the point for educators is the second concern, that of how to facilitate the influencing of human consciousness by natural rhythms and principles. Here it would seem that developing creative ways for students to experience the natural world without the customary cognitive filters is one route, and providing time and support for ecological concepts to be included in traditional curricula is another (e.g., Bradbury, 2003). The field of environmental education is a trove of resources in this regard, as is the developing field of educating for sustainability (e.g., Kearins & Springett, 2003). As more practitioners and educators realize the importance of environmental sustainability, these resources and approaches will become more numerous and more integrated into mainstream management education.

CONCLUSION

This article has argued that coevolution and O&NE are a natural fit together, both conceptually and in practice. Both are making their appearance on the landscape

of management research and education at this time, and it is suggested that both will be incorporated into given theoretical canon in fairly short order. The article has attempted to distinguish between coevolutionary logic, the now-commonplace idea that our entire world is interconnected, and the more radical concept of coevolutionary mechanisms, which are the microsites of boundary-crossing creativity where "nature" becomes interpreted and enacted in human action. Both are important, but without greater attention to the mechanisms of coevolution, the concept is in danger of dilution to the point of losing its value. The underlying premise of the article is that if we are to survive as a species, on a planet that retains the capacity to survive our presence, there must be more attention given to enhancing the coevolution of human organizations with what remains of "nature." Many organizational researchers, educators, and practitioners are already deeply engaged in such endeavors, and more are joining them every day. This article has attempted to provide an overarching theoretical framework for this work, along with some applications and implications. These are just a beginning, however, and scholars, educators, and practitioners are invited to expand on them and apply them across all areas of research and practice.

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