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Chapter Four. Intraorganizational Evolution

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Intraorganizational evolution (iOE) is a relatively new, emergent area of research. Although evolutionary metaphors have often surfaced in organization theory, attempts to analyze the evolutionary dynamics unfolding within organizations have been quite sparse and systematic only in recent years. The basic concepts and tools of iOE are thus still in the process of being shaped. As a subject of analysis, iOE is the set of processes through which intraorganizational entities of different types (e.g. routines, jobs, formal rules) reproduce and modify themselves, and change their relative frequency in populations of individuals carrying them. As a theoretical perspective, it is the attempt to apply the lens of evolutionary thinking to the observation and understanding of these processes. As it often happens, the object and the theoretical perspective are interdependent, and contribute to defining each other.

Despite its relative recentness, agreement on a core set of assumptions has quickly emerged. It would be too strong to claim that most studies on iOE fully rely on all of those postulates, but it is fair to say that they all build upon at least some of these assumptions, and are broadly consistent with the others. All these core assumptions reflect well-established ideas in the broader arena of evolutionary theories; the first two define minimal conditions allowing one to speak of an evolutionary process, while the remaining two qualify the nature of organizational evolution.

- 1 The “Malthusian” assumption: there are intraorganizational populations subject to selective pressures.
- 2 The “Darwinian” assumption: there are self-replicating entities subject to variation; fitter variants diffuse at faster rates than less fit ones.
- 3 The “hierarchical evolution” assumption: intraorganizational evolution is inserted in a nested hierarchy of levels of evolutionary processes.
- 4 The “cultural evolution” assumption: processes of replication, diffusion and variation of replicators, as well as most selective pressures, are cultural in nature.

These four assumptions serve to circumscribe the area of inquiry and distinguish it from the looser metaphorical uses of evolution so common in the organization and management literature. And, they are sufficient to foster questions and address issues that are still to a large extent open in organization science.

The Malthusian Assumption: Intraorganizational Selection

The “Malthusian” assumption is fundamental in positing that selection, one of the basic components of evolutionary processes, is at work. It focuses on ecological processes of competitive (but also potentially mutualistic) interactions within organizations.

The core concept here is that of selection, but the main operational definitions are those of population and vital events. Populations are usually defined as collections of individuals (or entities) that depend on a same environmental set of (scarce) resources. In general, it is also required that populations have a rather homogeneous character. The definition of a unitary character of the population can be rooted in the organizational “genetics” of the population (the ‘Darwinian assumption’); however, most of the time purely conventional classifications prevail – an exception is McKelvey (1982). The existence of selective pressures is checked indirectly, mostly through the analysis of death and birth events within the population, as related to intra-specific variables (e.g. population density), inter-specific variables (e.g. abundance of predators) and other environmental factors (i.e. environmental change). Thus, a pragmatically useful definition of an intraorganizational population would have to include entities that have well-defined vital events (e.g. birth and death), consume (and potentially produce) resources from a common pool, and have unitary character.

There have been different attempts to define intraorganizational populations. In a sense, there is a problem of abundance. It is not difficult to single out populations of potential interest. An organization can be seen as an ecosystem that hosts an amazing variety of populations. Human populations are obvious candidates: patients accepted in psychiatric hospitals, students enrolled in universities, employees in bureaucratic organizations are all legitimate study populations: they compete for scarce organizational resources and have often clearly definable organizational life events (e.g. entry/exit). However, evolutionary research has mostly focused on other kinds of entities, usually characterized by a more proper organizational identity. Examples include populations of administrative rules (Zhou, 1993; Schulz, 1998), formal jobs (Miner, 1991), strategic initiatives (Burgelman, 1983; 1991), or development projects (Warglien, 1995). These entities define populations whose dynamics are affected by density, inter-specific competition, and other classical ecological effects.

In general, these studies provide examples of the viability of a selection perspective on intraorganizational populations. In particular, most support the existence of selective pressures, as revealed by density-dependence effects, although often mediated by the effects of different kind of heterogeneity.

The ecology of organizational rules

One of the most interesting and successful attempts to study intraorganizational populations is research on populations of organizational rules (Zhou, 1993; Schulz, 1998). The study of "rule ecologies" has many appealing features, and provides an excellent illustration of intraorganizational "Malthusianism". Individuals are well-defined entities that have formal identities and formally recorded vital events. For example, a rule is born when a new rule document is put in force; it is revised when provisions are formally added or deleted from existing rules; it is suspended when it is removed and no successor takes it place. Populations are defined as collections of rules that apply to different organizational areas of activity – for example, in a University, administrative rules and academic rules. Systems of organizational rules are inherently interesting in themselves as building blocks of bureaucracy; thus, ecological properties can be plotted against the background of classic theories of bureaucracy (Weber, 1978) or more recent theories of rule-based organizational learning (Levitt and March, 1988).

Although populations of organizational rules are very neatly defined, the notion of their resource niche is less intuitive and direct. Schulz (1998) suggests that rules are bred by problems, and that the finiteness of organizational problem spaces places a limit on bureaucratic rule growth. Schulz also suggests that additional limits to rules generation operate on the "supply side": the allocation of the attention of rule makers, their jurisdictional bounds, and so on; his analysis, however, is mostly concentrated on the "demand side".

Schulz's main prediction is that rules foundings exhibit negative density-dependence: that is, that crowding of the problem space increasingly limits the rate of birth of new rules. Studying nearly a century of rule production in an important private North American University, Schulz finds that the rate of rules productions does indeed decline with the number of rules in the system. A second important prediction is that populations of rules that face different problem environments will have different ecological dynamics. In the populations of university rules studied by Schulz and Zhou, it is possible to identify and study subpopulations defined according to thematic criteria that reflect different problem environments, e.g. personnel rules, accounting rules, organization charts, etc. Schulz finds that sub-populations located at the interface between the organization and its environment experience higher founding rates, consistent with the idea that these areas are more generous in their problem supply. Other areas with high birth rates are those with diffuse agency problems (e.g. personnel rules) and those that have a heterogeneous problem-environment.

Although the characterization of the carrying capacity of the environment in terms of problem supply contributes to an explanation for why founding rates should be affected by the density of the population (saturation of the problem space), this conception of the carrying capacity for rules is not equally helpful in explaining why rules should be suspended or revised. Indeed, even after a problem disappears, many of the rules germane to that problem can survive without consuming any resource, and the main pressure they face after being born is competition from more effective solutions (i.e., rules) to a same problem. As problems disappear, so does the pressure of competing solutions, however. Thus, one may expect that rules ecologies can be more successfully studied on the side of the birth process.

The Darwinian Assumption: From Ecology to Evolution Through Replicators

Organizational genetics involves the study of self-replicating entities, whose reproduction rate is affected by selective pressure and whose replicable content is open to change over time. Defining and analyzing such ‘genealogical’ entities and the processes affecting their reproduction moves us from the domain of ecology into the domain of evolution.

The search for organizational replicators invariably characterizes all efforts to apply evolutionary ideas to intraorganization al phenomena. Once more, candidates abound. The most commonly studied intraorganizational replicators are listed here:

- • Double interacts (Weick, 1969): behaviors of one person are contingent on the behaviors of another person – the minimal unit of collective action
- • Routines (Nelson and Winter, 1982): regular, predictable, automatic collective behaviors
- • Comps (McKelvey, 1982): productive and organizing competences
- • Rules and procedures (Levitt and March, 1988)

- • Strategies (Axelrod and Cohen, 2000): how agents in a population respond to their environment and pursue their goals

Taken together with selective dynamics, reproductive processes generate a basic cycle that Campbell (1965) referred to as the (blind) variation-selection-retention model. Of course, there are constraints in bringing together Malthusian and Darwinian processes. The most critical of these is that the units of ecological analysis be aligned with the characterization of self-reproducing genealogical entities comprising them. Individuals, populations and “genes” must be defined so that individuals in a population are carriers of genetic information, and the genetic information, in turn, provides a basis for defining the boundaries of the population. Although this may seem a rather elementary constraint, it is sufficiently stringent to make empirically interesting examples satisfying it difficult to find. As a result, ecological and evolutionary empirical studies are still quite disjoint (Baum and Singh, 1994).

To date, the “routines” at the center of Nelson and Winter's (1982) influential *Evolutionary Theory of Economic Change* represents one of the most successful attempts to capture “organizational genes,” and their work provides an excellent illustration of attempts to translate evolutionary concepts into the organizational domain; see also McKelvey (1982).

What is a routine? Nelson and Winter conceptualize routines as a general term for “all regular and predictable behavioral patterns of firms” (Nelson and Winter, 1982, p. 14). The emphasis falls on the automatic, repetitive features of behavior in order to emphasize differences between routines and rationally deliberated actions. Nelson and Winter stress the tacit nature of knowledge and skills embedded in routines, providing a cognitive alternative to the explicit, calculative (neo)classical homo economicus.

In Nelson and Winter's view, the behavior of most large and complex organizations can be well approximated by the bundle of routines that they have developed and acquired. Routines tend to be stable enough to provide a good analog to the role that genes play in modern evolutionary biology (i.e., a vehicle for information transmission). The basic formulation of their theory follows a standard evolutionary scheme, in which routines are treated as stable entities that reproduce themselves across time and space at rates dependent on their relative fitness, and change through processes of recombination and mutation.

Stability is assured by organizational activities of routine control. Routine replication, however, is a process that can take shape at different levels. Simplifying, there can be both intraorganizational reproduction of routines (like in replicating the routines of an old plant in a new one) and inter-organizational reproduction (as in the case of imitation of successful routines by competitors).

Mutation is assured by control lapses in the process of reproducing routines. However, variation is also assured by processes of Schumpeterian recombination of preexisting routines that are used as building blocks of new ones. Nelson and Winter claim that “reliable routines of well-understood scope provide the best components for new combinations” (Nelson and Winter, 1982, p. 131). In this way, past successful experience is preserved at the core of the innovation process.

Of course, Nelson and Winter are fully aware of the risks of a metaphorical abuse of the notion of organizational genes, and provide many cautions in their “user instructions” (1982, pp. 134–6). The suggestion that routines are the organizational DNA conveys the sense that routines are *the* organizational replicator, at the price of hiding the great diversity of structures undergoing reproduction in organizations and the fundamental diversity of their reproductive processes. To capture this diversity, Winter recently proposed to broaden the notion of routine by introducing a concept of “quasi-genetic traits”, defined as “any trait that remains approximately constant in the organization long enough for significant feedback to accumulate at a level where outcomes are tested by an environment” (Cohen et al., 1996). Such traits encompass routines in a narrow sense, as well as rules of thumbs, heuristics and strategies, and paradigms or cognitive frameworks. It is worth noting that this articulation is mainly *cognitive*, in that it relies on the different nature of the cognitive processes underlying each kind of trait.

Tacit knowledge and capabilities replication

Empirical studies of routines have privileged issues related to the nature of knowledge embedded in routines. Some of the most interesting results have been obtained in laboratory research. Cohen and Bacdayan (1994) have shown how pairs of subjects could learn in the lab interlocked task performance patterns that displayed important features of organizational routines. Experimental subjects had to learn under efficiency pressure a sequence of coordinated moves in a series of similar (but not identical) card games with asymmetric information. Cohen and Bacdayan's analysis of the effects of novelty (changes in game configuration) and memory decay on learned sequences of actions support the view that routines are stored in procedural memory – that part of memory which is closely related to the tacit component of human knowledge. Replicating and extending Cohen and Bacdayan's experiment, Egidi and Narduzzo (1997), obtained analogous results and also demonstrated how routines create path-dependence and generate behavioral lock-in in novel situations (subjects tended to replicate in new task environments behavioral repertoires learned in previous rounds of the experiment, without adapting to the features of the new task).

Important results have also been achieved in field studies as well. An interesting example is the analysis by Zander and Kogut (1993, 1995) of the transfer of knowledge within multinationals. In a study on the international transfer of 44 major innovations in Swedish industrial firms, Kogut and Zander have conduced a questionnaire research, targeted on project engineers knowledgeable of the history of such major innovations. In particular, they have looked at the transfer of the capability to manufacture products as a basic process of replication of organizational “genetic information”. They have tried to identify the nature of such capability and the implications of its nature for fundamental issues such as the timing of reproduction and organizational boundaries.

Zander and Kogut, drawing on Rogers (1980) and Winter (1987), have operationalized three dimensions underlying the tacitness of productive knowledge:

- • *Codifiability* capturing the extent to which knowledge is captured by documents and explicit records
- • *Teachability* related to the ease of teaching productive knowledge to workers
- • *Complexity* defined in terms of intensity of interactions between components of an activity

On the ground of such operationalization, Zander and Kogut (1995) have shown that tacitness affects the reproduction process of manufacturing knowledge. In particular, codifiability and teachability appear to speed significantly the transfer of innovation. Since codifiability and teachability are negatively correlated to tacitness, the study confirms that tacitness implies higher levels of knowledge “stickiness”.

More fundamentally, Zander and Kogut (1993) illustrate how tacitness affects organizational boundaries in the growth process. The more tacit the manufacturing knowledge, the more likely is its transfer to a wholly owned subsidiary of the innovating firm. In other words, tacit knowledge is associated to the internal growth of the firm. This provides support to Nelson and Winter's (1982) thesis that tacit knowledge tends to be at the core of the idiosyncratic capabilities that characterize an organization's competitive advantage. Zander and Kogut's studies provide a comparison of the relative effectiveness of evolutionary and transaction cost economics explanations for organizational boundaries. Although the two theories are not necessarily incompatible as far as issues of transfer of knowledge are involved, transaction costs theories clearly emphasize market failures as reasons for the internal transfer of knowledge, while evolutionary theories emphasize the nature of capability reproduction processes as the source of internalization of growth. Zander and Kogut (1993) claim that their data clearly support the second view: ownership advantages in replication processes, not market imperfections, explain organizational boundaries of the firm.

The Hierarchical Evolution Assumption: Nested Processes

Processes of organizational evolution unfold at different levels, nested into each other (Baum and Singh, 1994). The concept of a multiplicity of nested evolutionary processes is often referred to as “hierarchical evolution”.

Conceiving organizational selection as hierarchical comes quite naturally. Organizations are themselves comprised of nested entities over which selection exerts its pressure. For example, in a divisional organization, new product development projects are selected within divisions (Burgelman, 1983). Divisions can be disbanded or can lose their charters (Galunic and Eisenhardt, 1996). The organization itself also constitutes an entity subject to selection (Hannan and Freeman, 1989). Furthermore, higher levels of aggregation (e.g.

communities of organizations) can be considered as legitimate targets of selective processes (Barnett and Carroll, 1987).

Self-reproducing entities can also be thought as forming hierarchical structures. Nelson and Winter (1992) suggest the existence of different kinds of “metaroutines” operating on lower level ones. For example, higher level replication routines may govern the process of lower level routines reproduction and diffusion within an organization. Furthermore, entire bundles of routines may be reproduced when entire organizational units are replicated (e.g. in a manufacturing transplant).

However, this hierarchy of self-reproducing entities (Baum and Singh's, 1994 “genealogical hierarchy”) need not necessarily match the hierarchy of selection levels. It can be conjectured that most replicators are to be found at the level of organizational genetics, while they are much less clearly definable at higher levels of aggregation. The simple fact that a set of competences is shared by a population of organizations (McKelvey, 1982) doesn't necessarily imply that these competences are entities of different level from competences that are more specific to a single organization – they may just be more diffused. However, a conspicuous variety of levels can be detected looking at reproductive processes instead of reproducing entities. For example, routines can be replicated within organizations (e.g. through transfer to new plants) or between organizations of a same population (e.g. through imitation) or even between organizations of different populations (e.g. again through imitation).

A central challenge of hierarchical approaches to organizational evolution is to understand how processes at different levels relate to each other. One critical theme is whether lower level entities are selected in ways that favor higher-level entities survival and reproduction. Although coherence between internal selection mechanisms and external selective pressures is clearly a goal of organizations' management (Burgelman, 1991), its achievement shouldn't be taken for granted. As the result of factors as diverse as goal displacement, agency problems, or institutional constraints, selection processes at lower levels may be on average unrelated (and occasionally dysfunctional) to higher-level evolutionary success (Meyer, 1994). From this point of view, a hierarchical framework provides an appropriate context for the classical debate on organizational adaptation vs. inertia: both properties can be more properly understood as the organization-level effect of underlying intraorganizational processes.

Furthermore, the hierarchical framework can help to reframe the debate on the continuous vs. discontinuous nature of organizational change. Discontinuous, punctuated change (Tushman and Romanelli, 1985; Sastry, 1997) at higher levels may result from the accumulation of more gradualist processes of evolution at lower hierarchical levels. Warglien (1995) explores through computer simulation how hierarchical selection generates “punctuated” change.

Hierarchical evolution in a population of strategic initiatives

Robert Burgelman's (1983, 1991) research on strategy making, internal venturing and strategic initiatives provides rich field study insight into the nesting of evolutionary processes within large corporations. Drawing on interviews, the analysis of internal organizational sources and longitudinal observation, Burgelman has observed the unfolding of new internal venturing initiatives in a major industrial organization and Intel's evolution from a memory company to a microcomputer company.

Burgelman views organizations as ecologies of strategic initiatives, struggling for the organization's resources to grow. He analyzes how processes of variation, retention and selection occurring in such ecologies shape the higher level adaptive response of organizations and redefine its strategy over time. His framework stresses the interactions between two basic intraorganizational evolutionary processes: induced and autonomous.

The induced process maintains organizational coherence by leveraging the lessons of experience. It is driven not only by an organization's strategy but also by the internal selective mechanisms that direct the allocation of resources and determine the structure of incentives. Variation is directed and channeled by the strategic and structural context inside the organization. In a detailed study of Intel, Burgelman (1991) shows how the alignment of internal selection mechanisms with the selective pressures in the environment enhances the ability of induced processes to promote organizational growth and survival.

Autonomous processes simultaneously emphasize internal variation and the exploration of new routines and environmental niches. They are not guided by the existing strategy but develop outside the induced internal selective context, and emphasize variation processes and the discovery of new opportunities for future reorientation. And, in contrast to induced processes, which benefit from the coupling of internal and environmental selection criteria, autonomous processes benefit from organizational slack (Cyert and March, 1963), loose coupling (Weick, 1976), and failures of control (Nelson and Winter, 1982). Burgelman's (1991) analysis of Intel focuses on two levels of evolutionary dynamics – the intraorganizational one (operational-level strategic initiatives) and the organizational one (organization-level strategies). His earlier work (Burgelman, 1983) on internal corporate venturing, however, shows a greater stratification of selection processes, with new internal ventures “escalating” the hierarchical ladders of the intraorganizational ecology as they grow. An important feature of organizations emerging from Burgelman's earlier work is that selection mechanisms are often quite different as one moves from lower to higher levels of the intraorganizational ecology, putting the emphasis on different performance dimensions and legitimation processes. Internal selection processes matter especially in the earlier phases, while market pressures are more crucial in subsequent phases of strategic forcing and strategic building. As a result, mortality of new ventures is often located at the transition between such different selective environments (Burgelman, 1983).

The Cultural Evolution Assumption: Artifacts, Language, and Apprenticeship

Despite the widespread use of genetic metaphors, intraorganizational evolution is a process of change in the frequencies of traits that are reproduced and transmitted in non-genetic ways – through individual learning, imitation, apprenticeship, instruction and other cultural transmission processes. Thus, organizational evolution ultimately depends on the nature of such cultural processes of reproduction and transmission. As the literature on cultural evolution has clarified (Cavalli-Sforza and Feldman, 1981; Boyd and Richerson, 1985), processes of cultural transmission show significant analogies with the mechanisms of natural evolution but may differ on substantial aspects. For example, deep analogies can be found in the similarity of the pattern of diffusion of an innovation with the diffusion of a new fitter trait in a population (Cavalli-Sforza and Feldman, 1981). At the same time, while transmission of traits in nature happens only from one generation to the following (vertical transmission), and is constrained to happen between parents and their offspring, in cultural evolution – as compared to the biological one – diffusion of traits follows different, less constrained paths, that may result in a different pace and quality of the evolutionary process. Not only cultural traits can be transmitted to non-offspring, but also diffusion may be unconstrained by generational precedence (the older can learn from the younger, or there can be intra-generational diffusion).

The emphasis on the cultural nature of organizational evolution brings naturally into focus the role of artifacts, language and apprenticeship in the transmission process- three classical objects of cultural analysis.

Cultural evolution is intimately connected to the use of artifacts as a form of social memory. Tools and objects embed in their functionality and even in their shapes and affordances useable knowledge about the world. This is recognized in the literature on organizational evolution. For example, the role of artifacts as carriers of “genetic information” is a central theme in the concept of routines: Nelson and Winter often refer to plant layouts, equipment and other physical features of the working environment as storage devices for organizational routines. Analysis of learning curves – see for example Epple et al. (1991) – confirms that manufacturing artifacts embody significant cumulative experience acquired through learning-by-doing, although clearly not all of it.

Despite the great relevance accorded by authors such as March and Simon (1958) and Arrow (1974) to organizational codes as (often organization-specific) forms of knowledge storage, little or none exists on the evolutionary role of language in intraorganizational diffusion. Despite such lack of empirical research, it is clear that language plays a key role in assuring that individual knowledge can be shared and the results of experience can be transmitted and survive its original carriers. Consider the straightforward example of the diffusion of best practices. Best-practice diffusion is built on the assumption that experience generates successful routines to be reproduced and diffused. Diffusion of such successful routines invariably requires a large effort to set up a “technology of replication” process including

- (a) learning a language within which to encode successful routines
- (b) creating cognitive artifacts that can be diffused (work-flow charts or other replicable representations)

- (c) translating the high level description contained in the cognitive artifact into actual practice, generating a new routine adapted to the new context; see Hutchins and Hazelhurst (1991) for a similar conceptualization of the role of language and learning in the cultural evolution process).

All three steps clearly imply the use, creation and maintenance of language, which seems to be the most underinvestigated factor in intraorganizational diffusion.

Apprenticeship has received increasing attention as a result of ethnographic studies of organizational learning in the workplace (Orr, 1990) which reveal that cultural transmission of skills and productive knowledge in organizations occurs not through the learning of specific practices, but instead through becoming members of communities of practice (Lave and Wenger, 1991; Brown and Duguid, 1991). Howard Aldrich (1999) recently suggested an evolutionary interpretation of communities of practice as emergent entities, which are shaped by a multitude of variation and selective retention processes operating on information, cognitive schemata of members and social ties. These processes sharpen the boundaries of communities, defining their identity while at the same time creating new entities over which selection can exert its pressure.

Intraorganizational diffusion

Diffusion of innovations is a peculiar example of social transmission of a new cultural trait, and its analysis (Rogers, 1980) has been perhaps the single most important empirical contribution of economic disciplines to the early study of cultural evolution. However, while innovation diffusion at the inter-organizational level has been widely analyzed, research on intraorganizational diffusion is still almost lacking – notable exceptions are Attewell (1992), Leonard-Barton (1990), and Cool et al. (1997). Cool et al. (1997) suggest that the scarcity of studies reflects the assumption that intra and inter-organizational diffusion processes are similar. However, there appear to be many conditions under which intraorganizational diffusion may be distinct. One reason for this is that agents within an organization have very different degrees of freedom in adoption (Leonard-Barton and Deschamps, 1988; Attewell, 1992). They may be differently constrained by hierarchical roles, directives, and reward systems. Furthermore, adoption processes may be very different when they are "broadcasted" from the top of the hierarchy or when they result from the aggregation of local choices distributed across the organization. Organizations charts and other organizational policies may also shape networks of diffusion.

Cool et al.'s (1997) recent study of the diffusion of electronic switching in the Bell System from 1971 to 1982, shows interesting structural features of the intraorganizational diffusion process that match well the evolutionary framework sketched in this chapter. Adopting an "ecological perspective," Cool et al. define the organization as a collection of intraorganizational entities within each of which a single process of diffusion takes place. In the Bell System case, ecological units correspond to the different Bell Operating Companies. This perspective is especially useful when the process of adoption is gradual, i.e. does not result from a single choice but from the cumulation of a long sequence of choices over time. In this case, the ecological lens focuses on different rates of adoption across different organizational units and the existence of different “critical-mass” thresholds in the process of diffusion. This allows in turn singling out two regimes in the adoption process of each unit.

Cool et al.'s (1997) findings indicate that the rate of diffusion of electronic switching in the Bell system was influenced by different factors before and after a “critical mass” or threshold of installations occurred in each unit (following Rogers (1980), critical mass was fixed at the 25 percent level). The most striking result is that before the critical mass threshold is reached, factors driving the rate of diffusion are fundamentally related to the “internal” environment of the organization (“supply-side factors”, as Cool et al. label them): the cost of internal production of the switches, and the flow of resources generated by depreciation policies of the units. As the critical mass threshold is passed, the diffusion regime switches to a “demand-side” orientation, dominated by the “external” environmental variables (e.g., population density and population growth in service areas) or variable related to the interaction with the external environment (e.g., profitability of the organizational units). This result allows Cool et al. (1997) to emphasize the role of supply factors in diffusion processes, especially at the intraorganizational level.

The temporal shift from internal to external selection mechanisms has also been observed in other studies of intraorganizational processes, such as Burgelman's (1983) study of internal venturing, suggesting that such shifts may be typical of the evolution of a variety of internal processes. In general, such level shifts are related to the hierarchical nature of organizational evolution, and suggest the need for closer attention to the dynamics of diffusion in hierarchical systems as opposed to more homogeneous diffusion environments.

Summary of Empirical Results

Despite the rather homogeneous nature of their basic assumptions, evolutionary theories of intraorganizational dynamics have generated up to now a quite sparse supporting set of empirical evidence. Table 4.1 summarizes some of the key studies discussed above. The table reveals a great variety of objects of analysis and methods. This is a striking contrast with the highly structured body of evidence generated, for example, by the “population ecology of organizations” research program (see Baum and Amburgey, this volume). Variety of methods and objects is not necessarily a negative feature of a research program, particularly when divergent methods provide convergent findings, as is the case here. Nevertheless, the diversity can impede the cumulation of findings, make it more difficult to identify a core set of propositions, and develop a well-defined domain of inquiry. Exploration still dominates exploitation; if this is without doubts a sign of juvenile vitality, nevertheless it significantly exposes the field to the liabilities of newness.

Current Debates

Selectionism, adaptationism, and intraorganizational evolution as search and learning

The emergence of the "population ecology of organizations" research program (Hannan and Freeman, 1989; Baum and Amburgey, this volume) brought into focus a tension between selectionist and adaptationst views of organizations. The tension contrasts the driving action of selection over relatively inert organizations with the role of organization-level adaptation and learning. From the viewpoint of intraorganizational evolution, however, the conceptual distinction between selection and adaptation seems more a matter of hierarchical levels than of radically different processes. Adaptation and learning at the organizational level are seen mostly as the outcome of intraorganizational ecological and Darwinian dynamics.

Table 4.1 Synopsis of selected empirical studies on intraorganizational evolution

Reference	**Object of analysis**	**Key variables**	**Key predictions and findings**	**Research method**
Miner, 1991	Ecologies of formal jobs	Hazard rate for job death; job founding types, job characteristics	Department size, job-founding type, job novelty	Estimation of a hazard model on a formal jobs population in a major private university, over a six-year period
Schulz, 1998	Ecologies of organizational rules	Rule births	Negative density-dependence of birth rates; differential rates of growth in different sub-environments	Estimation of a model of the rule birth process in a population of organizational rules in a private university (1889–1987)
Cohen and Bacdayan, 1994	Cognitive nature of routines	Time per move, forgetting rate	Routines are stored in procedural memory.	Laboratory experimentation
Zander and Kogut, 1993, 1995	Transmission of manufacturing competences	Codifiability, teachability, complexity of competences; time of transfer and internal vs. external transfer	The timing and the organizational boundaries of transfer are affected by tacitness.	Estimation of hazard model on data from questionnaire
Burgelman, 1983, 1991	Hierarchical evolution in populations of	Process variables related to the development of	Two basic evolutionary processes:	Qualitative field research

Reference	Object of analysis	Key variables	Key predictions and findings	Research method
	strategic initiatives	strategic initiatives	induced and autonomous Higher level change is generated by lower level evolution.	
Epple et al., 1991	Intra-plant transfer of knowledge	Direct labor hours per product unit	Knowledge acquired through learning-by-doing is (partially) embodied in technology.	Estimation of learning curve models
Cool et al., 1997	Diffusion of technology in intraorganizational ecologies	Adoption rate, supply-side and demand-side variables	There are two phases in the adoption process, the first driven by internal selective environment, the other by external selective pressures.	Multiple regression analysis on data from multiple documentary sources

The intuition that a system can respond adaptively to its environment by mimicking inside itself the basic dynamics of evolutionary processes was already present in Darwin (1859); but it is mostly after the work of Holland (1975) that some basic features of evolution as a search and learning process have been clarified. Holland's central idea can be expressed in terms of problem solving. Checking a population of solutions against the problem-environment allows parallel search of the problem space; the virtues of parallel search fully blossom when processes of recombination of past solutions allow extraction from experience "schemata" or building blocks that can be assembled in new solutions. Selective pressures assure that (on average) fitter building blocks reproduce and diffuse at faster rates than less useful ones. Mutation assures that potentially useful missing information can be randomly constructed. As a result, "good" adaptive responses develop out of the Darwinian dynamics of populations of solutions.

Holland (1975) has suggested that these basic processes of "evolutionary search" are at the heart of the adaptive performance of complex systems. In two important papers, Cohen (1981, 1994) has shown how this intuition can work for modeling organizations and their adaptive responses to environments. Organizations are modeled as structures governing the interaction between multiple agents with bounded information processing resources, trying to evolve an organizational policy out of populations of building blocks for policies. An organization policy can be thought as a bundle of routines or standard procedures, and organizations essentially structure individual responsibilities, the interaction between policy makers, and define internal rewards and other governance mechanisms such as choice procedures. Computer simulations show how artificial organizations can respond to complex tasks by exploiting parallel search and recombination of policy building blocks. Cohen has also shown how different organizational structures can foster different adaptive responses, leading to the conclusion that organizational structures can be conceived as search heuristics. Furthermore, it has been possible to explore in this perspective the role of conflict in improving the performance of population search (Cohen, 1984).

While Cohen's still stands as the most systematic attempt to model organizational adaptation as parallel search, other models have delved further into the adaptive virtues of intraorganizational ecologies. Warglien (1995) has modeled the evolution of organizational competences in a population of R&D projects, using a mix of neural network machinery and Holland's ideas on evolving populations of solutions; the model reproduces phenomena such as “punctuated” adaptation, competence traps and the endogenous regulation of search efforts. Bruderer and Singh (1996), using Holland's genetic algorithm and treating organizational capacity to learn as a “gene,” show how environmental selective pressures shape a population of organizations with the right “ability to learn”. Although Bruderer and Singh do model evolutionary dynamics only within the population of organizations, and learning as an intraorganizational process is limited to random search, they succeed in showing how learning and evolution interact in a hierarchy of processes, and how interactions between such levels matter.

When conceptualizing intraorganizational evolution processes as search and learning, the key issue is how these processes perform two basic functions: exploitation and exploration (Holland, 1975). Exploitation refers to the ability to use the results of past experience to improve performance. Exploration refers to the search for new unexplored solutions. To stay evolvable, an organization needs to perform both functions. But exploration and exploitation involve important trade-offs in the use of resources and the allocation of risk: exploration is riskier than exploitation and absorbs in the short run resources whose return in the long run is highly uncertain. How do organizations deal with this trade-off? March (1991), in his computer model of the development and diffusion of organizational knowledge, offers a pessimistic answer, arguing that in the long run exploitation drives out exploration. His conclusions thus converge with the view that in the long run learning processes force organizations into inertia and competency traps (Levinthal, 1991). However, the picture may not be so bleak. Although there are trade-offs between exploration and exploitation – many efforts to engineer organizational evolution (March, 1994) turn out to be attempts to move the trade-off line itself, rather than reposition the organization along the line. Thus, organizations may search simultaneously for additional exploitation and exploration opportunities. The power of recombination, for example, stems from its exploitation of the wisdom of past success (the building blocks) while looking for new combinations – more exploitation and more exploration.

Unanswered Questions: Representation and Expression

Much debate on iOE often blurs the useful evolutionary distinction between representation and expression – genotype and phenotype, in the classical evolutionary vocabulary (Cohen et al., 1996). From this point of view, theories of organizational evolution tend to over-emphasize the behavioral – the concept of routine being a prominent example. In biology, there is a clear distinction between the structure that stores the genotypic information to be transmitted from individual to individual, and the phenotypic expression of such information. There seems to be no such distinction in the concept of routines. Yet, the behavioral definition of routine clearly suggests that what is reproduced is a pattern of action – a "phenotype". Yet even in nonbiological contexts it seems to make sense to keep a distinction between the ways in which "genetic" information is stored and the expression that is generated when such information is used to generate behavior. For example, there is often a neat difference between the formal definition of a job and its actual execution.

The representation/expression dualism is also helpful in defining how "genetic information" is stored and reproduced. Consider once more routines: how are they stored in organizational memories? It has been suggested (Cohen et al., 1996) that there may be different kinds of organizational supports maintaining the representation of patterns of actions. For example, production routines in a "lean" manufacturing process are "stored" in participants memories, in the physical layout of the plant, in the equipment affordances, in standard procedures constraining behavior, in other linguistic records and so on. All or part of these need to be reproduced when the routine is reproduced, say, in a new plant. The actual patterns of behavior clearly require these supports in order to be enacted, although they may differ from what is stored; for example, actual behavior may diverge form the standard procedure, but still use it as a generative resource for action (Narduzzo et al., 2000). Of course, a purely behavioral definition of routine would make these useful and important distinctions disappear.

Absent a distinction between representation and expression, the notion of replication is also problematic because it is not always clear what a "reproductive" event is. For example, when is a work routine "reproduced"? When it is just carried over time by a same work group, when the group is partially changed in its composition, or when it is used by a entirely different group of workers? This question is tied directly to the definition of the "carrying units" of the organizational genetic repertoire, and cannot been resolved until a choice is made in this respect (of course, the choice may depend on the specific context and on the goals of the analysis). Indeed, this choice coincides with the definition of what intraorganizational individuals and populations are. Here, evolutionary and ecological issues clearly intersect. However, as already remarked, a coherent joint definition of ecological units and genetic entities is still to a large extent missing in theories of iOE.

Future Directions

The topology of interaction

In organizations, variation, selection and retention do not happen in homogeneous, uniform interaction spaces. Each member of an intraorganizational population belongs to multiple relational structures that define its neighborhood relations, its relative position, etc. This structure affects each element of the evolutionary process. For example, diffusion happens in networks shaped by relational structures. Variation by recombination of capabilities is considerably facilitated by the contiguity of individual bearers of different competences, as in heterogeneous design teams. And intraorganizational selection is often a process dominated by local competition (for example between development projects in a same division). Despite the importance of the topology of interactions in determining the evolutionary fate of organizations, little work has been done to advance our understanding of how the structure of local interaction affects the global behavior of intraorganizational evolving populations. As a first step in this direction, Axelrod and Cohen (2000) have suggested to distinguish two classes of interaction determinants:'proximity,'which determines the likelihood of interaction, and 'activation factors,'which determine the sequencing of activity.

Proximity is not just physical contiguity, although the latter clearly matters in many interaction structures. Other spaces are as well relevant: for example, networks of friendship ties, the conceptual space of interaction designed by an organization chart, the neighborhood relations designed by personal positions in a community of practice. All these spaces shape the likelihood of interactions, and thus affect the flow of evolutionary events in a population. Activation patterns relate to time. It makes a difference whether processes activate interacting units in sequence (and in which sequence) or simultaneously. Much of the debate on concurrent engineering and "parallel teams" implicitly recognizes that the way competences are recombined in a design process crucially depends upon patterns of activation.

Of course, the topology of interaction is not something imposed onto intraorganizational populations (although it may to some extent be designed). To an extent, it is a self-organizing phenomenon that results from myriads of individual decisions. Axelrod and Cohen suggest several mechanisms acting on neighborhood relations in populations of agents including following another agent, copying, following signals, and tagging (developing properties detectable by other agents). Riolo (1997) has shown that allowing agents to develop tags in a population playing an iterated prisoner's dilemma facilitates the aggregation of cooperating agents, allowing the creation of subpopulations of neighboring reciprocating agents. Research on the emergence of intraorganizational networks can provide important inputs for this line of evolutionary research.

Finally, it should be remarked that as technologies of information and communication (ICT) develop and diffuse, physical constraints to the creation of conceptual spaces of interaction tend to wane; as a result, organizations are expected to considerably increase the intricacies of their patterns of interaction. From this point of view, evolutionary studies of intraorganizational dynamics will have much to gain from close interaction with research on the impact of ICT on organizational life.

Evolution as design

Since the very first pages of *The Origin of Species*, Charles Darwin (1859) directs our attention to human uses of variation and selection "under domestication". Whether he looks at domestic pigeons, horses or spaniels, he unceasingly recalls how humans have always used evolutionary processes as a design tool for improving the usefulness of domestic animals.

Recently, March (1994) has suggested that evolutionary thinking has moved from predicting history to engineering history. It is a constant theme of iOE research that a better understanding of evolutionary processes may lead to improve our ability to intervene on them, using evolution as a design tool.

One can think of "evolutionary design" as a non-obtrusive design strategy that leverages on emergent processes by tuning their parameters without trying to directly control their outcomes. Broadly speaking, "evolutionary design" has two complementary faces. On the one hand, it can try to manipulate the parameters of some basic processes, like recombination or retention. On the other hand, it can try to manipulate the fitness landscape to which intraorganizational populations adapt, e.g. designing incentive structures. Another way to frame this dual approach is to say that one can act on the population search heuristics or manipulate the problem space. Both approaches are of course complementary, and it is only a matter of conceptual convenience to separate them.

Tuning how intraorganizational populations search their problem environment is probably the most immediate way to leverage on evolutionary processes (Axelrod and Cohen, 2000). For example, organizations may alter patterns of competence recombination by manipulating the composition and mobility flows in design teams. Levels of variation can be further tuned by tightening or loosening organizational control over slack resources. Retention can be altered by personnel policies affecting employee turnover. As far as many organizational policies affect one or the other component of the evolutionary cycle, they can be thought of as potential tools for evolutionary design.

A complementary approach to evolutionary design (Levinthal and Warglien, 1999) is grounded on the observation that individuals, groups and other intraorganizational entities adapt through a variety of processes to the "fitness landscape" they confront, i.e. the payoff surfaces designed by their task environment and by task interdependencies. Drawing on Stuart Kauffman's (1993) theory of fitness landscape, Levinthal and Warglien show how the tuning of organizational interdependencies generates a continuum of fitness topographies, ranging from simple, single peaked landscapes (associated to low interdependencies) to rugged landscapes (generated by high interdependencies). Single peaked landscapes favor incremental learning and generate uniform outcomes, while rugged landscapes favor variety at the cost of coordination problems. Designing fitness landscapes allows one to engineer the context within which autonomous evolutionary dynamics take shape. Of course, this does not exclude designing the "search heuristics" governing intraorganizational evolution – quite at the opposite, different fitness surfaces may imply different strategies for searching the landscape.

Connections Across Levels of Organization

In organization theory, evolutionary arguments are often applied recursively at different levels of analysis. Thus, it is not surprising that many common threads can be found in the chapters of this *Companion* dedicated to intraorganizational, organizational and inter-organizational evolution. However, it is fair to say that most of these connections are rarely developed beyond the level of more or less deep analogies. Exploring in more systematic ways across-level connections may turn out to be a priority issue in the research agenda of evolutionary thinking in organization theory. One example is the topology of interaction. Co-location in geographic space has been shown to deeply affect inter-organizational evolution processes (Greve's chapter). At lower levels, different kinds of spatial proximity may play a prominent role; for example, both formal structure and social networks affect the frequency of interactions within organizations (Amburgey and Singh's chapter, this chapter), shaping evolutionary dynamics (e.g. diffusion patterns or aggregation processes). A better understanding of the nature of different neighborhood types is needed to go beyond simple analogies and compare interaction spatial structures at different levels; connections with network analysis may prove strategic under this respect; see Raider and Krackhardt (this volume).

Another example is the theme of path-dependence, also surfacing as the problem of inefficiency of evolutionary histories (Greve, this volume) or as the relevance of prior change histories (Amburgey and Singh, this volume). While there seems to be a diffused consensus on the proposition that evolutionary dynamics may lead to inefficient outcomes, little is known about the mechanisms explaining the emergence of inefficient solutions. Most researchers would agree that inefficiency can be explained by the presence of positive feedback in evolutionary processes, but the nature and the sources of such positive feedback are still poorly understood. In particular, little research has been conducted on how lock-in at one level may affect the dynamics of other levels: for example, lock-in phenomena at the intraorganizational level may increase inertia at the organizational level, and thus affect the balance between adaptation and selection as modes of change (Levinthal, 1991; Amburgey and Singh's chapter, this volume).

One particular theme, however, deserves privileged attention for its role in bridging levels of analysis. The concept of hierarchical evolution directly calls for a conceptual integration of different scales of interaction, and suggests that stable configurations of nested processes can emerge. Furthermore, this issue clearly connects evolutionary themes with complexity theory. Although the problem was neatly stated since Simon's classic “architecture of complexity” paper (Simon, 1962), much has still to be done in such direction. Even basic issues concerning the forms or configurations of hierarchically organized evolutionary processes, their stability over time, not to speak about their emergence, are still to a large extent virgin territories for organizational research – a notable exception is the work of Padgett (2000) on the genesis of banks in renaissance Florence. Moving from analogies to the analysis of actual connections between levels will require progress on the hierarchical structure of evolutionary processes.

Conclusion

As an emergent field of research, intraorganizational evolution is probably facing a two-sided development challenge. On the one hand, it needs to reinforce its identity, structuring its core concepts and methods and defining a shared research agenda. For instance, it is often remarked that empirical research has been biased towards the analysis of selection processes, while retention and variation have captured much less attention; see Greve (this volume) for similar considerations. However, the problem is far from being only one of empirical nature – rather, it is the expression of underlying theoretical gaps. The lack of empirical research on variation clearly reflects a lack of theoretical work, allowing one to define units of analysis and sources of variation; see Axelrod and Cohen (2000) for a first substantial step in that direction, and some examples in Amburgey and Singh (this volume). The conceptual core of intraorganizational evolution is still very partially developed, and attempts to complete it are likely to absorb much energy in years to come.

On the other hand, the impact of intraorganizational evolution research will crucially depend on its capability to establish fruitful interactions with other research perspectives. Social network analysis and complexity theory seem the most natural scientific allies, but new intellectual partnerships are worth exploring outside the traditional boundaries of organization research. One example is evolutionary game theory: interesting organizational phenomena have been shown to be tractable with its tools. For instance, the emergence of coordination can be quite accurately modeled as processes in which social learning approximates dynamics leading to evolutionary stable equilibria (Crawford, 1991). A fresh look at the evolutionary dynamics of other important phenomena, like norms and conventions, diffusion in networks, bargaining, and the evolution of contracts (Young, 1998) may result from an open dialogue between evolutionary thinking in game and organization theories.

While the need to simultaneously reinforce identity and strengthen interactions with other research streams may appear as a source of conflicting strains, it also provides an incentive for innovative work. The relative immaturity of this green research field is also its source of opportunities.

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Chapter Five. Intraorganizational Cognition and Interpretation

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Subject Business and Management » Organization and Management Theory

Key-Topics cognition

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