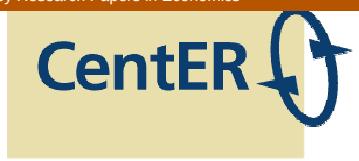

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ORGANIZATION, EVOLUTION, COGNITION AND DYNAMIC CAPABILITIES

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Organization, Evolution, Cognition and Dynamic Capabilities

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Abstract

Using insights from 'embodied cognition' and a resulting 'cognitive theory of the firm', I aim to contribute to the further development of evolutionary theory of organizations, in the specification of organizations as 'interactors' that carry organizational competencies as 'replicators', within industries as 'populations'. Especially, I analyze how, if at all, 'dynamic capabilities' can be fitted into evolutionary theory. I propose that the prime purpose of an organization is to serve as a cognitive 'focusing device'. Here, cognition has a wide meaning, including perception, interpretation, sense making, and value judgements. I analyse how this yields organizations as cohesive wholes, and differences within and between industries. I propose the following sources of variation: replication in communication, novel combinations of existing knowledge, and a path of discovery by which exploitation leads to exploration. These yield a proposal for dynamic capabilities. I discuss in what sense, and to what extent these sources of variation are 'blind', as postulated in evolutionary theory.

Introduction

Outside biology, a generalized evolutionary framework, with its basic principles of *variety generation, selection and replication*, has been applied to a wide range of socio-economic phenomena, such as organizations (Aldrich 1999, Baum and Singh 1994, McKelvey 1982), industries (Hannan and Freeman 1977, 1984, 1989), economies (Hodgson 1993, 2002b, Hodgson and Knudsen 2005, Metcalfe 1998, Nelson and Winter 1982, Veblen 1919, Witt 1993, 2004), knowledge (Campbell 1974), neural structures (Edelman 1987) and culture (Boyd and Richerson 1985, Hull 1988).

The evolutionary perspective has a number of attractions. It accounts for development of forms under limited foresight. In economics and management it keeps us from the error of an unrealistically rational, magical view of development as the achievement of somehow prescient, or even clairvoyant, managers, entrepreneurs and scientists, as well as from the opposite error of institutional or technological determinism (McKelvey 1982). It helps to deal with what in sociology is called the problem of agency and structure. It forces us to recognize both the role of actors, with their individual preferences and endowments, in the processes of variety generation and transmission, and the enabling and constraining conditions for action, in structures of markets and institutions, in the process of selection. While characteristics of entrepreneurs and organizations have a causal effect on survival and growth of firms, causality can also go to other way, with characteristics being the result of processes of selection and retention (Aldrich 1999: 336). It forces us to recognize causes of change both within organizations ('autogenic') and outside them ('allogenic') (McKelvey 1982). It makes allowance for the radical uncertainty of innovation (Shackle 1961), and for evident and ubiquitous error and failure in human endeavor. It forces us to accept diversity as an essential element of development. Competition in markets and the constraining and enabling effects of institutions are straightforwardly seen as yielding a process of differential survival and retention of products and practices of firms. There is plausibility in seeing entrepreneurship and invention as sources of variety generation, and personnel turnover, training, personnel transfer, imitation, consultancy and growth as the replication of proven success.

Anyone who has studied socio-economic evolution recognizes that in many respects it differs radically from biological evolution. While earlier literature was often based on analogies from biological evolution, in more recent literature (Hodgson 2002b, Hodgson and Knudsen 2004, 2005) a radical abstraction has been made, in the definition of 'universal Darwinism' (Dawkins 1983) in terms of only the overall, 'meta-theoretical framework' (Hodgson and Knudsen 2005: 16) of *variety generation, selection and replication*, regardless of the very different ways in which they operate in different areas of application. Hodgson and Knudsen claim that this overall framework applies universally to biological as well as economic, cultural, and cognitive systems. It is needed to explain why some organizations last longer or grow more than others, and why some are imitated more than others (Hodgson and Knudsen 2005: 6). While universal Darwinism gives a useful conceptual orientation of research, it leaves most of the explanatory work still has to be done, in a specification of the processes of variety generation, selection and replication, in terms of people, work, management, innovation, organizations, industries, markets and institutions. It is my aim to contribute to that.

I adopt two further notions from evolutionary theory. The first is the distinction between *replicators* and *interactors* (Campbell 1974, McKelvey 1982, Hull 1988) or *vehicles* (Dawkins 1982) and the second is the notion of *populations.* Interactors/vehicles (in biology: organisms) interact with their selection environment, and are members of *populations* of similar but differentiated interactors (in biology: species). To function as an interactor, an entity must have a reasonably cohesive and stable set of components. This is the *ecological* side of evolution (Baum and Singh 1994). Interactors carry replicators (in biology: genes) that generate, in interaction within the interactor as well as with its environment (in biology: gene expression in ontogenetic

development), characteristics of interactors that affect their survival and replication. Note that it is not the replicators themselves that determine survival but the characteristics that they produce. Replicators from surviving interactors are replicated and re-combined, mostly within populations of interactors that partake of a common pool of replicators. This is the *genealogical* side of evolution. Organizations, in particular, are seen as interactors, in their environments of markets and institutions, as members of industries seen as populations, and their competencies (McKelvey 1982) are seen as the corresponding replicators, with industries sharing a common pool of such competencies.

The contribution of this paper lies in the analysis of the three least researched aspects of the evolution of organizations (Baum and Singh 1994): the identity of interactors, the nature and characteristics of replication, and the process of variety generation. The structure of the paper is as follows. First I give a discussion of key issues in evolution in socio-economics, in order to specify the questions addressed in this paper. Second I give a sketch of the theory of cognition used in this paper, and the cognitive view of organizations to which it leads. This yields a view on the nature of their replicators, their identity as interactors, and on intra- and inter-population differences between them. Third I give an analysis of the sources of variation. The paper ends with a summary of conclusions.

In the literature on organizations, the present paper falls squarely in what Aldrich (1999) called the 'knowledge development' stream of organization theory. In this paper, use of insights from cognitive science is inspired by the fact that in socio-economics both replication and variety generation are fundamentally cognitive and linguistic processes.

1. Issues in Evolutionary Theory of Organizations

This paragraph discusses key issues in evolutionary theory of organizations, in order to specify the questions to be answered in this paper. The first issue concerns the nature of replicators relevant for organizations and the identity of organizations as interactors. The second issue concerns the influence that interactors may have on selection conditions. The third issue concerns replication of competencies by means of imitation and communication, and its relation with the generation of variety. The fourth issue concerns the extent to which, and in what sense, variety generation is 'blind' and how it may be guided by experience in selection.

Interactors, Replicators and Organizations

The literature on evolutionary theory of organizations allows for connected evolutionary processes on multiple levels: of skills, jobs; of workgroups or *communities of practice* (Brown and Duguid 1996), within organizations (Burgelman 1983); of organizations within industries; and of industries in wider socio-economic systems (Baum and Singh 1994). However, it is not always clear what, precisely, the interactors and replicators are, on different levels. Here I focus on organizations as interactors in industries as populations. The following questions arise.

For groups of people, such as organizations, to operate as interactors, there must be group selection. For that to work, individual interests must somehow be subjugated to collective interest. Organizational identity, cohesiveness and stability may be prevented by the dominance of centrifugal individual or group interests within the firm (Campbell 1994). So, what provides organizational cohesion and stability?

If organizations are interactors, what are the corresponding replicators? McKelvey (1982) proposed that organizations are characterized by 'dominant competencies'. Nelson and Winter (1982) used the term 'routines', but there is some ambiguity and confusion around that term, and I prefer McKelvey's terminology. What, precisely, are these organization-level competencies?

For industries to make sense as populations of organizations, there must be both differences and similarities between firms within an industry, and possibilities for replication that are greater within than between industries. Due to imitation and personnel mobility between organizations in

an industry, or even between industries, organizational identities may not be sufficiently differentiated and isolated for selection to work (Boyd and Richerson 1985). How do we account for intra- and inter-industry differentiation?

Finally, in this section, a question is to what extent interactors can affect or shape the replicators they carry, on the basis of experience with evolutionary selection. To the extent that they can, evolution is, at least in part, Lamarckian, with 'inheritance of acquired characteristics'. It is commonly agreed that in socio-economics this does widely apply. However, as argued, among others, by Hodgson and Knudsen (2005), if direct shaping of replicators by their carriers were complete and fast, so that replicators reflect any shift or variety of the selection environment, evolution would break down. Survival would no longer be an indicator of success, and many unproven, worthless or deleterious traits would be imitated along with favorable ones. In other words, as recognized by most authors, for evolution to work there must be some isolation of replicators from influence by interactors, or, in other words, some inertia of interactors. For organizations this entails that they cannot instantly and completely adjust all their competencies to perceived exigencies of the environment (Hannan and Freeman 1984). While this is plausible, analysis is needed to show why this is so, and to what extent organizations may still escape from inertia, and that also is a subject for this paper.

In sum, the questions in this section are: what constitutes the replicators of organizations, in the form of organization-level competencies, how do these yield a cohesive and stable organizational identity, how does this yields differences as well as similarities within industries, more opportunities for replication within than between industries, and some but limited shaping of competencies as a function of experience in environments of markets and institutions. I will investigate this on the basis of a 'cognitive theory of organization' (Nooteboom 1992, 2000) that is based, in turn, on a branch of cognitive science that is becoming to be known as 'embodied cognition' (Damasio 1995, 2003, Edelman 1987, 1992, Lakoff and Johnson 1999).

Efficiency of Selection

A second issue in evolutionary theory of organizations is that singly or collectively they can to a greater or lesser extent affect or mold the selection environment of markets and institutions to favor their survival and reproduction, in 'co-evolution' or 'niche-construction' (Aldrich, 1999). While this is not unique for selection in socio-economics, and also occurs to a considerable extent in biology, in economic systems the scope for it seems an order of magnitude larger, on the basis of some intelligent inference of causalities of selection, the ability, power and political influence to set standards of technology and legitimation, to shape market structure (e.g. distribution channels), to erect entry barriers, and to develop economies of experience.

A well-known example of the setting of selection conditions concerns the rivalry between competing technologies, and correspondingly different standards of acceptance, for hearing aids in the form of cochlear implants (Garud and Rappa 1996). Here, let me give another illustration. In the innovation of a cotton carpet (instead of wool), it was first introduced for bedrooms, in view of the moisture regulating properties of cotton and its nice feel to bare feet. However, cotton fiber does not have the natural resilience of wool, so that in use the pile of a cotton carpet rapidly flattens, but after vacuuming regains its fresh look. Now, resistance of carpets to such pile flattening was a key feature in certification of quality, thus favoring wool over cotton, and the new carpet could effectively enter the market only after the large innovator managed to have the certification procedure modified to accept vacuuming prior to inspection. Such actions to mold the selection environment are also amply illustrated by Aldrich (1999: 334).

However, while for these reasons selection may be limited or inefficient, not even the most visionary entrepreneur, nor the most powerful of corporations, can completely mold their environment to guarantee success, survival and dominance, and some selective pressure will remain. The limits are not only limits of power, but also cognitive limits. One may make mistakes in inferring what structure of selection favors differential survival and growth, for lack of insight

in causalities of selection and opportunities that any change might yield to unforeseeable new innovations that constitute a threat to incumbent organizations. Returning to the example of the cotton carpet, the most salient thing is perhaps that it took trouble to alter the selection conditions, even in only one though crucial respect, which might have failed, in which case the innovation would likely not have survived. While there is much more to be said about this issue, it is not a subject for the present paper, since although selection seems very imperfect it still seems sufficient to let this issue pass.

Replication

A third issue concerns processes of replication, and the relation between replication and variety generation. In socio-economic evolution, replication entails reproduction and imitation of knowledge and competencies, on different levels. This occurs on the basis of observation, communication and apprenticeship. Successful products and practices are copied or imitated on the basis of observation and inference, reverse engineering, publications and documents, oral presentations, courses, reports and explanations by consultants, and the like. Apprenticeship may merit special notice. Knowledge is externalized not only in speech, documents, software and ostensive activity, or role models, but is also embodied in tools, in a general sense including machines, procedures and forms of organization. In learning to use tools, an apprentice may reconstruct some of the mental schema's that lay behind the design and production of the tool.

In socio-economics, these forms of replication entail linguistic processes of expression, sense and reference, and cognitive processes of assimilation into mental *schemata* (Aldrich 1999, Piaget 1970, 1974) or *mental models* (Johnson-Laird 1983) that constitute *absorptive capacity* (Cohen and Levinthal 1990). Fundamentally different from replication of genes in biology, replication of knowledge and competencies is:

- At least partly voluntary and subject to choice: one adopts what is perceived to be successful
- Partial: one may, within restrictions of systemic coherence, adopt only part of a bundle of replicators associated with a given interactor
- Subject to decay, distortion, reduction, extension and transformation (going far beyond the copying errors, deletions and duplications of genes in biology). In other words, replication at the same time entails a degree of variety generation.

This issue will be analyzed with the use of insights from the embodied cognition branch of cognitive science.

Variation

A fourth issue, in evolutionary theory, and this is the third subject for the present paper, concerns the sources of variation, and, in particular, how blind, or random, and how independent from selection, variety generation is.

According to most evolutionary accounts, the main trigger of radical innovation is a shock in the form of a break or shift of the selection environment, which may increase competition for scarce resources, disadvantage incumbent species, and create new opportunities for new variety. Such a shift or shock may be due to natural disaster, political upheaval and war, a shift in demand, a shift in institutions (e.g. regulations for protecting the environment), or a shift due to developments in related industries or markets. However, this tells us only of new opportunities, of how radical innovation is enabled or challenged, not of how it is generated.

In evolutionary theory, generation of new variety, in new interpretations or new ideas is generally ascribed to errors in replication, mistakes, random, uninformed trials as steps into the dark ('mutations'). In socio-economic evolution there is no doubt much trial and error in entrepreneurial venturing, and more so to the extent that the innovation is radical, i.e. entails destruction of existing competencies (Anderson and Tushman 1990, Tushman and Anderson 1986), technologies, and forms of organization, without the opportunity to build on existing

knowledge and competence. However, evidently in socio-economic evolution there is invention and knowledge development that is informed, somehow, by experience from failures and resulting inferences about where sources of failure may lie and where to look for improvements. This is too obvious to ignore or deny, and Aldrich (1999), Foster and Metcalfe (2001) and Nelson and Winter (1982), to name only a few, all recognize that next to blindness there is also intentional, deliberate, and somehow directed variety generation.

Thus, according to Foster and Metcalfe (2001: 10)

> 'The rate of economic progress that we observe reflects guided variation within conceptual schemes that channel explorative, creative enquiry in particular directions'. However, they immediately add: 'Of course, all variation is, in effect, blind variation, since it necessarily deals with the unknowable consequences of a present decision.

What does it mean that variation is both guided and blind? Little, if anything, in the evolutionary literature, is said how the 'guidance' or 'direction' of variation works in 'explorative, creative enquiry'. More generally, the generation of variety is the least developed side of evolution in socio-economic systems (Baum and Singh 1994: 18).

According to Hodgson and Knudsen (2005: 11) evolution is blind in two senses. First,

> … particular outcomes are not necessarily prefigured or predicted in advance.

I agree with that. However, this leaves open the possibility of an intelligent design of a path of discovery, guided by experience from selection, that is likely to yield radical novelty, even though it cannot be predicted what that will be. That is precisely what I will argue.

According to Campbell (1987),

> .. any capacity for foresight or prescience must be based on tried and tested knowledge, otherwise we have no grounds to presume its effectiveness. Accordingly, when genuine innovations are launched, we are unable to assess the probability of their success or failure (Hodgson and Knudsen 2005: 11).

I agree with the first part (experience is needed to presume effectiveness) but I disagree with the second part. Because we can make inferences from experience we can 'presume effectiveness', i.e. increase likelihood of success beyond blind trials, even if perhaps that cannot be rendered in terms of probability theory (cf. Shackle 1962).

Campbell (1974) specified blindness as entailing variations that are (1) independent of each other, (2) separate from the environment, (3) uncorrelated with the solution, and (4) later variations are not corrections of former ones. Applying these criteria, I will argue that there is non-blind variation.

The often-heard claim that a theory of invention would be self-defeating or even self-contradictory, because by definition invention cannot be predicted, is based on confusion between prediction and explanation. One can claim to have some understanding of processes of invention without thereby claiming to be able to predict its outcomes. That applies to evolutionary theory more broadly: it explains principles of process without claiming to predict its outcomes.

In the evolutionary literature, some authors have allowed for variations that are guided from higher level, variety generating 'search' routines (Nelson and Winter, 1982). Other literature also suggests that there are higher level 'dynamic capabilities' that direct the change of lower level capabilities (Teece et al. 1997). Dynamic capabilities include rational inference of cause-effect relations, rules for experimentation, and ability to utilize organizational memory. They also include exchange of codified knowledge with others, in what (Nonaka and Takeuchi 1995) called 'knowledge combination' and Zollo and Winter (2002) later called 'deliberate' as opposed to

'experiential' learning. So, the question now is to what extent, and how, organizations can develop dynamic capabilities (Teece et al. 1997) to escape from inertia (Lewin and Volberda 1999, Zollo and Winter 2002). In what sense, and to what extent is this blind? How is it related to selection, and to what extent can it anticipate success in selection?

2. A Cognitive Theory of Organization

This paragraph summarizes the 'embedded cognition' view used, and the cognitive theory of organization to which it leads.

Embodied Cognition

I adopt a view of knowledge and learning that is much used in the organization literature, and is known as the 'activity theory' of knowledge (Blackler 1995), according to which mental models or categories or schema's of knowledge are developed from experience in interaction with the (physical and social) world (Kolb 1984, Levitt and March 1988). Though not often recognized, this goes back to the developmental psychology of Piaget (1970, 1974) and Vygotsky (1962), according to which 'intelligence is internalized action'. For example, in child development groping and prodding develop into pointing, which forms the basis for reference that is the basis for language. Playing with blocks provides a basis for learning to count, add and subtract. Experience in dealing with physical objects yields metaphors by which we construct abstract concepts (Lakoff and Johnson 1980).

In sociology this view is related to symbolic interactionism (Mead 1934, 1982). In philosophy, it is closely related to American pragmatism (since Peirce 1957) and the 'organicism' of Whitehead (1929), according to which any element in the system is an outcome of relations with other entities, and in which individuals both constitute and are constituted by society (Hodgson 1993: 11).

This organic, interactionist view is crucial, since it provides a perspective from which we may transcend the otherwise seemingly irreconcilable gap between economics, with its methodological individualism, and sociology with, in some branches, its tendency towards methodological collectivism. The individual is social in that one derives one's individuality in interaction with others, but what one makes of the interaction is not the same as what others make of it. Individuality is a function of inherited endowments of mental constructive potential and interactions along individual courses of life that yield the experience for construction. Hence there is 'cognitive distance' between people to the extent that they have developed along different paths, in different environments. This distance is both a problem, for mutual understanding and collaboration, and an opportunity, to learn something new from people who have constructed their cognition differently (Nooteboom 1992, 1999).

While the perspective of cognition adopted here is connected with interpretive views of knowledge and meaning (Berger and Luckmann 1967, Weick 1979, 1995), it is less subjectivist than some of them. I maintain that even though we cannot claim to know the world objectively, since we cannot 'descend from our mind' to test the claim, it is reasonable to assume that an external reality does exist, somehow, and that if indeed our mental structures are constructed in interaction with it those structures in some sense represent that reality, in what Lakoff and Johnson (1999) called 'embodied realism'.

In cognition, a mental 'neural Darwinism' seems to obtain, in which neural structures emerge, in selection, reinforcement and reproduction, according to their performative success (Edelman 1987, 1992). The activity based view of cognitive construction is consistent with this. Cognition is thus 'embodied' as well as embedded in the outside world, and its embodiment denies any Cartesian dualism of body and mind (Damasio 1995). There is a continuum of bodily, endocrinal, involuntary neural, emotional, and rational levels of activity that interact (Damasio 2003).

Note that in this perspective cognition is a fundamentally social notion, in its construction from interaction. It is also a broad notion, including value judgments, feelings and emotions As a result, cognitive distance has many dimensions. It has a more substantive side of cognition in a narrower sense of job-related knowledge and skills, and a more intentional, normative, moral side of goals, values, interests and ways of resolving conflicts. One of the attractions of embodied cognition is that it provides continuity with social psychology, with its insights into decision heuristics that mingle emotions and rationality (Bazerman 1988).

Note that this constructivist, interactionist view of cognition implies that mental schema's and corresponding competencies are formed from interaction with the external selection environment. In that sense, the selection environment not only selects interactors in which ideas are implemented in action, but also contributes to the Lamarckian formation of replicators in the course of action.

Organizational Identity

Hodgson and Knudsen (2004) usefully argued that the cohesiveness of the interactor, needed for evolution to work, requires at least a core of components that stand or fall together with each other and with the interactor as a whole. More precisely, the probability of survival of one component is connected with the survival of other components in that core. The question now is how organizations achieve the cohesion and stability required for interactors.

Here, the notion of cognitive distance, developed previously, leads to a *cognitive theory of the firm* (Nooteboom 1992, 1999, 2000). One problem for achieving collective goals lies in the cognitive distance between its members. If it is too large, it is very cumbersome to coordinate competence and governance. More precisely, it would be cumbersome, and inefficient, to achieve mutual understanding on perceptions of the environment, goals and priorities of the firm, relevant technologies, products, markets, actions in jobs and roles, and technical coordination between them, in 'dominant competencies' (McKelvey 1982), on the competence side, and categories and instruments for alignment of interests, and conflict resolution, on the governance side. To function as a coordinated system of actions, organizations need some more or less specialized shared language or jargon, perceptions, understanding and morality, as part of organizational culture (Schein 1985). Without such focus of shared perceptions, meanings, understandings and values, too much effort, time and aggravation would have to be spent on disambiguating meanings, eliminating misunderstanding, setting priorities, establishing directions, coordinating activities, and negotiating the terms of collaboration. This cognitive focus constitutes the advantage of organization over market, in contrast with, but not entirely separate from, the logic of transaction cost economics (Nooteboom 1999). This is the view of organization as a system for 'sense-making' (Weick 1995), 'collective mind' (Weick and Roberts 1993), system of 'shared meanings' (Smircich 1983).

The intentional, moral, institutional side of organizational focus, concerning values and norms of behavior and conflict resolution is needed, among other reasons, because imperfect monitoring and measurement of performance hinder alignment of purpose and conflict resolution by means of incentives. Moral guidance partly replaces, and complements, purely extrinsic motives by more intrinsic ones that require less monitoring. The importance of this has increased since work has become more professional and based on higher levels of knowledge work that are more difficult to monitor and measure.

The main point here, for the present paper, is that organizational cognitive focus, produced and reproduced by organizational culture, forms the core of organization-level competence, to achieve coordinated bundles of competencies that constitute the replicators of organizations. Organizational focus constitutes a cohesive whole of perceptions, meanings and values that define roles, relations and procedures of interaction, and thereby yield the requisite cohesion and stability of organizations as interactors. While the *raison d'être* of organization as a focusing device is that it enables cognitive and moral coordination, for the sake of efficient goal

achievement, and is therefore positively selected for in market competition, it also helps to create the stable and differentiated organizational identities needed for evolutionary selection of organizations to work.

In addition to the distinction between the competence and governance side of focus, there are three dimensions for both: *width*, i.e. the range of different areas of knowledge, competence and governance, *depth*, i.e. the variety of concepts and rules in each area, and *flexibility*, i.e. allowance for improvised, unforeseen meanings, standards, division of labor, roles, skills, procedures, and the like. The distinction between width and depth is similar to such distinction in product differentiation and portfolio's of products in general. There, width refers to the different kinds of products, and depth to the variety of qualities and brands in each. Here, the contrast between firms and markets appears: firms yield maximum scope, variety and flexibility, in both competence and governance. That would be impossible to coordinate, in central planning, and when tried would yield stagnation: the fixing of ideas, meanings, standards, division of labor to maintain exploitation would disastrously limit the scope for exploration.

Organizational focus cannot be integrally and instantly re-shaped as a function of experience in selection, and this limits Lamarckian adaptation, and yields some organizational inertia. The limits to such change lie in the systemic cohesion of elements of cognitive focus and in the fact that cognitive focus serves as an absorptive capacity that tends to mostly confirm itself in its functioning (imprinting). However, and this will be discussed later, there is a process by which absorptive capacity does transform itself in its functioning, so that there is some Lamarckian mechanism, and an escape from inertia, but in a series of conditioned steps that require time. It is an empirical question to what extent the speed of that is sufficient to escape from selective pressures.

Organizational focus emerges from the imprint from the entrepreneur who started the organization, is subject to some drift due to turnover of staff, and to shifts due to crises, caused, in particular, by shifts in the environment, or by new, challenging interpretations of the environment, and by the weeding out by selection, in population effects. When resources are scarce and competition is tight, selection is likely, in the long run, to yield organizational cognitions and structures that reflect the exigencies of the environment of markets and institutions. Consider, for example, the view that stable environments tend to favour 'mechanistic' environments while turbulent environments tend to favour 'organic' ones (Burns and Stalker 1961), or more specialist vs. more generalist organizations (Hannan and Freeman 1977).

Organizational focus will be narrowest, and cognitive distance smallest, in single-person, owner-manager firms, wider in work groups, wider yet in larger firms consisting of multiple groups, and widest in multi-divisional firms. In larger firms, especially distance in job-related competence is larger, in a wider and deeper division of labor, but distance on the moral side of cognition is not necessarily larger. In fact, since in face-to-face work groups there is more informal, spontaneous social control of free-ridership (Simmel, 1950), there the need for more explicit moral focus is less. In larger organizations more attention may be needed to the moral dimension of organizational focus across different work communities. A difference in culture between large and small firms lies in the fact that with a more extensive division of labor, with coordination between greater numbers of people across possibly distant organizational units, knowledge and rules need to be codified to a greater extent than in small firms, where coordination can take place by direct supervision (Mintzberg, 1983).

Organizational Boundaries

This cognitive perspective of organization also gives a new slant on organizational boundaries and on inter-firm alliances. Aldrich's (1999) definition of organization as goal-directed, coordinated activity systems (which I adopt) includes the maintenance of more or less clear, stable boundaries (which I reject). While clear and stable boundaries may apply to most

traditional organizations, it is much less the case for modern web-based, 'virtual' enterprises and network forms of organization. Apparently, the assumption of clear and stable boundaries is deemed necessary to yield the organizational cohesion needed to make evolutionary selection work. But why would entrepreneurs or managers want that selection to work? If with fuzzy and/or variable boundaries and imitation and buy-out of personnel from other firms they can escape selective forces, why shouldn't they? The following conundrum then arises. If organizations are selected, in evolution, for their ability not to have clear and stable boundaries, while those are necessary for selection to work, how can this be?

My view is that the notion of cognitive focus is sufficient for a stable and cohesive identity of organizations and does not require clear and stable boundaries of activity.

Organizational focus creates organizational myopia, and in addition to all the other motives for inter-firm alliances, familiar from the extensive alliance literature, this gives an additional, cognitive reason, to prevent myopia by means of complementary outside cognition from alliance partners (Nooteboom 1992, 1999). Here, cognitive distance applies to organizations, as differences in shared language, meanings, perceptions, understandings and values and norms of behaviour. In empirical work, measures of the cognitive distance between firms have been constructed on the basis of indicators from organizational data and technological profiles derived from patent data (Wuyts et al. 2005).

Note here the condition, familiar from the alliance literature, that when organizations outsource activities they must often still retain absorptive capacity with respect to those activities, to properly collaborate and coordinate with outside sources (Granstrand, Patel and Pavitt 1997). In other words, some of the related competence remains part of organizational focus. Note also that while organizations may not have clear boundaries of activities, in sharing activities with other organizations, and may have shifting boundaries, in outsourcing and integrating activities, firms do and should have a clear legal identity, as pointed out by Hodgson (2002a). Unclear boundaries of legal ownership and liability would create institutional havoc

3. Differences in Organization

This paragraph analyses the implications of cognitive theory of organization for differences between organizations within and between industries.

Intra- and Inter-Population Differentiation

Cognitive distance also applies to the higher aggregation level of organizations, in differences in organizational focus, i.e. differences in shared language, meanings, perceptions, understandings and values and norms of behaviour (Schein 1985). In empirical work, measures of the cognitive distance between firms have been constructed on the basis of indicators from organizational data and technological profiles derived from patent data (Wuyts et al. 2005, Nooteboom et al. 2005).

Within industries, cognitive distance, thus difference in organizational focus, is limited, particularly concerning the competence side of technologies and competencies, due to shared technologies, market demand, market structures, technical and professional standards, etc., yielding what may be seen as a common pool of competencies (McKelvey 1982). As a result, staff exchange between organizations is feasible and can create and confirm the identity of an industry (McKelvey 1982: 197), yielding 'industry recipes' (Spender 1989). This is also enhanced by pressures towards conformity from needs of social, political or financial legitimation (Dimaggio and Powell 1983).

However, even within industries organizational focus is more varied, and organizational cognitive distance is correspondingly greater, on the governance side of the moral, intentional, institutional order, in different styles or cultures of management. Deep differences in fundamental perceptions, views and (largely tacit) assumptions concerning man, his knowledge (e.g. objective or constructed), his relation with his environment (passive or active), his morality (basically good

or bad), and relations with other people (egotistic or altruistic) (Schein 1985), yield differences in risk perception and acceptance, pro-activeness ('locus of control'), formality or informality, rivalry or cooperation, intrinsic or extrinsic motivation, instruments and styles of governance and conflict resolution. From an evolutionary perspective, the persistence of such differences, in spite of selection pressures, suggests that on the moral, intentional side there are different ways to be successful, within an industry.

As indicated earlier, a central issue is how to make the combination of exploitation and exploration (March 1991). While earlier some industries were relatively stable, allowing for a focus on exploitation, and others were in a state of flux, yielding a focus on exploration, now the combination of the two is needed in most if not all industries. Combination of the two is particularly difficult when exploitation is highly systemic, as defined earlier. Then, by definition, units within the system hardly have any room for the experimentation and deviation needed for exploration, since they would jeopardize systemic integrity. In that situation, exploration needs to be relegated to a different time or place. The classic case is the division between departments for production and for R&D. This yields the classic problem of divergent mentalities and priorities between them, with resulting misunderstandings, conflicts and recriminations. It is difficult to find an organizational focus that accommodates both. One method is to engage in cross-functional teams, and another is frequent staff rotation, with an organizational focus to support that. Another would be to create more flexibility by decomposing the exploitation system into more autonomous parts, as long known from systems theory. Such choices may be made differently by different firms even within an industry.

Cultural differentiation between organizations is maintained, in spite of turnover and exchange of staff, because in the entry into an organization there is self-selection according to expected fit to organizational culture, as well as adaptation by socialization into organizational culture. Furthermore, according to the idea of intelligence as internalized action the further development of cognition reflects the environment, in this case the organization, in which it takes place. This confirms the problem of limited opportunity and speed of integrating new staff, identified by Penrose.

Between firms in different industries there are greater differences also on the competence side of cognitive focus. There are, for example, deep differences in professional skill. As McKelvey (1982: 202) phrased it '.. Would you fly on an airplane that had recently been staffed with non-airline employees? Would you enter a coal mine operated by hotel employees? Would you eat in a restaurant staffed by truckers?' However, even between industries isolation is far from complete, and replication across industries does take place. McKelvey (1982: 206) suggested that to the extent that organizations are simpler characteristics are more easily exchanged, also between industries.

For an illustration, consider the emergence of self-service. It emerged in retailing, largely outside large firms, initiated by independents but swiftly adopted by large chain store firms after it proved a success. Self-service retailing constitutes a distinct 'species' from service retailing, with a different structural logic, in that a fundamental reversal of roles occurred between shop attendant and customer. In service, the attendant moves about to collect items for a shopping basket, while the customer remains stationary at a counter, and in self-service these roles are switched, with the customer picking out its own goods, and a stationary attendant at a check-out, in a different lay-out of the shop. This eliminated an obstacle to shop size. In a large shop, with many products, under service the attendant would have to move about too far, with an unacceptable increase of waiting time for the customer. The emergence of self-service, with its attendant opportunity for larger shop size, was favored by a shift of the selection environment towards knowledgeable customers who no longer needed advice from shop attendants, an increased demand for less frequent, 'one-stop' bulk shopping, due to greater scarcity of time, enabled by transport capacity from car ownership and by refrigerated home storage capacity. In its turn, self-service affected selection conditions, in co-evolution, in that it enabled economies of

scale that pushed out small shops. With its demand for pre-packaged goods, it also had wide repercussions for the selection conditions in packaging and food industries. In replication, however, isolation was very limited. The principle of self-service was quickly and widely adopted in other industries, such as restaurants.

It is doubtful whether organizational focus could survive a merger or acquisition, and this contributes to their frequent failure. In view of greater difference in focus between than within industries, mergers and acquisitions are more likely to succeed within industries than between industries (Nooteboom 1999), and this is confirmed empirically (Bleeke and Ernst 1991).

Absorptive Capacity and Isolation

The notion of a population requires 'isolating mechanisms' between them. Baum and Singh (1994: 12) listed a number of such isolating mechanisms: technological interdependencies (restricting the replication of single, isolated elements from bundles), institutional pressures of isomorphism (Dimaggio and Powell 1983), complexity of learning (difficulty of absorption), resistance to learning, imprinting, and 'network closure'. This section further develops the more cognitive aspects of complexity and difficulty of learning and imprinting.

Interactively constructed mental categories constitute our *absorptive capacity* (Henderson and Clark 1990): we *assimilate* input from our senses into those categories (Piaget) and in so doing make sense of them, interpret them, and make inferences on the basis of them. Thus it is better to speak of the 'reproduction' rather than the 'sharing' or 'copying' of knowledge. At greater cognitive distance assimilation is more difficult, replication is less complete and faithful, and more knowledge and interpretation will be 'added'. In other words, at larger cognitive distance replication entails more variety generation.

Knowledge, in the form of mental schema's or frames corresponding with competencies is often largely tacit and stored in 'procedural memory', as 'know-how', and can only imperfectly be codified into declarative knowledge of facts, logic and causal relations, as 'know-that' and 'know-why' (Cohen and Bacdayan 1996). Knowledge 'sharing', with minimal change of knowledge in communication, requires a certain commonality of absorption, or limited cognitive distance, as between practitioners of the same jobs (Miner 1991). Mutual understanding is quick, with few words needed, in jargon. Communication will be less faithful and fast but next best inside work groups (Gersick 1988) or *communities of practice* (Brown and Duguid 1996).

Recall that mental schema's and cognitive distance include not only cognition in the narrow sense of intellect, but also more emotion-laden moral categories of how to deal with relational risks from mutual dependence and rivalry. Different ways of dealing with such risks are legal or hierarchical coercion, balance of mutual dependence, reputation, and less self-interested motives of ethical conduct, empathy, identification and routinized conduct (Nooteboom 1999). However, note also that mutual understanding does not by itself entail lack of rivalry. Indeed, rivalry may increase with similarity, if similarity entails competition, and between professionals in the same field, or at the same organization, rivalry may be greater than between professionals in different fields or organizations.

While cognitive distance yields some 'reproductive isolation', with limited replication, maintaining distinctive identities of organizations and industries, it is far from perfect, for two reasons. First, on the level of communities of practice, outsiders, from different communities, can enter and become members, after some time needed for initiation and socialization, in *legitimate peripheral participation* (Lave and Wenger 1991). Second, even at large cognitive distance one may still be able to selectively assimilate single but crucial elements of externalized knowledge, even from distinct industries. The case of self-service, emerging in retailing but copied by restaurants, discussed earlier, gives an illustration.

4. Sources of variation

This paragraph analyses sources of variation, i.e. the generation of new knowledge and competencies, or, in other words, dynamic capabilities (Teece et al. 1997). The question is how invention takes place, and how blind or directed it is. Three sources are indicated: transformation of meaning in communication, novel combinations of existing knowledge, in learning by interaction, and experience-based learning on a path of exploitation that leads up to exploration. While the first of these is blind and accidental, the second can be deliberate and designed (Nonaka and Takeuchi 1995, Zollo and Winter 2002), and the third is directed by selection and can also to some extent be designed (Nooteboom 2000).

Variation by communication and collaboration

As indicated earlier, absorption or assimilation is to a greater or lesser extent accompanied by expansion and transformation of the knowledge absorbed. In that sense, communication not only yields 'replication', but also contributes to the generation of variety. In communication, in expression by the 'sender' tacit knowledge can never be fully codified and externalized, so that expressed knowledge is always incomplete, and in absorption, or assimilation, knowledge is complemented and supplemented from the existing cognitive framework of the 'recipient'. Furthermore, what is 'left out' by the sender and what is 'added' by the receiver, and how this is done, depends on clues from the context. Thus, meaning is always context dependent.

A relevant concept here is that of 'scaffolding' (Hendriks-Jansen 1996, Shanon 1990). The context of practice and learning, including the people involved, disambiguates meaning (a universal becomes specific by its place in a sentence, in a context of action), triggers relevant associations and cuts irrelevant ones, from a 'seamless web of belief' (Quine and Ullian 1970). Classic examples are mothers that stimulate appropriate responses from infants (Hendriks-Jansen 1996) and teachers who draw out pupils beyond their current level of performance (cf. Vygotsky 1962: 'zone of proximal development'). Another example is the role of tools in apprenticeship, indicated before, in the construction of corresponding mental schema's.

This source of variation is indeed, as expected from an evolutionary perspective, blind, accidental, and not deliberate, planned or designed. Using the four criteria of blindness suggested by Campbell (1974), indicated earlier, it is blind in all but one aspect: they do not seem to be independent from each other, but to cohere in a 'seamless web' of cognition.

March (1991) suggested that the generation of new ideas, in exploration, follows from personnel turnover, where people from outside an organization carry fresh ideas into the organization that may disturb the efficiency of exploitation but contribute to exploration. That is certainly part of the process of variation, but it is also limited due to the isolating mechanisms indicated before, especially between industries, self-selection of entrants to fit organizational focus, and socialization into that focus.

More generally, new knowledge and competence can be generated deliberately and by design by seeking novel combinations of existing knowledge, in collaboration between different people and organizations. Nonaka and Takeuchi (1995) recognized this as innovation by 'combination', and Zollo and Winter called it 'deliberate learning', in contrast with experiential learning. While Nonaka and Takeuchi as well as Zollo and Winter claimed that such learning by combination requires articulation and codification of the knowledge involved, I disagree. While codification certainly has its advantages, it is neither necessary nor fully possible. As argued earlier, knowledge can never be fully articulated and codified, and a greater or lesser degree of tacitness necessarily remains. Novel combinations of tacit knowledge can also arise, in close collaboration in teams.

As indicated before, in learning by interaction one runs into both the problem and the opportunity from cognitive distance: greater distance makes mutual understanding and acceptance (absorptive capacity) more difficult, but also generates novelty value. If the first decreases, say linearly, with cognitive distance, the second increases with it, and performance of learning by interaction is the mathematical product of absorption and novelty value, an inverse U-shaped

relationship results, with an optimal cognitive distance, large enough to yield novelty value but not so large as to preclude understanding and collaboration (Nooteboom 1999). This optimum is not fixed. In particular, absorptive capacity depends on the accumulation of knowledge and competence from past R&D (Cohen and Levinthal 1990), production, marketing, organization, and, in particular, experience in collaborating with others at sufficient cognitive distance. In other words, experience in dealing with others who think differently yields competitive advantage. An increase of absorptive capacity yields an increase of optimal cognitive distance. The hypothesis of optimal cognitive distance, and its dependence on cumulative R&D, was empirically confirmed by Nooteboom et al. (2005), in an econometric study of the productivity of learning by interaction in terms of patents from 994 alliances between 116 firms in several industries in the period 1986-1996.

Inter-organizational collaboration requires cognitive coordination and governance of relational risks. A detailed discussion of the latter goes beyond the scope of the present paper. For governance, there is a toolbox of instruments such as: contracting plus requisite monitoring, in so far as feasible in view of uncertainties of environment and behaviour, a balance of mutual dependence, posting of hostages, typically in the form of competitively sensitive information, reputation mechanisms and trust building by cultural alignment of values, personal empathy and identification, and routinization of conduct (Nooteboom 1999, 2002).

In conclusion, one type of dynamic capability is the ability to find partners, at optimal distance, and to effectively understand and collaborate with them, in the governance of 'relational risk'. This dynamic capability in the form of alliance capability can be developed by building absorptive capacity and experience in communicating and collaborating with partners who think differently.

How blind is variation by collaboration? Collaboration requires communication, and as indicated this is always imperfect, and can yield unintended and unnoticed variation. That is one reason why collaboration is blind in the sense that it is subject to more or less random disturbance and fluctuation of interpretation and meaning. It is also blind in the sense that one cannot predict the precise outcome of learning by interaction, since it is not based on experience, unless collaboration is embedded in some experiential process, to be discussed later. However, it is not blind in that it is informed by selective success: one selects partners in learning who have demonstrated to be competent in some respect. It is designed: one may have a fair guess of cognitive distance and select partners at optimal distance. Applying Campbell's (1974) criteria of blindness, variations from planned collaboration are not independent, are not separate from the environment, and later variations can be corrections of former ones. They are not, however, correlated with the solution, in the strong sense that the outcome can be predicted.

A Heuristic of Invention

According to Piaget, in individual cognition assimilation, or absorption, not only shifts the knowledge absorbed, but can in the process of assimilation shift the mental schema's employed in assimilation. That entails seeing new things or seeing and interpreting things in new ways. This, I propose, yields a source of invention in experiential learning. Nooteboom (2000) proposed that this is related to the issue of 'exploitation and exploration' (Holland 1975, March 1991), and proposed that it yields a path by which exploitation (assimilation) can lead on to exploration (invention).

According to Piaget (1970, 1974, see also Flavell 1967) the process of assimilation contributes to the change of mental structure (called 'accommodation') in the following steps, with an increasing deviation from previous knowledge structures. First, in *repetition* schema's are confirmed and stabilized in repeated application. In *generalization* existing schema's are applied to novel contexts. In *differentiation* 'proximate' changes are made, in 'local search', in an attempt to satisfy the requirements of the novel context. Next, in *reciprocation* new elements are adopted from previously unrelated cognitive schemata, in a process of hybridization, called *reciprocation*,

which then leads on to *accommodation* in the form of entirely novel mental architectures of elements from old and previously unrelated schema's. Nooteboom (2000) proposed that this may yield a general 'logic of discovery', applicable also to organizational learning, as source of variation that is guided by selection.

On some level, depending on how competence destroying an innovation is, and in how many dimensions it innovates, the entrepreneur has to escape from the grip of the existing selection environment, within a job, profession, organization, industry, country or wider economic system. The first reason for such exit or escape is to gain the *opportunity* of being different, without thereby succumbing to the grip of selection (Baum and Singh 1994: 13). However, there are other reasons (Nooteboom 2000) to exit to a different environment.

A second reason is to gain the *motive* to change a dominant design, a third reason is to gain new *insight* into where the limitations of existing dominant designs lie, and a fourth is to gain novel experience and insight into *elements of novelty*, in experimentation with *hybrids* (Holland 1975, Hannan and Freeman 1989, Powell 1991) that leads on to insight into what more wide-reaching, architectural change is needed, and how it might be tackled, to allow for the full realization of an emerging innovation's potential.

It is only when existing dominant designs are subjected to new challenges, threatening survival, that one is *willing* to make the sacrifices of modifying or replacing proven and efficient assets for exploitation. The idea that failure to achieve objectives is an important motivational condition for change is an old one (Cyert and March 1963, March and Simon 1958). What is new here is that one need not passively wait for a new environment to arise as a new challenge but can actively and intelligently choose an environment that yields interesting new challenges.

Next to motivation for change, it is only under such novel demands that one gets new *evidence* of where limitations of validity and hence priorities for change lie. At first, one will seek differentiation of dominant designs, staying close to them, in proximate or 'problemistic search' (Cyert and March 1963), to maintain exploitation as much as possible. Here, one may tap from earlier experience, going back in organizational memory to what was tried but failed in earlier exploration, at the time that current dominant designs had not yet emerged.

Next, when that does not meet challenges of survival, looking further afield by comparing one's own failures with apparent successes in newly encountered practices of others in the novel environment one can obtain hints as to how inadequate performance may be repaired by adopting elements from such local practice. And, finally, it is by experimentation with hybridization, incorporating foreign elements into one's own practice, that one has an opportunity of experimenting with novelty before surrendering the basic architecture or logic of the dominant design, and one is willing to make more drastic, architectural or fundamental change, because now one has a clue how to do it, in eliminating barriers to the full realization of the proven potential of novel elements or principles, currently constrained by the dominant design. It is in this last stage, of experimenting with novel architectures or basic principles of new configurations of old elements from the old dominant design and new elements from dominant designs found in the new environment, that radical innovation emerges.

Note that this process yields a path of exploitation that leads on to exploration, where one sticks as tenaciously as possible to the dominant design while yet being prepared to deviate from it, in increasingly drastic departures, in a process of discovery based on shifting practice.

In this account, the shift of environment is undertaken voluntarily and by design. It may also be imposed unexpectedly from the outside, when an invading competence destroying innovation forces one to adapt. That is the environmental shock recognized in standard evolutionary theory.

An empirical illustration of the proposed path towards exploration is the practice that emerges, in the past mostly unintended, from multinational companies (MNC's) transferring products to new markets, where they run up against novel demands and constraints that require adaptation, and give new insights from previously unfamiliar local practice for doing things differently, from local competitors, suppliers and customers. While in the past MNC's stumbled

on such invention or discovery from other motives for expanding into foreign markets, such as maintenance of growth, or escape from intense price competition in saturated home markets, they now discover its potential for discovery, and use it as a deliberate policy for that purpose (Bartlett and Goshal 1989, Nooteboom 2000). In culture studies also, it is a familiar principle that novel culture tends to arise at, and penetrate from, the periphery of existing culture (Lotman 1990).

This heuristic of invention shows how Lamarckianism may work, in a stepwise process, yielding the possibility of an escape from inertia, with an organization changing its cognitive identity by learning from novel environments. It also shows how speciation may work, in the development of novel industries on the basis of inventions, by organizations breaking up and yielding new configurations of cognition and competencies, in new forms of organization.

In conclusion, a second type of dynamic capability is the ability to transfer activity to novel contexts that yield opportunities to maintain exploitation while yielding novel challenges and opportunities for a step by step process of exploration. This includes the ability to choose novel contexts of exploitation that are sufficiently different to yield novel challenges and insights for elements and directions of change and sufficiently similar to allow for some continuation, at least initially, of familiar competencies. It also includes the capability to tap from memory concerning earlier experience with exploration, to engage in differentiation. It also includes the ability to select local partners, in the novel context, to engage in experimentation with hybrids, in reciprocation. This corresponds with the capability, discussed previously, of selecting partners at optimal cognitive distance, and the ability to build mutual understanding and governance of relational risk.

How blind is this source of variation? It is blind in the sense that the innovative outcome of the process cannot be predicted. However, it is not blind in that novel selection environments can be selected purposely, as likely to generate opportunities to continue exploitation while yielding novel challenges and indications of elements and directions for exploration. The process is informed by success and failure in selection. Applying Campbell's (1974) criteria of blindness, variations from the process are not independent, are not separate from the environment, and later variations can be corrections of former ones. They are correlated with the solution, in the sense that experience with failure and indications of solutions inform the process. However, the outcome still cannot be predicted.

5. Conclusions

When evolution is completely abstracted from biological evolution, in 'Universal Darwinism', with only the bare notions of variety generation, selection and replication, without specification of how those processes work, on the whole it can be made to fit socio-economic evolution to large extent. The attempt to maintain an evolutionary perspective is useful for developing a coherent combination of internal and external causes of change, and of agency and structure, avoiding both an overly rational view of managerial design and a view of environmental determinism without actors. However, with such a bare, abstracted framework, most of the explanatory work still has to be done. With this paper I aimed to make a contribution, building on the organizational literature, focusing on issues that have been most neglected or incompletely developed in previous literature. I specified four issues, concerning:

- The nature of the replicators carried by organizations interpreted as interactors, the sources of cohesion and stability of organizations as interactors, and the causes and extent of their differences within and between industries interpreted as populations
- The extent to which the selection environment of markets and institutions can be molded by organizations.
- The nature of replication, and its relation to variety generation
- How blind variety generation is, and the extent to which it may be guided by design and by learning from selection

In an attempt to deal with these issue, I offered an analysis on the basis of a 'cognitive theory of organization', which is in turn based on an 'embodied cognition' branch of cognitive science that yields, among other things, the notion of 'cognitive distance' between people to the extent that they have developed their cognition along different life paths.

Concerning the first issue, this yields the notion of an organization as a 'focusing device', to limit cognitive distance for the sake of efficient achievement of collective organizational goals. It consists of a culturally generated and maintained bundle of replicators in the form of basic perceptions, interpretations, meanings and value judgements concerning goals, priorities, technology, jobs and roles, on the competence side, and norms and values of conduct and conflict resolution, on the governance side. These yield requisite cohesion and stability of organizations as interactors, intra-industry differences mostly on the governance side, inter-industry differences on both the competence and the governance side, and limited possibilities for integral and instantaneous revision of replicators (organizational cognitive focus) by the interactor (organization), and thus implying a certain amount of inertia. The analysis also allows us to drop clear and stable boundaries of activities as part of the definition of organizations.

Concerning the second issue, without detailed analysis I concluded that while indeed markets and institutions can to a greater or lesser extent be molded by organizations, singly or collectively, and in that sense evolutionary selection can be inefficient, significant selection pressures generally remain.

Concerning the third issue, I gave an analysis of replication on the basis of communication, and of how next to very imperfect replication this also yields variety generation. However, while in communication there is much decay, reduction, expansion and transformation of knowledge and competencies some similarity in transmission remains.

Concerning the fourth issue, I argued for the intelligent design of innovation by collaboration, and of a path of cumulative insight and experience, guided by selection in a variety of chosen selection environments, that is conducive to outcomes that are unpredictable but have some enhanced chance of success.

Overall, the evolutionary processes are more strongly interrelated than in biology, with units of selection being more able to mold selection conditions, interactors being able, to some extent, to change their replicators (Lamarckianism), replication entailing more variation, and ways in which experience in selection can direct variety generation. The last point appears to generate the largest deviation, perhaps even from universal Darwinism, in the sense that while the outcomes of variety generation still cannot be predicted, the process in not blind in that it is subject to intelligent choice and experience based inference.

The analysis yields two kinds of dynamic capability. One is the ability to achieve novel combinations of existing knowledge by collaboration with outside partners, selecting partners at optimal cognitive distance, and building absorptive capacity and the ability of governing relational risk. Second is the ability to seek novel contexts of application as a source of novel insight and motives for change, along a path of differentiation and hybridization of knowledge and competence. For the purpose of hybridization, this includes the ability to optimally select partners and manage collaboration.

References

Aldrich, H. 1999. *Organizations evolving*. London: Sage.

Anderson, P. and Tushman, M. 1990. Technological discontinuities and dominant designs: A cyclical model of technological change. *Administrative Science Quarterly*, 35/4: 604-633.

Bartlett, C. and S. Goshal 1989. *Managing across borders - Transnational solution.* Boston MA: Harvard Business School Press.

Baum, J.A.C. and Singh J.V. 1994. Organizational hierarchies and evolutionary processes: Some reflections on a theory of organizational evolution. In J.A.C. Baum and J.V. Singh (Eds.), *Evolutionary dynamics of organizations:* 3-20. Oxford: Oxford University Press:

Bazerman, M. 1998. *Judgement in managerial decision making*. New York: Wiley.

Berger, P. and Luckmann, T. 1967. *The social construction of reality.* New York: Doubleday.

Blackler, F. 1995. Knowledge, knowledge work and organizations: An overview and interpretation. *Organization Studies*, 16: 1021-1046.

Boyd, R. and Richerson, P.J. 1985. *Culture and the evolutionary process*. Chicago: University of Chicago Press.

Brown, J.S. and Duguid, P. 1996. Organizational learning and communities of practice. In M. D. Cohen and L. S. Sproull (Eds.), *Organizational learning:* 58-82. London: Sage.

Burgelman, R.A. 1983. A model of the interaction of strategic behavior, corporate context, and the concept of strategy. *Academy of Management Review*, 8: 61-70.

Campbell, D.T. 1994. How individual and face-to-face group selection undermine firm selection in organizational evolution. In J.A.C. Baum and J.V. Singh (Eds.), *Evolutionary dynamics of organizations:* 23-38. Oxford: Oxford University Press:

Campbell, D.T. 1987. Blind variation and selective retention as in other knowledge processes. In: G. Radnitzky and W.W. Bartley III (Eds.), *Evolutionary epistemology, theory of rationality, and the sociology of knowledge*: 91-114. La Salle: Open Court.

Campbell, D.T. 1974, reprinted in 1988. Evolutionary epistemology. In D.T. Campbell, *Methodology and epistemology for social science*: 393-434. Oxford: Oxford University Press.

Cohen, M.D. and Levinthal, D.A. 1990. Absorptive capacity: A new perspective on learning innovation. *Administrative Science Quarterly,* 35: 128-52.

Cyert, R.M. and March, J.G. 1963. *The behavioral theory of the firm.* Englewood Cliffs NJ: Prentice-Hall.

Damasio, A.R. 1995. *Descartes' error: Emotion, reason and the human brain*. London: Picador.

Damasio, A.R. 2003. *Looking for Spinoza*. Orlando: Harcourt.

Dawkins, R. 1983. Universal darwinism. In D.S. Bendall (Ed.), *Evolution from molecules to man*: 403-425. Cambridge: Cambridge University Press.

DiMaggio, P.J. and Powell, W.W. 1983. The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review,* 48/2: 147-160.

Edelman, G. M. 1992. *Bright air, brilliant fire; On the matter of mind.* London: Penguin.

Edelman, G. M. 1987. *Neural Darwinism; the theory of neuronal group selection.* New York: Basic Books.

Flavell, J. H. 1967. *The developmental psychology of Jean Piaget.* Princeton NJ: Van Nostrand.

Foster, J and Metcalfe, J.S. (Eds.) 2001. *Frontiers of evolutionary economics: Competition, self-organization and innovation policy.* Cheltenham UK: Edward Elgar.

Garud, R. and Rappa, M.A. 1996. A socio-cognitive model of technology evolution; The case of cochlear implants'. In J. R. Meindl, C. Stubbart and J. F. Porac (Eds.), *Cognition within and between organizations*: 441- 74. London: Sage.

Gersick, C. J. G. 1988. Time and transition in work teams: Toward a new model of group development. *Academy of Management Journal*, 31: 9-41.

Granstrand, O., Patel, P. and Pavitt, K. 1997. Multi-technology corporations: Why they have distributed rather than distinctive core competencies. *California Management Review*, 39/4: 8-25.

Hannan, M. T. and Freeman, J. 1977. The population ecology of organizations. *American Journal of Sociology*, 88: 929-964.

Hannan, M. T. and Freeman, J. 1984. Structural inertia and organizational change. *American Sociological Review*, 49: 149-164.

Hannan, M. T. and Freeman, J. 1989. *Organizational ecology.* Cambridge MA: Harvard University Press.

Henderson, R.M. and Clark, K.B. 1990. Architectural innovation: The reconstruction of existing product technologies and the failure of established firms, *Administrative Science Quarterly*, 35: 9-30.

Hendriks-Jansen, H. 1996. *Catching ourselves in the act; situated activity, interactive emergence, evolution and human thought.* Cambridge MA: MIT press.

Hodgson, G.M. 2002a. The legal nature of the firm and the myth of the firm-market hybrid, *International Journal of the Economics of Business*, 9/1: 37-60.

Hodgson, G.M. 2002b. Darwinism in economics: from analogy to ontology. *Journal of Evolutionary Economics* ,12: 259-281.

Hodgson, G.M. 1993. *Economics and evolution: Bringing life back into economics.* Cambridge: Polity Press.

Hodgson, G.M. and Knudsen, T. 2005. Why we need a generalized Darwinism, and why generalized Darwinism is not enough. *Journal of Economic Behavior and Organization*, forthcoming.

Hodgson, G.M. and Knudsen, T. 2004. The firm as interactor. *Journal of Evolutionary Economics*, 14: 281-307.

Holland, J.H. 1975. *Adaptation in natural and artificial systems.* Ann Arbor, MI: University of Michigan Press.

Hull, D.L. 1988. *Science as process; An evolutionary account of the social and conceptual development of science.* Chicago: University of Chicago Press.

Johnson-Laird, P. N. 1983. *Mental models.* Cambridge: Cambridge University Press

Kolb, D. 1984. *Experiential learning: Experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice-Hall.

Lakoff, G. and Johnson, M. 1999. *Philosophy in the flesh.* New York: Basic Books.

Lakoff, G. and Johnson, M. 1980. *Metaphors we live by*. Chicago: University of Chicago Press.

Lave, J. and Wenger, E. 1991. *Situated learning; Legitimate peripheral participation.* Cambridge: Cambridge University Press

Levitt, B. and March, J. G. 1988. Organizational learning, *Annual Review of Sociology*, 14: 319-340.

Lewin, A.L. and H. Volberda 1999. Prolegomena on evolution: A framework for research on strategy and new organizational forms, *Organization Science*, 10/5: 519-534.

Lotman, Y. M. 1990. *Universe of the Mind; A semiotic theory of culture*. London: I. B. Tauris.

March, J. 1991. Exploration and exploitation in organizational learning. *Organization Science*, 2/1: 101-123.

March, J. 1981. Footnotes to organizational change. *Administrative Science Quarterly*, 26: 563-577.

March, J. and Simon, H. A. 1958. *Organization.* New York: Wiley.

McKelvey, W. 1982. *Organizational systematics: Taxonomy, evolution, classification.* Berkeley: University of California Press.

Mead, G. H. 1934. *Mind, self and society; from the standpoint of a social behaviorist.* Chicago: Chicago University Press.

Mead, G. H. 1982. *The individual and the social self.* Unpublished work of G.H. Mead, D.L. Miller (Ed.). Chicago: University of Chicago Press.

Metcalfe, J.S. 1998. *Evolutionary economics and creative destruction.* London: Routledge.

Miner, A.S. 1991. Organizational evolution and the social ecology of jobs. *American Sociological Review,* 56: 772-785.

Mintzberg, H. 1983. *Structure in fives: Designing effective organizations*. Englewood Cliffs NJ: Prentice-Hall.

Nelson R. R. and Winter, S. 1982. *An evolutionary theory of economic change.* Cambridge: Cambridge University Press.

Nonaka, I. and H. Takeuchi 1995. *The knowledge creating company*, Oxford: Oxford University Press.

Nooteboom, B. 2000. *Learning and innovation in organizations and economies.* Oxford: Oxford University Press.

Nooteboom, B. 1999. *Inter-firm alliances: Analysis and design.* London: Routledge.

Nooteboom, B. 1992. Towards a dynamic theory of transactions. *Journal of Evolutionary Economics*, 2: 281-299.

Nooteboom, B., W.P.M. van Haverbeke, G. M. Duysters, V.A. Gilsing and A. van den Oord 2005. *Optimal cognitive distance and absorptive capacity*, paper under review.

Piaget, J. 1970. *Psychologie et epistémologie.* Paris: Denoël.

Piaget, J. 1974. *Introduction a l'épistémologie génétique.* Paris: Presses Universitaires de France.

Powell, W.W. 1991. Expanding the scope of institutional analysis. In W.W. Powell and P.J. Dimaggio (Eds.), *The new institutionalism in organizational analysi:* 183-203. Chicago: Chicago University Press.

Quine, W.V. and Ullian, J.S. 1970. *The web of belief.* New York: Random House.

Schein, E. H. 1985. *Organizational culture and leadership*. San Francisco: Jossey-Bass

Shackle, G. 1961. *Decision, order and time in human affair.* Cambridge: Cambridge University Press.

Shanon, B. 1990. What is context? *Journal for the Theory of Social Behaviour*, 20/2: 157-166.

Simmel, G. 1950. *The sociology of Georg Simmel,* Translation Kurt Wolff, Glencoe Ill.: The Free Press.

Smircich, L. 1983. Organization as shared meaning. In L.R. Pondy, P.J. Frost, G. Morgan and T.C. Dandridge (Eds.), *Organizational symbolism*: 55-65. Greenwich Conn: JAI Press.

Spender, J. C. 1989. *Industry recipes.* Oxford: Basil Blackwell.

Teece, D. G. Pisano and A. Shuen 1997. 'Dynamic capabilities and strategic management', *Strategic Management Journal*, 18: 509-533.

Tushman, M.L. and Anderson, P. 1986. Technological discontinuitties and organizational environments. *Administrative Science Quarterly*, 31: 439-465.

Veblen, T.B. 1919. *The place of science in modern civilization and other essays.* New York: Huebsch.

Vygotsky L. 1962. *Thought and language*, edited and translated by E. Hanfmann and G. Varkar. Cambridge MA: MIT Press.

Weick, K.F. 1979. *The social psychology of organizing*. Reading, MA: Addison-Wesley.

Weick, K.F. 1995. *Sensemaking in organisations*. Thousand Oaks CA: Sage.

Weick, K.F. and Roberts, K.H. 1993. Collective mind in organizations. *Administrative Science Quartery*, 39, reprinted in M. D. Cohen and L. S. Sproull (Eds.). 1996. *Organizational learning:* 330-358. London: Sage.

Witt, U. 2004. On the proper interpretation of 'evolution' in economics and its implications for production theory. *Journal of economic methodology*, 11: 125-146.

Witt, U. (Ed.) 1993. *Evolutionary Economics.* Cheltenham UK: Edward Elgar.

Wuyts, S., Colombo, M., Dutta, S. and Nooteboom, B. 2005. Empirical tests of optimal cognitive distance. *Journal of Economic Behaviour and Organization*, 58/2: 277-302.

Zollo, M. and S.G. Winter 2002. Deliberate learning and the evolution of dynamic capabilities, *Organization Science*, 13/3: 339-351.