



Laboratory of Economics and Management
Sant'Anna School of Advanced Studies

Piazza Martiri della Libertà, 33 - 56127 PISA (Italy)
Tel. +39-050-883-343 Fax +39-050-883-344
Email: lem@sssup.it Web Page: <http://www.lem.sssup.it/>

LEM

Working Paper Series

**On the Convergence of Evolutionary and
Behavioral Theories of Organizations:
a Tentative Roadmap**

Giovanni DOSI
Luigi MARENGO

LEM, Scuola Superiore Sant'Anna, Pisa (Italy)

2007/01

January 2007

ISSN (online) 2284-0400

On the convergence of evolutionary and behavioral theories of organizations: a tentative roadmap.

Giovanni DOSI and Luigi MARENGO

*LEM, Laboratory of Economics and Management
Scuola Superiore Sant'Anna
Piazza Martiri della Libertà, 33 – 56127 PISA, Italy
g.dosi@sssup.it, l.marengo@sssup.it*

ABSTRACT

The behavioral theory of the firm has been acknowledged as one of the most fundamental pillars on which evolutionary theorizing in economics has been built. Nelson and Winter's 1982 book is pervaded by the philosophy and concepts previously developed by Cyert, March and Simon.

On the other hand, some behavioral notions, such as bounded rationality, though isolated from the context, are also at the heart of some economic theories of institutions such as transaction costs economics.

In this paper, after briefly reviewing the basic concepts of evolutionary economics, we discuss its implications for the theory of organizations (and business firms in particular), and we suggest that evolutionary theory should coherently embrace an "embeddedness" view of organizations, whereby the latter are not simply efficient solutions to informational problems arising from contract incompleteness and uncertainty, but also shape the "visions of the world", interaction networks, behavioral patterns and, ultimately, the very identity of the agents. After outlining the basic features of this perspective we analyze its consequences and empirical relevance.

Acknowledgments: we would like to thank Marco Faillo, Daniel Levinthal and Sidney Winter as some of the ideas presented in this paper have been developed in joint works with them. Of course the usual caveats apply. This paper has been produced as part of the EU-funded DIME Network of Excellence.

1. INTRODUCTION

Evolutionary economics is microfounded on a theory of firms, organizations and institutions which owes many of its concepts and most of its philosophy to the behavioral theory of the firm. Part II of Nelson and Winter (1982), entitled “Organization-Theoretic Foundations of Economic Evolutionary Theory” has plenty of citations to the work of Cyert, March, Simon. However evolutionary economics has mainly used this theory, until recently, as a tool for providing those foundational concepts alternative to neoclassical theory on which to build a theory of industry and technological change. Routines, boundedly rational search, productive knowledge, unresolved conflict provide an alternative to profit maximization, production function, optimal agency contracts.

Until recently evolutionary theory has not on the contrary developed a fully fledged theory of organization based upon behavioral concepts. In Nelson and Winter’s book and in most of the works it has inspired, routines are the fundamental units of selection and boundedly rational search is the fundamental variational mechanism which generates the variety of organizational behaviors on which market selection operates.

On the other hand, concepts and ideas from behavioral theory are also at the heart of other theories of organization both within the realm of economics, e.g. transactions costs theory which takes bounded rationality as one of its core concepts, and management and organization sciences, e.g. the resource-based and the capabilities theories of the firm.

In this paper, after briefly reviewing the basic concepts of evolutionary economics, we discuss its implications for the theory of organizations (and business firms in particular), and we suggest that evolutionary theory could well offer, together with capability based theories, an “embeddedness” view of organizations, whereby the latter are not simply efficient solutions to informational problems arising from contract incompleteness and uncertainty, but also shape the “visions of the world”, interaction networks, behavioral patterns and, ultimately, the very identity of the agents.

The paper is organized as follows: in the next section we very briefly review some basic building blocks of evolutionary theory. In section 3 we review some recent developments in, broadly speaking, evolutionary theory and competence based theory (largely overlapping). In section 4 we focus on the issues of organizational learning and competence accumulation and, finally, we draw some implications and empirical predictions and we conclude by outlining some unresolved problems and possible issues for further research.

2. EVOLUTIONARY THEORIES: SOME BUILDING BLOCKS

For the purposes of this work, let us confine ourselves to some basic features of evolutionary theories of *economic* change.¹

1. Notwithstanding possible differences in other more substantive hypotheses, evolutionary theories share the methodological imperative “*dynamics first*!”. That is, the explanation for why something exists, or why a variable takes the value it does, ought to rest on a process account of how it became what it is. Loosely speaking, that amounts to the theoretical imperative: provide the process story either by formally writing down some dynamical system, or telling a good qualitative historical reconstruction (or, much better, *both*). Or, putting it in terms of negative prescriptions: be extremely wary of any interpretation of what is observed that runs just in terms of *ex-post* equilibrium rationalizations (“it has to be like that, given rationality”). Never take as a good ‘explanation’ either an existence theorem or a purely functionalist claim (entity *x* exists because it performs function *y*). This methodological stance is indeed fully shared with behavioral theory, where process accounts of decision making have represented one of the major points of departure from standard neoclassical economics.

Given this general epistemological prescription (admittedly not an obvious one or even generally accepted amongst economists), the following substantive building blocks give shape to a full-fledged evolutionary research program.

2. *Theories* ought to be *micro-founded*, in the sense that they ought to be grounded explicitly (though perhaps indirectly) in a plausible account of what typical agents do and why they do it.

3. *Realism* is a virtue and in certain respects a necessity. Although theories are necessarily abstract and admit less of reality than they omit, there are some broad features of reality that they are omitted at the theorist’s peril – in the sense that the conclusions are unreliable guides to the interpretation of reality, though perhaps instructive regarding important mechanisms or otherwise useful.

4. Among these features is the fact that agents have at best *imperfect understanding* of the environment they live in, and, even more so, of what the future will deliver. Hence, “bounded rationality” is generally assumed, with its specific content varying with context.

5. Also, imperfect understanding and imperfect, path-dependent, learning entails persistent *heterogeneity* among agents, even when facing identical information and identical

¹ For a more detailed account we refer the reader to Nelson and Winter (2002), Hodgson (1993), Nelson (1995), Silverberg and Verspagen (1995), Metcalfe (1992), Anderson et al. (1988), Witt (1993), Dopfer (2005) and Lesourne and Orlean (1998).

notional opportunities. Capturing heterogeneity is crucial to the representation of aggregate dynamics; a model without heterogeneity cannot be a real evolutionary model.

6. The knowledge margin is always active: agents are always capable of discovering new technologies and ways of organizing, and adopting new behavioral patterns. Allowing for the *immanent possibility of novelty* in the system is a major theoretical and modeling challenge that cannot safely be ignored.

7. While (imperfect) adaptation and discovery generate variety (often in a seemingly random fashion), collective interactions within and outside markets operate as *selection mechanisms*, generating differential growth (and possibly also survival) of different entities that are the ‘carriers’ of diverse technologies, routines, strategies, etc.

8. As a result of all this, aggregate phenomena (e.g. regularities in the growth process or in industrial structures, etc.) are often captured theoretically as *emergent properties*. i.e. the collective and largely unintentional outcome of *far-from-equilibrium micro interactions* and heterogeneous learning. Such properties often have a meta-stable nature, in the sense that while persisting on a time scale longer than the processes generating them, they disappear ultimately with probability one.²

9. A similar style of representation and interpretation should apply to the emergence and self-maintenance of *organizational forms* and institutions: they are partly the result of directed (purposeful) action by the agents but also, partly, the unintentional outcome of the interplay of agent learning and collective interactions.

10. The relation of the “higher level” regularities manifested in institutions, rules and organizational forms to “lower level” evolutionary processes is a complex one of *co-evolution* across *levels of analysis* and *time scales* and ought properly to be modeled as such. While the former are emergent phenomena of the latter, they may be considered as relatively invariant structures which constrain and shape the latter on short time scales. Modeling approaches that take these higher level quasi-invariants as given have the same provisional legitimacy granted more generally to models that exclude, in the imperative spirit of dividing the difficulties, significant forms of novelty.

This is the grand program, as we see it. It is obviously impossible to review here the rapidly-growing literature of contributions that share some or all of the foregoing theoretical ‘building blocks’.³

² On the notions of the “emergence” and “metastability”, cf. the suggestive discussion in Lane (1993); see also below.

³ Note that, given the above broad definition of an ‘evolutionary research programme’, it may well partly cover also contributions of authors who could not call themselves ‘evolutionist’ in any strict sense.

Suffice it to mention, first, the flourishing number of formal models and historical interpretations of economic growth as an evolutionary process propelled by technical change which have followed the seminal work of Nelson and Winter (1982). Second, the diffusion of innovations has been fruitfully analyzed, from different angles, as an evolutionary path-dependent process. Third, the very development of an evolutionary perspective has been deeply intertwined with the historical analysis of the processes by which technical change is generated, ranging from the microeconomic level all the way to ‘national systems of innovation’. Fourth, a growing number of industrial case studies and models of industrial change fits quite well the evolutionary conjectures outlined above. Fifth, one is starting to explore learning itself as an evolutionary process at the levels of individuals, organizations and markets. This links also with a wide tradition of studies in the fields of organizational economics which is impossible to review here (but see the remarks in Winter 1986 and 1995).

Indeed we do have a rich and growing body of economic literature which at last tackles change and evolution, whereby increasing returns are the norms rather than the exception (and, with that, also the possibility of “lock-ins”), history counts, and agents are presumed to be less than perfectly rational and knowledgeable. But where do organizations fit in this picture?

Let us now turn to this issue.

3. THE NATURE OF BUSINESS ORGANIZATIONS

Business organizations are *behavioral entities*⁴ characterized by seemingly quite different arrangements in terms of operational and cognitive division of labor, as well as equally different hierarchical set-ups, pattern of access to information, incentives and control structures.

Correspondingly, economic organizations embody also specific and rather inertial compromises between different functions. Indeed, they perform (i) resource allocation; (ii) information processing; (iii) efforts elicitation; (iv) coordination (largely through non-price devices) among multiple cognitive and ‘physical’ tasks; (v) governance of competing claims upon the total generated surplus; (vi) experimentation and learning⁵. In turn these different organizational ‘functions’ yield also multiple co-existing levels of interaction amongst organizational members.

Clearly, a thorough understanding of what organizations are and how they operate ought to take on board the analysis of all the foregoing organizational processes. One still falls well short of

⁴ We borrow this expression from Kreps (1996)

⁵ This categorisation refines upon a similar one suggested in Coriat and Dosi (1998).

such an objective. However, over the last four decades one has witnessed multiple endeavors enriching our understanding of the nature of economic organizations.

As one discusses at greater length in Dosi, Levinthal and Marengo (2003), quite diverse interpretative efforts range between two extreme archetypes.

At one hand, the dominant strand of contemporary economic analysis starts with ‘primitives’ of the interpretation of the nature of organizations based on sophisticated, self-seeking, agents. Together, the behaviors of these self-interested actors are viewed as typically directed by market forces. Only in those settings in which, due to failures of information and contract incompleteness, markets are less effective in this task, then organizations are called for to surrogate such imperfections. It is a story too familiar to be repeated here⁶.

Conversely, a small - but not negligible and growing - minority of the economic profession has placed his “primitives” of the analysis of the nature of economic organizations in their *problem-solving features*, in turn nested in ubiquitous forms of human “bounded rationality”, grossly imperfect processes of learning and diverse mechanisms of social distribution of “cognitive labor”. The root of this approach can be found in the works of Herbert Simon, Alfred Chandler, Richard Cyert, James March, Richard Nelson and Sidney Winter, and finds indeed a fundamental root in the *behavioral theory of the firm* (cf. Cyert and March (1963)).

The problem-solving activities of the firm can be conceived as combinations of physical and cognitive acts, within a procedure, leading to the achievement of a specific outcome. Its internal organization determines the distribution of the informational inputs across specific task units and, as such, the division of the cognitive labor. The general idea is that firms possess the specific problem-solving competencies associated with their own operational procedures and routines, in turn embedded into the patterns of intra-organizational division of labor and assignments of decision entitlements. Through problem-solving firms generate their productive knowledge and shape their organizational structure.

An illustrious antecedent of this view dates back, indeed, to Adam Smith’s “Pin Factory” example in the *Wealth of Nation*:

“One man draws out the wire, another straightens it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations; to put it on, is a peculiar business, to whiten the pins is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which, in some manufactories, are all performed by distinct hands, though in others the same man will sometimes perform two or three of them.”

⁶ A few more detailed epistemological remarks are provided in Dosi (1995) and Coriat and Dosi (1998).

And, relatedly, such patterns of division of labor match specific channels of information flows and "lines of command".

Table 1 offers a comparison between the two approaches along some significant dimensions and theoretical building blocks.

Table 1		
Pure incentive view vs. pure problem-solving view of organizations		
<i>Dimension of analysis and theoretical building blocks</i>	<i>Pure incentive view</i>	<i>Pure problem-solving view</i>
1. Problem solving/cognition/knowledge	No	Yes (central dimension of analysis)
2. Incentive governance	Yes (central dimension of analysis) via equilibrium contracting	Not so far (but see Coriat and Dosi, 1998 and Dosi , Levinthal and Marengo, 2003)
3. Behavioral microfoundations	Perfect, far-sighted, rationality	Bounded rationality (usually with 'myopic' attributes)
4. Organizational behavior	Strategic (in the game-theoretic sense)	Driven by routines, heuristics, rules etc.
5. Learning	No	Yes (central dimension of analysis)
6. Unit(s) of Analysis	<ul style="list-style-type: none"> - transactions - Strategies - Allocation of information - Allocation of property rights 	<ul style="list-style-type: none"> - Elementary 'bits' of knowledge - Routines and other elementary behavioral traits.
7. Non- economic dimensions of organizations	Not as 'primitive' dimensions	Power, trust, identity building etc.

Clearly there are elements of truth in both the *incentive view* and the *problem solving view*, and bridging them ought to be part of the research ahead.

In any case, the starting point for such a bridge-building has important consequences for the sort of bridge one creates. The starting point embodies a commitment to some assumptions on first order vs. second order effects. Forced to such a choice here we pick the second *weltanschauung* as a provisional point of departure (which also happens to be the least explored one).

We do need to assume *weak incentive compatibility* to begin with (see Dosi and Marengo (1995)) in the sense that there exists some selection pressure which, in turn, generates some connection between performance and rewards. But, well in tune with the behavioral theory of the firm, such connection is likely to be quite loose. However, having that, one precisely focuses (as a first theoretical approximation) on the diverse problem solving characteristics of different

organizations, and only in the second instance one tackles the ways in which incentive structures interact with problem-solving knowledge.

Putting it in another way, the archetype "incentive view" fully censors any competence issue associated with what organizations do and how well they do it –except for issues of misrepresentations of "intrinsic" individual abilities and adverse selection, or incentive misalignment in effort elicitation. As an extreme characterization, given the "right" incentives any firm can make microprocessors as well as Intel, or bioengineering as well as Genetech.

The second, "problem-solving", archetype, on the contrary, censors precisely the incentive-alignment issue. In a sense, all agents are in a first approximation willing to cooperate in order to achieve a common organizational goal, though they might have different views and ideas on how to do it. Conversely, it focuses on the problem-solving efficacy of what they do, especially in so far as what they do does not stem from any differential "ontological" ability but rather from the social division of tasks and their combinations. So, the basic units of analysis are *elementary physical acts*, such as moving a piece of iron from one place to another, and *elementary cognitive acts*, such as applying inference rules. Problem-solving can be straightforwardly understood as combinations of elementary acts, within a procedure, leading to a feasible outcome (e.g. an engine, a chemical compound, etc.)⁷.

At this level of analysis, an organization embodies problem solving in at least three senses. *First*, it displays the operational competencies associated with its actual problem solving procedures (much in accordance with the routines discussed in Nelson and Winter (1982); see also M. Cohen, *et al.* (1996). *Second*, the organizational structure – both the formal and informal ones – determines the distribution of informational inputs of the processing tasks and of the "allowable acts" (i.e. "who can do what to whom") and, as such, it determines all the decompositions of problem-solving procedures that are, so to speak, "legal". *Third*, it shapes the search heuristics for yet-unsolved problems –e.g. a new engine, a new chemical compound, etc.- , that is, broadly speaking, the heuristics of innovative search.

One can also describe it the other way round. Given all the problem-solving procedures leading to a given "outcome" (e.g. an engine, etc. or, for that matter, a theorem, a statement about the purported structure of the observed world) - which might well be an infinite set - one may decompose them in sub-sequences of elementary acts of varying length that may be eventually performed according to various execution architectures (e.g. sequential, parallel, hierarchical...).

Such a *capability-centered view of business firms* straightforwardly finds a core root in those elements of the behavioral theory of the firm emphasizing the view of organization as an "adaptive

⁷ See Marengo et al. (2000) and Marengo and Dosi (2005) for further discussion of this point.

system” which solves problems relying on shortcuts, routines, standard operating procedures (Cyert and March (1963)), which in turns are modified through time via processes of adaptive learning and “problemistic search” (*ibid.* pp 169-176).

The “capabilities”- (or knowledge-) based view builds on such intuitions by exploring in increasing detail (i) the link between organizational knowledge and patterns of organizational behaviors (e.g. organizational routines, etc.); (ii) the forms and outcomes of organizational learning; (iii) the relationship between the latter and the patterns of “cognitive” division of labor within organizations; and (iv) the implications of organizational capabilities in terms of corporate boundaries and corporate performances.

Fundamental questions in the interpretation of the nature of organizational competencies/capabilities concern - as already mentioned - first the *loci* where they reside, and, second, the extent to which they are *additive* in the skills and knowledge of organizational members

In order to highlight some major underlying issues let us dramatize two alternative views. The first archetype, which shall call the *modular view*, holds that "organizational knowledge" is primarily a shorthand for the knowledge of the individuals belonging to the organization. By the same token, in this perspective, strong warnings come - as Simon puts it - against “reifying the organization and talking about it as 'knowing' something or learning' something. [Rather,] it is usually important to specify where in the organization particular knowledge is stored and who has learned it” (Simon, 1991).

Here one of course is far from denying the importance of individual skills as constituents of the broader organizational competencies /capabilities. However, largely in tune with an alternative *collective view* of organizational knowledge, let us suggest that competencies have indeed a dimension which is not easily reducible to those of the individual organizational number: "it is firms, not people that work in firms, that know how to make gasoline, automobiles and computers" (Winter, 1982); and, dynamically, organizational learning is a social phenomena and cannot be reduced to individual learning processes of the members of the organization (more in Marengo, 1996).

Let us suggest here that organizational knowledge is not only incorporated into the heads of organizational members but also into a) a set of routines, other organizational practices and shared representations, and, b) a set of material artifacts which shape intra-organizational relations and individual behaviors. Germane discussions are in Cohen *et al.* (1996) and McGrath and Argote (2000)⁸ who argue that knowledge is embedded in organizational members, tools (technological components), and tasks (organizational goals, intentions and purposes), as well as in the sub-

⁸ See also Argote and Darr (2000) and Argote and Ingram (2000).

networks resulting from the combination of these three elements. Thus, for example, the task network (organizational routines and procedures) incorporate the knowledge about how to perform a sequence of tasks, while knowledge about which member performs which task (division of labor) is embedded in the members' task network.

4. PATTERNS OF LEARNING AND COMPETENCE ACCUMULATION

In acquiring and adapting their competencies/capabilities over a period of time, organizations are doing something that can reasonably be called *organizational learning*. As behavioral and evolutionary theories espouse a process view of decision making, where organizational behavior is based upon routines and is strongly history dependent (Levitt and March, 1988), we could argue that learning is the most fundamental process through which routines are formed and organizational knowledge is created and stored.

In the most general terms, learning may occur in all circumstances whereby agents have an imperfect understanding of the world in which they operate due to a) lack of information about it, b) or, more fundamentally, to an imprecise knowledge of its structure c) or when they master only a limited repertoire of actions in order to cope with whatever problem they face, as compared to the notional set of actions that an omniscient observer would be able to conceive d) or, finally, when they have only a blurred and changing understanding of what their goals and preferences are.

It is straightforward that learning, so defined, is an ubiquitous characteristic of individual and organizational behaviour, especially in cases in which: a) heterogeneous agents systematically display various forms of “bounded rationality”; b) there is a persistent appearance of novelties, both as exogenous shocks, and, more important, as the result of technological, behavioural and organisational innovations by the agents themselves; c) markets (and other interaction arrangements) perform as selection mechanisms; d) aggregate regularities are primarily emergent properties stemming from out-of-equilibrium interactions (a more detailed discussion is in Dosi, Marengo and Fagiolo, 2005).

Here again there is a large literature embracing a wide range of specific intellectual ambitions, methodologies, and techniques. There are a few works that seek to speak directly to managers (a notable and influential example being Senge, 1990). Facilitating certain types of organizational learning is a major objective of quality management, and indeed the large literature on such topics provides another port of entry into the subject of organizational learning and hence to organizational

capabilities. Classics in the area include Deming (1982), and Juran (1989); for a recent assessment of the quality movement see Cole (1999). More recently, consultants and corporate executives have evinced great interest in “Knowledge Management”, a rubric that seems to span a substantial number of distinguishable concerns - but some of these concerns clearly relate to the effort to improve capabilities through learning.⁶ In particular, the quest of improved performance through “benchmarking” and the identification and transfer of “best practices” is an activity that is widely and systematically pursued. Careful studies of the microprocesses of organizational learning have been conducted both in the field as in Hutchins (1991), Adler (1993), Von Hippel and Tyre (1995), Narduzzo et al. (2000) and in the laboratory (see Cohen and Bacdayan (1994) and Egidi (1996), among others).

Let us thus introduce some notions of organizational learning. As to the sources of learning, Levitt and March (1988) distinguish between learning from direct experience, learning from the interpretation of experience itself and learning from the experience of others. The former is mainly learning-by-doing, whose importance has been long recognized by economists and organization scholars, and the latter have outlined the circumstances which lead to higher rates of learning by doing (Reagans, Argote and Brooks, 2005). The second is a kind of cognitive learning which has been discussed by some work in evolutionary theory (Gavetti and Levinthal, 2000, Marengo, 1996, just to quote two examples) and is in some sense the prototypical notion of learning: interpretation of experience leads to the construction and modification of models and theories about the world in which individuals and organizations operate, and in turn such learning is shaped by the organizational structure.

It should be noted however that evolutionary economics considers a further type of learning as prominent: learning through selection. Selection operates both at the population level, whereby the population of organizations adaptively learn new routines, practices and technologies as inferior ones are selected out while superior ones diffuse, and at the level of the individual organization, whereby both the economic incentives and organizational cognitive representations form an intra-organizational selection environment.

In this respect we can pinpoint two alternative archetypes of organizational knowledge, which we call the *modular* and *collective* views, find a mirror image in the representation of organizational *learning*. So, well in tune with the former, Simon (1991) emphasizes that strictly speaking “organizational learning” is only a metaphor since “all learning takes place inside human heads”: thus, “an organization learns in only two ways, (a) by the learning of its members, or (b) by injecting new members who have knowledge the organization did not previously have”.

⁶ On this valuable reference is the special issue on 'Knowledge and the Firm' (R.E. Cole, ed.) of the *California Management Review* (v. 40, Spring 1998).

Conversely, while not denying at all the importance of the foregoing learning modes, a number of authors have attempted to disentangle – both in theory and from empirical evidence - the patterns of change of some sort of *collective intelligence* which organizations embody: see, in particular, Levinthal (2000), and Marengo et al. (2000) on the theory side; Narduzzo et al (2000), Fujimoto (2000), Coriat (1995), Dosi, Hobday and Marengo (2003) for empirical investigations, Warglien (1999) on both.

Of course, both caricatures (the “modular” and the “collective” one) should not have difficulties in acknowledging that diverse organizational structures:

- foster learning by individual members of the organization in certain *directions* and hinder it in others;
- affect the rates at which individuals learn;
- shape the efficacy at which individual skills are exploited and contribute to the overall performance of the organization;
- affect the rates at which individual skills and broader competencies are diffused throughout the organization.

Given all that, the “collective view” also adds dynamic aspects to the idea that there is an intrinsically organizational dimension of organizational knowledge embodied in the routines, hierarchical structures, culture of an organization. Hence:

- organizational learning of whatever origin goes together with changes in routines and possibly organizational structures; and
- “in order to become organizational, the learning that results from organizational inquiry (and, we would like to add, also that absorbed from the environment) must be embedded in the images of organization held in its members’ mind and/or in the epistemological artifacts (the map, memories and programs) embedded in the organizational environment” (Argyris and Schön, 1996)⁹.

Organizational learning is obviously linked with the change of individual skills – sometimes indeed with the loss of some of them -, but also with changes of collective representations, rules, and even of hierarchical set-ups (cf. Narduzzo et al (2000)).

In essence, organizational knowledge and organizational learning ought to be partly considered – in the “collective view” – as an *emergent property*, shaped by the interaction amongst multiple learning/ adjustment processes occurring within the organization itself – ranging from the

⁹ Kieser and Koch (2002) propose an alternative view of organizational learning based on the idea of “transactive memory”. Members of the organization can hold a very specialized knowledge but at the same time they can simulate a joint memory through which it is possible to identify the relevant knowledge and to localize it without the need for sharing it. Routines and formal organizational rules provide the basis for the recombination of the knowledge of specialized members and mechanism like prototyping can represent the means through which they can contribute without extending their cognitive capabilities. See also Lewis, Lange and Gillis (2005) on this point.

levels of the individual, to teams, departments, plants, etc.

Some important implications are also worth emphasizing:

I. the organizational nature of learning is also reflected by its being linked with changes in organizational practices which might not display any evident correlation with what individual “know”;

II. all forms of long-lasting organizational learning imply some mechanisms of codification of knowledge and interaction procedures.

Despite a fundamental incompleteness of codification mechanisms themselves, codification - also in the form of archives, documents, training practices, etc. - (imperfectly) deals with the persistence organizational knowledge well beyond the mobility of organizational members. (For discussions on such a vexed debate cf. Dosi, Marengo and Fagiolo (2005), Pavitt (1987) and *Industrial and Corporate Change*, 2, Special Issue, (2000)).

Relatedly, the very codification of individual skills is a fundamental aspect of the establishment of an organizational memory.

III. Organizational learning is never a purely cognitive process: Rather it finds a crucial ingredient in processes of social adaptation, learning and modification of organizational rules, development of shared interaction patterns, etc.

In many respects, the point mirrors dynamically the relation between technological and organizational competencies we made earlier. Changes in the collective “knowledge of nature” and the procedures to master it - being it related to the design and production of a new machine tool, a new drug, a new type of airplane, etc. - usually go together with changes in skills distributions, information flows, action patterns and sometimes even “cultures” within the organization. But the converse does not necessarily hold: one may indeed observe even significant changes in the social division of labor, in action patterns, etc. without any dramatic change in the technical competencies the organization holds. In fact, this lack of one-to-one correspondence between technological and organizational innovation is also a necessary premise for the comparison of the performances of diverse organizational set-ups, while holding strictly technological knowledge roughly constant. In turn, this bears far-reaching implications in terms of comparative assessment of different organizational archetypes (e.g. “the Japanese firm” vs. “the American firm”, etc.)

IV. Organizational learning is ridden with path-dependencies whereby incumbent

competencies shape and constrain the patterns of future exploitation.

One might not be prepared to subscribe Weick and Westley (1996) extreme view that “organizing and learning are essentially antithetical processes...to learn is to disorganize and increase variety”. Still it should come relatively easy to acknowledge the widespread occurrence of competence traps, and lock-ins into history-reinforced specializations, “way of doing things”, hierarchical arrangements, action patterns (cf. Levitt and March (1988), Cohen and Sproull (1996) Levinthal (2000), Cantwell (2000)).

In the broadest definition, some form of organizational innovation (whether successful or not is a different matter) occurs whenever an organization changes its protocols for the coordination of the information and knowledge distributed across its individual members; for the monitoring and governance of its conflicts of interest across organizational members; and for the distribution of authority assignments. All this, to repeat, might or might not go together with changes in technological competencies and organizational knowledge. Having said that, a crucial but still largely unexplored question is how organizational innovations occur. More specifically:

V. one may distinguish two “ideal types” of learning processes, namely, first, internal learning processes vs., second, acquisition of external competencies and organizational models.

Let us begin with internal learning and notice that, as far as organizational competencies are concerned, one hardly finds any equivalent to R&D search concerning technological innovation. There is no functionally specialized locus invested with “organizational search”. Rather, experimentation and adjustments are diffused throughout the organization. But with that come delicate problems of interpretation of experience, opaqueness in the relations between actions and outcomes, ambiguities in “credit assignments” of successes and failures to sub-units of the organization (Argyris and Schön (1996), Sproull (1981) and Levinthal (2000)).

The problem associated with the acquisition of external practices and competencies are those more generally stemming from forms of indirect experience. First, learning tends to concern primarily codified forms of knowledge. Second, issues of interpretation of “external models” and local adaptation remain fundamental, and with that also the question of the degrees to which one can maintain that there are identifiable, relatively invariant, organizational models that undergo inter-organizational diffusion.

Moreover, both “internal” and “external” forms of organizational learning entail subtle links with organizational structures. So, for example, as Marengo (1996) emphasizes there is an intrinsic tension between knowledge decentralization – as such a fundamental source of variety and

experimentation -, and centralization which guarantees coherence in the exploitation of these diverse forms of learning. So it might well be that higher degrees of decentralized learning are not necessarily conducive to higher degrees of *organizational* learning: they are so, only in so far as the former can be ‘pulled together’ and made coherent with the overall organizational learning process.

5. INTERPRETATIVE IMPLICATIONS AND EMPIRICAL PREDICTIONS

To begin with, note that the whole foregoing discussion suggests that the interpretation of observed corporate structures and performances ought to concern primarily the relationships between the internal working of firms themselves and the interactive environment in which they operate.

Indeed , one of the fundamental propositions shared by evolutionary economics and the “capability view “ of business organizations is that firms have ways of doing things that show strong elements of continuity. A related and equally fundamental proposition is that firms have distinctive ways of doing things: firms are generally heterogeneous even in the ways they accomplish functionally similar tasks, not to mention the large-scale differences that separate the chemical firm, the automobile manufacturer, the mass retailer, etc.. Taken together, these propositions set the stage for the dynamic interplay of the evolutionary triumvirate of variation, selection, and retention. Variety in the form of heterogeneous firm behavioral patterns and structures gives the market selection process something to work on. If variety is not a transient property, bound to disappear as selection does its job, but on contrary is persist, then market selection and promotion of successful firms ought to bear significant systemic consequences over time.

Early roots of the idea go back to Edith Penrose’s (1959) notion that the profitability and the growth of a firm should be understood in terms of its possession and development of unique and idiosyncratic resources. It is nowadays shared albeit with different interpretation by “resource-based” and “capability-” or “knowledge-based” views of the firm.

Scholars who identify themselves with the “resource-based view” examine the question of what sorts of resources confer lasting competitive advantages, how these advantages can be extended and “leveraged”, and what considerations prevent the elimination of the gap between the cost of the resources and the market value of the output produced.

Many discussions in this vein seem to imply that firm resources are “idiosyncratic” in only a weak sense; they are relatively discrete and separable from the context of the firm and are the sorts of things that would naturally carry a market price correctly reflecting their value for any

organization. On this interpretation, the resource rubric does not subsume capabilities. Some authors, notably Dierickx and Cool (1989), offer a sharply contrasting view, suggesting that competitively significant resources are gradually accumulated and shaped within the firm, and are generally non-tradable. Unique, difficult-to-imitate capabilities acquired in a protracted process of organizational learning are examples of the sort of resources they see as sources of competitive advantage. Needless to say, an implication of the “capability view” discussed above is that strong idiosyncratic differences across firms ought to be widespread, notwithstanding the powerful influence that specific types of problem-solving activities exert upon the structure and boundaries of business organizations. Moreover, another fundamental implication is that idiosyncratic capabilities persistently shape corporate performances.

Let us first consider the idea that the nature of problem-solving activities is central to the explanation of organizational forms. If this is so, taxonomic exercises on “types of problems” ought to map into corresponding taxonomies of organizational forms.

Consider as a sort of extreme reference the Taylorist/Fordist organizational archetype. In the foregoing terminology, the decomposition of the overall design/production/distribution problem is, so to speak, solved “top-down” and “once-and-for-all”, involving a first “cut” of broad sub problems (e.g. production) attributed to the various divisions and a much finer decomposition at operational level into minute tasks to be tackled in highly routinized fashions.

At the opposite extreme, however, a much less studied archetype is when organizational design problems cannot be solved once-and-for-all and therefore the distribution of problem-solving knowledge is bound to be much more fluid. Indeed, Dosi, Hobday and Marengo (2003) consider six ideal types of organizational forms, ranging from the pure functional form, with separated functional departments, to the project-based form, where the entire organization is dedicated to one or more complex projects and there are no clear-cut functional boundaries.

Within such a taxonomy, they present an analysis of the co-evolution of problem-solving knowledge and organizational design in complex, non-routinized and non-stable tasks. In particular, they focus on the so called *complex product systems* (CoPs), broadly including complex capital goods, consisting of many interconnected and customized elements, which sometimes exhibit even emergent properties during their production- i.e. unpredictable properties which reveal themselves only at the stage of system engineering and integration, or later during their actual use.

CoPs include relatively traditional goods, such as train engines, but also mobile communication systems, military systems, corporate information technology networks, aircrafts, air traffic control systems, tailored software packages, and many others. Their complexity is also due to

the number of components and inputs required, the presence of many design choices, the degree of customization and the breadth and depth of knowledge involved in design and production.

The project-based form, one argues, seems to be well suited to the problem-complexity and fuzzy decomposition tasks characteristics of CoPs. A good illustration of how the nature of technical/organizational problems and of the related knowledge bases shape organizational arrangements stems from the comparison of the role of the project manager under “project-based” form, on the one hand, and under traditional “functional” patterns of division of labor, on the other. In the former mode, “decompositions” tend to be rather loose and credit assignments/incentive schemes rather ill-defined. This, however, demands a core role for the project manager, who represents the main channel of communication and is pivotal in the coordination and integration of specialist functions and would-be solutions to sub-problems. Indeed, the evidence suggests that the overall project management is undertaken by distinct firms which perform as *system integrators* (cf. Brusoni, Prencipe and Pavitt (2001)).

At the other end of the spectrum, one finds integrated organizations which may well produce complex products but do so under rather precisely defined decompositions, lines of command and incentive schemes (think of the “classic” Fordist automobile industry). In these circumstances “project management” is nothing but one of the many functions within the firm.¹⁰

Another promising domain to which the “capability view” can be fruitfully applied regards the proximate ‘boundaries’ of the firm. It is well known that almost all large firms and a good deal of small ones are multiproduct, both in a ‘vertical’ sense, i.e. firms produce some of their own inputs, and in a ‘horizontal’ sense i.e. they produce more than one output. Moreover, as Rumelt (1974 and 1982) has shown, after World War II, at least in the U.S., the largest corporations have increasingly diversified their production. Between 1949 and 1974 “the proportion of the largest 500 industrial firms that were substantially diversified more than doubled, rising from 30 to 63 per cent” (Rumelt 1982). Using a sample of 100 firms and the definition of categories of firms ranging from single business to unrelated business, based upon Rumelt (1974), he observes a steady decline of the number of single product firms and a rapid growth of diversified ones. A similar pattern is described by Montgomery (1994) for the period 1985-1992. She also cites evidence about other countries (Japan and UK) which are in line with this conclusion.

There are of course different theoretical candidates for the explanation of such empirical patterns, including these broadly deriving from “agency” theories (cf. the discussion in Holmstrom and Roberts (1998), transaction cost considerations - limitedly to *vertical* integration - (Williamson

¹⁰ In the literature one begins to find also exploratory attempts to identify, so to speak “bottom-up”, the seemingly viable combinatorics amongst multiple inter-related organizational traits: see, on automobile manufacturing, McCarthy et al. (1997).

(1975), (1985) and (2000) , and again Holmstrom and Roberts (1998)), and the (partly overlapping) ‘resource’ and ‘capabilities’ views. Here , let us focus on the achievement of the latter (see Montgomery (1994), Rumelt (1982), Markides and Williamson (1994), Bettis (1981), Palepu (1985), Zollo and Reuer (2001), Teece et al (1994)).

In particular, Teece et al. (1994) stress three fundamental characteristics of modern corporations , namely, (i) their multi-product scope; (ii) the non-random distribution of product portfolios of firms conditional on their principal activities; (iii) the stability in the composition of firms’ portfolios over time. This work suggests that firms are ‘coherent ’ in their portfolios in so far as they diversify by adding activities which share with the existing ones some market or technological characteristics: they build on the capabilities which they already have .

Teece et al (1994) make use of two measures of “coherence”. The first one indicates the degree to which an activity i is related to all the other activities of the firm. Relatedness is defined by the comparison between the observed number of corporations which are active in any combination of industries with the number of them that would be expected under the hypothesis that diversification be random . The second measure of coherence refers to the strength of association between activity i and its closest neighbors.

The empirical analysis, based on 1987 TRINET data base, largely corroborates the notion of ‘coherent diversification’ .The suggested interpretation is that the boundaries of the firm - and thus the predicted degrees of diversification and coherence - can be understood in terms of characteristics of (i) learning, (ii) path-dependencies, (iii) technological opportunities, (iii) selection environments, and in terms of (v) firms endowments of complementary assets. Thus, for example, rapid learning, rich technological opportunities and tight path-dependencies will correspond to (nearly) single product, fast-growing, firms. Conversely, within a context of rapid learning, converging technological trajectories and tight selection one can expect to see coherent diversifiers. Moreover , the interpretation suggests that unrelated diversification is likely to be viable only under conditions of weak market selection.

A complementary analysis is by Chang (1996) who studies both diversification and divestment decisions through the examination of the entry-exit patterns, triggered by ‘satisfying ‘ criteria of performance and driven by the human resource profiles which the organization embody. The evidence, from the TRINET and COMPUSTAT databases, with some caveats, supports the behavioral, knowledge-driven, model of diversification.

So far we have discussed the evolutionary and capability-centered views with an emphasis on the determinants of the *horizontal* boundaries of the firm. Let us now focus on the *vertical* ones. A well-known interpretation of the latter is in terms of relative costs of governing market-mediated vs.

hierarchically coordinated transactions (Williamson (1975), (1985), (2000)). However, while not denying the importance of transaction cost considerations, a few studies have begun to explore resource-/capability-based explanations of the choices between market and other forms of governance of input/output flows (see, among others, Argyres (1996), Jacobides (2000), Jacobides and Hitts (2005), and Delmas (1999)). The central conjecture here – as well as in the earlier discussion of the governance of CoPs – is that the degrees of vertical integration and the selection of governance forms is shaped by the nature and distribution of problem-solving knowledge. Consider for example Delmas (1999), reporting a study of the waste industry, characterized by high technological and regulatory uncertainty. Her evidence corroborates the idea that a major determinant of the vertical boundaries of the firm rests in the distribution of capabilities across segments of activities and across firms: “firms will rely on alliances for tacit technologies in highly uncertain environments. Although incurring high transaction costs, collaborations are perceived as possessing the flexibility and the adaptability necessary to build competencies and to gain a competitive advantage” (p. 664).

So far we have mentioned *some* of the interpretative implication of a “knowledge centered” theory of the firm and the related empirical predictions. But what are the implications of such a theory for strategic management? That is if the theory holds, what does it predict that manager do? And at which variables and processes *should* they look in order to improve organizational performance?

Indeed, an important theme in the recent strategy literature is the idea that the most distinctive role of the business firms in general and of strategic management in particular is the way they bring knowledge to bear on productive effort. This and related ideas have been discussed under the heading of the “knowledge-based” theory of the firm (Grant, 1996, Kogut and Zander, 1992, and Dosi and Marengo, 1995). As with the notion of resources, this discussion converges with the capabilities discussion in so far as knowledge is conceived as know-how embedded in the organization’s activities, as opposed to passive, library-like stocks in the heads of participants¹¹.

In this perspective, as forcefully argued by Teece, Pisano and Shuen (1997), strategic management has a key role in shaping

- (i) *organizational processes*, by the establishment of specific organizational structures and, equally important, by introducing *and by breaking* particular organizational routines;
- (ii) the *position* of the firm (broadly defined to cover their specific assets, their locations along the value chain and their relationship with suppliers and customers); and,
- (iii) *paths* (i.e. the patterns of change in the former two sets of characteristics).

¹¹For broader discussion of the recent emphasis on capabilities in the strategic management literature, see Rumelt et al. (1991), Teece et al. (1997), and Stalk et al. (1992).

These activities are indeed at the core of what Teece, Pisano and Shuen (1997) call the *dynamic capabilities* of the firm.

Moreover, managerial tasks involve:

- (iv) presiding over the *replication* within the organization of well-performing bundles of routines (Szulanski and Winter, 2002, Winter, 2005);
- (v) defining the *cognitive frames* and the *aspiration levels* of the organization (that is also the shared “representations” and perceived “fitness landscapes”)¹², and
- (vi) mastering the persistent and tricky dilemmas *between exploitation and exploration*, as March (1991) put it, that is between the improvement of what the organization “is already good at”, on the one hand, and the search for more radical innovative opportunities, on the other.

These tasks, in turn, involve the “rethinking of traditional management tools – such as team staffing and mobility, incentive policies and information storage and retrieval – conceptualizing them as tools for setting the parameters of intra-firm (exploitation/exploration) dynamics” (Warglien, 1999). In such a context, the management of a *variety of exploration trajectories* implies a view of an organization as an “artificial ecology” (Levinthal, 2000) wherein managers look somewhat like contemporary bioengineers trying to “fine tune” ex ante the discovery of new traits/biochemical properties, etc. and ex post test and select among them.

It is important to notice that this perspective on organization, organizational learning and their management clearly shifts the focus of analysis from “clever strategizing” against market rivals to the process of problem-solving and organizational governance and, dynamically to capability-enhancing strategies (Tidd, Bessant and Pavitt, 1997 is an insightful and thorough management text in this perspective).

6. CONCLUSIONS AND RESEARCH TASKS AHEAD

We concluded the previous section by outlining how behavioral, evolutionary and capability theories sketch a vision of managerial (but more in general human) agency which is indeed in sharp contrast with traditional “rational” decision theory. Behavioral theory has pioneered an impressively rich and stimulating new research line on the topic, which in our opinion has still to be fully accomplished in some of its most important consequences. Consider for instance, as a useful contrast, how in economics and other disciplines that employ the theoretical tools of decision

¹² For some impressionistic cf. Massini, *et al.* (2002)

theory, key assumptions about skills and capabilities often remain implicit. Take, for example, the simple and basic tool called ‘pay-off matrix’: an array with choice alternatives on one side, ‘states of the world’ (or opponent choices) on the other, and the outcome utility values in the cells. Typically, choices are actions or entail actions. While in some cases the choices listed are everyday actions that are familiar and perhaps available to the typical reader of the analysis (‘carry umbrella’), in other cases they emphatically are not (‘conduct seismic tests’, ‘shut down nuclear reactor’). In these latter cases, the availability of the actions is apparently presumed to inhere in the identity of the decision maker, and this presumption goes unnoticed. Arguably, the development of the menu of future choices would be a candidate for the first exercise introducing the topic of sequential decision analysis. In fact, the question of where the menu comes from is generally ignored.

Further, choices available to the decision maker are, in decision theory, feasible by definition: any uncertainty attached to the consequences of *trying* to take specific action (the sort of choice that is in fact readily available) is subsumed in the uncertainty attached to states of the world. This is in principle an inconsequential formal convention, but in practice significant questions of feasibility tend to get swept under the carpet in the process of abstracting an analyzable problem from a real situation. The rich sequences of unfolding events that often follow a failed attempt-sequences that may involve wholly unanticipated outcomes and learning, among other things- could be represented in a sufficiently elaborate decision-theoretic formalism, but generally are not.

These habits of decision-theoretic thought contribute to the obscurity in which capabilities issues have long resided in economic analysis. The entries in the menu of choices are specified and promptly taken for granted, one situation at a time- even when choices involve complex actions. Little is seen of the costly and protracted learning process that place alternatives on the menu. The consequences for future menus of the choices made today, for example the likely strengthening of the capabilities that are exercised and the likely withering of those are not, are generally abstracted away. These practices leave a major gap in the understanding of behavior, a gap best filled, perhaps, by the use of other tools than decision theory.

Just as the market system accomplishes remarkable feats of coordination without the aid of a central plan, organizational learning produces the coordinated performances of organizational capabilities without the aid of a recipe and without the aid of a comprehensive plan, optimized or not. According to the mainstream tradition in economics, economic actors do not have to understand the price system for it to work. Similarly, an organization produces coordinated activity without anyone knowing how it works, although participants may well be aware of managerial intentions to achieve coordination. There are far more of these details than any amount of

observation will uncover or any imaginable set of manuals will ever record. Tentative choices that are actually incompatible or substantially subversive of the overall performance get rooted out in the course of learning, not in response to the imperative “follow the recipe!” but in response to “try something different!”. Choices compatible with the overall performance are allowed to stabilize and become habitual, without either the choices or the habits necessarily being recognized as such along way. Finally, in the well-established capability, the activity in progress is its own best and only operating manual.

In all that one role of management is to painstakingly steer the process at the level discussed above while both recognizing the weight of the path-dependencies in knowledge and organizational practices inherited from the past and trying to detect the “windows of opportunities” ahead.

Certainly, there is no general recipe for the managerial success (and there *cannot* be). Simply, consider the foregoing remarks as pointing at *managerial heuristics* and *diagnostic tools* which, in our view, are at the core of the dynamic capabilities of business organizations.

On the interpretation side, it is time to for a more complete view of organizational processes taking explicitly on board first, their “political” aspects, conflicts and their *quasi-resolution*. This is where further structure in the “garbage can” of organizational behaviors can be identified. And it is also where refinements upon the seminal behavioral theory of the firm can offer accounts of (imperfect) incentive governance in organizations which do not rely upon empirically implausible assumption on individual rationality and collective equilibria.

Second, another very important part of the original “behavioral theory” has been almost entirely neglected by subsequent developments and ramifications. This concerns those organizational capabilities associated with procedures leading to organizational actions with an immediate economic relevance, such as *setting the price, a desired output, a policy, a schedule for expansion investments*. Cyert and March (1963) still offer one of the best examples of a sequence of routines leading to price setting. Little work has been done in this area since. Progress here, however, is likely to yield fascinating returns also concerning the predictions which organization theory has to offer in terms of *micro* and *aggregate* properties, such as production, prices, investments. Indeed a major frontier bridging organizational and economic analysis.

REFERENCES

- Adler, P.S. (1993), ‘The Learning Bureaucracy: New United Motors Manufacturing, Inc.’ in B. M. Staw and L. L. Cummings (eds.), *Research in Organizational Behavior*, 15:111-194, Greenwich, CT: JAI Press.
- Anderson, P., K. Arrow and D. Pines (eds.) (1988), *The Economy as an Evolving Complex System*, Redwood City, CA: Addison-Wesley.

- Argote L. and Darr E.(2000), 'Repositories of Knowledge in Franchise Organizations' in Dosi, Nelson and Winter (2000), 51-68.
- Argote, L. and Ingram, P. (2000), 'Knowledge Transfer: A Basis for Competitive Advantage in Firm', *Organizational Behavior and Human Decision Processes*, 82: 150-169.
- Argyres N. (1996). 'Evidence on the role of firm capabilities in vertical integration decisions', *Strategic Management Journal*. 17: 129-150
- Argyris, C. and Schön, D. (1996). *Organizational Learning II. Theory, Method, and practice*, Reading MA, Addison-Wesley.
- Bettis, R.A. (1981). 'Performance Differences in Related and Unrelated Diversified Firms', *Strategic Management Journal*, 2, pp. 379-393.
- Brusoni, S., Prencipe, A. and K. Pavitt (2001). 'Knowledge Specialization and the Boudaries of the Firm :Why Firms Know more than they Make ?' *Adiministrative Science Quarterly*, 46: 597-621.
- Cantwell, J. (2000). 'Technological lock-in of large firms, since the interwar period', *European Review of Economic History*, 4: 147-174.
- Carroll, G. R., (1997), 'Long term evolutionary change in organizational populations: Theory, models and empirical findings in industrial demography,' *Industrial and Corporate Change*, 6: 119-143.
- Chang S.J. (1996). 'An evolutionary perspective on diversification and corporate restructuring. entry, exit, and economic performance during 1981-1989', *Strategic Management Journal*, 17: 587-611.
- Cohen, M. D. and P. Bacdayan (1994). 'Organizational routines are stored as procedural memory', *Organization Science*, 5: 554-68.
- Cohen, M. D., Burkhart R., Dosi G., Egidi M., Marengo L., Warglien M, Winter S. (1996), 'Routines and Other Recurring Action Patterns of Organizations: Contemporary Research Issue', *Industrial and Corporate Change*, 5: 653-699.
- Cohen, M. D. and Sproull, L. S. (Eds.) (1996), *Organizational Learning*, Thousand Oaks CA, Sage Publications.
- Cole, R.E. (1999), *Managing Quality Fads: How American Business Learned to lay the Quality Game*, Oxford+: Oxford University Press.
- Coriat, B. (1995), 'Variety, routines and networks: the metamorphosis of the Fordist firms', *Industrial and Corporate Change*, 4: 205-28.
- Coriat, B. and G. Dosi (1998), 'Learning how to govern and learning how to solve problems: On the co-evolution of competences, conflicts and organizational routines', in Chandler, A., Hagström, P. and Sölvell, Ö. (eds.). *The Dynamic Firm*, Oxford/New York, Oxford University Press.
- Cyert, R.M. and J. March (1963), *A Behavioral Theory of the Firm*, Englewood Cliffs, NJ: Prentice Hall.
- Delmas, M. 1999 "Exposing Strategic Assets to Create New Competencies: The Case of Hazardous Waste Management Industry," *Industrial and Corporate Change*, 8: 635-672.
- Deming, W.E. (1982), *Out of the Crisis*, Cambridge, Mass.: MIT Center for Advanced Engineering Study.
- Dierickx, I. and K. Cool (1989), "Asset stock accumulation and sustainability of competitive advantage", *Management Science*, 35: 1504-1511.
- Dopfer, K.(ed.). (2005), *The Evolutionary Foundations of Economics*, Cambridge: Cambridge University Press.
- Dosi, G. (1995), 'Hierarchies, market and power: some foundational issues on the nature of contemporary economic organizations', *Industrial and Corporate Change*, 4: 1-19.
- Dosi G., Hobday M. and Marengo L. (2003), Problem-Solving Behaviors, Organizational Forms and the Complexity of Tasks, in C.E. Helfat (ed.) *The Blackwell/strategic Management*

- Society Handbook of Organizational Capabilities: Emergence, Development and Change*, Oxford, Blackwell, 167-192.
- Dosi, G., D. Levinthal and L. Marengo (2003), 'Bridging contested terrain: linking incentive-based and learning perspectives on organizational evolution', *Industrial and Corporate Change*, **12**: 413-436.
- Dosi G., Marengo L. (1995), Toward a Theory of Organizational Competencies, in R.W. England (ed.), *Evolutionary Concepts in Contemporary Economics*, Michigan University Press, 157-178.
- Dosi, G., L. Marengo and Fagiolo, G. (2005), 'Learning in Evolutionary Environments', in Dopfer, K.(2005), 255-328.
- Dosi, G. R. Nelson and S. Winter (eds.) (2000), *The Nature and Dynamics of Organizational Capabilities*, Oxford, Oxford University Press.
- Egidi, M. (1996), 'Routines, hierarchies of problems, procedural behaviour: some evidence from experiments', in K. Arrow, E. Colombatto, M. Perlman and Ch. Schmidt (eds.), *The rational foundations of economic behavior*, London, McMillan, 303-332.
- Fujimoto T. (2000). 'Evolution of Manufacturing Systems and Ex Post Dynamic Capabilities', in Dosi et al. (eds.)(2000), 244-279.
- Gavetti, G., and Levinthal, D.E. (2000), 'Looking Forward and Looking Backward: Cognitive and Experiential Search', *Administrative Science Quarterly*, **45**: 113-137.
- Grant, R.M. (1996). 'Toward a knowledge-based theory of the firm', *Strategic Management Journal* **17**: 109-122.
- Hodgson, G. (1993), *Economics and Evolution*, Cambridge: Polity Press; Ann Arbor, MI: University of Michigan Press.
- Holmstrom, B. and Roberts J. (1998) 'The Boundaries of the Firm Revisited', *Journal of Economic Perspectives*, **12**: 73 – 94.
- Hutchins, E. (1991). 'Organizing work by adaptation', *Organization Science*, **2**: 14-39.
- Jacobides, M.G., (2000), 'Capabilities, Transaction Costs and Limits to Growth: A formal Model of Scope and Profitability in Mortgage Banking'. *Working Paper, Wharton Financial Institutions Center*, The Wharton School
- Jacobides M.G. and L.M. Hitt, (2005) "Losing Sight of the Forest for the Trees? Productive Capabilities and Gains from Trade as Drivers of Vertical Scope", *Strategic Management Journal*, **26**. 1209-1227
- Juran, J. M. (1989). *Juran on Leadership for Quality. An Executive Handbook*, New York: Free Press.
- Kieser A. and Koch U. (2002) 'Organizational Learning through rule adaptation: from the behavioral theory to transactive organizational learning' in Augier M. E. and J.G. March (eds.), *The Economics of Choice, Change, and Organization: Essays in Memory of Richard M. Cyert*, Cheltenham, Edward Elgar.
- Kogut, B. and U. Zander (1992). 'Knowledge of the firm, combinative capabilities, and the replication of technology', *Organization Science*, **3**: 383-97.
- Kogut, B. and Zander V. (1996). 'What Firms Do? Coordination, Identity and Learning', *Organization Science*, **7**:502-18.
- Kreps, D.M. (1996), 'Markets, hierarchies and mathematical economic theory', *Industrial and Corporate Change*, **5**: 561-596.
- Lane, D. (1993), 'Artificial worlds and economics', Parts I and II, *Journal of Evolutionary Economics*, **3**: 89-107 and 177-197.
- Lesourne, J. and A. Orléan, eds, (1998), *Advances on Self-Organization and Evolutionary Processes*, Paris, Economica.
- Levinthal, D. (2000). 'Organizational Capabilities in Complex Worlds', in Dosi., Nelson and Winter (eds.), 363-379.

- Levitt, B. and March J.G. (1988). 'Organizational Learning', *Annual Review of Sociology*, 14: 319-340.
- Lewis, K., D. Lange and L. Gillis (2005) 'Transactive Memory Systems, Learning, and Learning Transfer', *Organization Science*, 16: 581-98.
- March, J.G. (1991), 'Exploration and Exploitation in Organizational Learning', *Organization Science*, 2: 71-87.
- Marengo, L. (1996). 'Structure, Competence and Learning in an Adaptive Model of the Firm', in G. Dosi and F. Malerba (Eds.), *Organization and Strategy in the Evolution of the Enterprise*, London, Macmillan, 124-154.
- Marengo, L., Dosi, G., Legrenzi, P. and Pasquali, C. (2000). 'The Structure of Problem-solving Knowledge and the Structure of Organizations', *Industrial and Corporate Change*, 9: 757-788.
- Marengo, L., and G. Dosi (2005), "Decentralization and market mechanisms in collective problem-solving", *Journal of Economic Behavior and Organization*, 58: 303-326.
- Markides C.C. and Williamson P.J. (1994). 'Related Diversification, Core Competencies and Corporate Performance', *Strategic Management Journal*, 15: 149 165.
- Massini S., Lewin A.Y., Numagami T. and Petigrew A.M. (2002) "The evolution of organizational routines among large Western and Japanese firms", *Research Policy* 31: 1333-1348.
- McCarthy I., Leseure M., Ridgeway K. And Fielles N. (1997), 'Building a Manufacturing Cladogram', *International Journal of Technology Management*, 13: 2269-96.
- McGrath, J.E. and Argote, N. (2000), "Group Processes in Organizational Context" in M.A. Hoggs and R.S. Tindale (Eds.), *Blackwell Hanbook of Social Psychology, Group Processes (Vol.3)*, Oxford, UK: Blackwell.
- Metcalf, S. (1992), 'Variety, structure and change: An evolutionary perspective on the competitive process', *Revue d'Economie Industrielle*, 65: 46-61.
- Montgomery C.A. (1994). 'Corporate Diversification', *The Journal of Economic Perspectives*, 8: 163-178.
- Narduzzo, A., Rocco, E and Warglien, M. (2000) 'Talking about Routines in the Field', in Dosi, Nelson and Winter (2000), 27-49.
- Nelson, R. R. (1995), 'Recent evolutionary theorizing about economic change', *Journal of Economic Literature*, 33: 48-90.
- Nelson, R. and S. Winter (1982), *An Evolutionary Theory of Economic Change*, Cambridge, MA, Belknap Press of Harward University Press.
- Palepu K. (1985). 'Diversification Strategy, Profit Performance and the Entropy Measure' , *Strategic Management Journal*, 6: 239-255.
- Pavitt, K. (1987). 'The Objectives of Technology Policy', *Science and Public Policy*, 14: 192-198.
- Penrose, E. (1959). *The Theory of the Growth of the Firm*, New York: Wiley.
- Reagans, R., L. Argote and D. Brooks (2005), "Individual Experience and Experience Working Together: Predicting Learning Rates from Knowing Who Knows What and Knowing How to Work Together", *Management Science*, 51: 869-881.
- Rumelt R.P. (1974). *Strategy, Structure and Economic Performance*, Boston, Harvard Business School.
- Rumelt R.P. (1982). 'Diversification Strategy and Profitability' , *Strategic Management Journal*, 3: 359-369.
- Rumelt, R. D. Schendel and D. Teece. (1991). 'Strategic management and economics', *Strategic Management Journal*, 12: 5-29.
- Senge, P.M. (1990), *The Fifth Discipline: the Art and Practice of the Learning Organization*, New York: Doubleday.
- Silverberg, G. and B. Verspagen (2005), 'Evolutionary theorizing on economic growth', *Dopfer (2005)*, 506-538.

- Simon, H.A. (1991). 'Bounded Rationality and Organization Learning', *Organization Science*, 2: 125-134.
- Sproull, L. S. (1981). 'Beliefs in Organizations', in P.C. Nystrom and W.H. Starbuck (1981), *Handbook of Organizational Design*. Oxford, UK: Oxford University Press.
- Stalk, G., P. Evans and L. E. Shulman (1992). 'Competing on Capabilities : the New Rules of Corporate Strategy', *Harvard Business Review*, March-April : 57-69.
- Szulanski G. and Winter S. (2002) 'Getting it Right the Second Time', *Harvard Business Review*, January: 63-69.
- Teece, D.J., Rumelt R., Dosi, G., Winter S. (1994) 'Understanding corporate coherence. Theory and Evidence', *Journal of Economic Behavior and Organization* 23: 1-30.
- Teece, D.J., Pisano G. and Shuen, A. (1997). 'Dynamic capabilities and strategic management', *Strategic Management Journal*, 18: 509-33; a revised version is published in Dosi, Nelson and Winter (2000), 334-361.
- Tidd, J., Bessant J., Pavitt, K. (1997). *Managing Innovation*, New York, Wiley.
- Von Hippel, E., and Tyre, M.J. (1995). 'How learning by doing is done. Problem identification in novel process equipment', *Research Policy*, 24: 1-12.
- Warglien M. (1999). 'The evolution of competencies in a population of projects: a case study', Sant'Anna School of Advanced Studies, LEM, Pisa, Italy: *Dynacom working paper series*.
- Weick, K. E. and Westley, F. (1996). 'Organizational Learning: Affirming an Oxymoron', in S. R. Clegg, C. Hardy and W. R. North (eds.), *Managing Organizations*, Thousand Oaks CA, Sage Publications.
- Williamson O.E. (1975) *Markets and Hierarchies: Analysis and Antitrust Implications*, New York, The Free Press.
- Williamson O.E. (1985) *Economic Institutions of Capitalism*, New York, The Free Press
- Williamson O.E. (2000) 'Strategy Research: Governance and Competence Perspective' *Strategic Management Journal*, 20: 1087-1108; now in N. Foss and V. Mahnke (eds.), *Competence, Governance, and Entrepreneurship: Advances in economic strategy research*, Oxford U.P.
- Winter, S.G. (1982). 'An Essay on the Theory of Production', in H. Hymans (Ed.), *Economics and the World around It*, Ann Arbor, University of Michigan Press, 55-93.
- Winter, S.G. (2005) 'Toward and Evolutionary Theory of Production', in Dopfer (2005), 223-253.
- Zollo, M. and Reuer, J.J. (2001) 'Experience Spillovers across Corporate Development Activities', Wharton School Center for Financial Institutions, University of Pennsylvania, Center for Financial Institutions Working Papers.