Competences, Capabilities and Corporate Performances

Dynacom Project

Final Report prepared by Giovanni Dosi, Benjamin Coriat and Keith Pavitt with the help of all the Dynacom Researchers.

November 2000

Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, via Carducci 40, Pisa, Italy, Tel. +39-050-883343, Fax +39-050-883344, E-mail: lem@sssup.it.

ABSTRACT

The project addresses the nature of corporate organizations, their “competences” and “capabilities” and their learning patterns. The analysis is undertaken at different levels of observations - ranging from firm-level studies of the patterns of technological and organizational change all the way to broad cross-national comparisons .

Along with a wide set of empirical investigations, the projects explore the theoretical implications of a competence/capability based view of the firm.

Finally, drawing from the observed relationships between competences and various indicators of organizational performances, the project is able to suggest a few "diagnostic" consequences for the European economy together with some policy implications.

1. BACKGROUND AND OBJECTIVES OF THE PROJECT: AN INTRODUCTION.

The analysis of the nature of corporate organizations, their “competences” (or “capabilities”; see below for a finer distinction), their learning patterns and their embeddedness into broader national and sectoral institutions is possibly one of the most alive areas of microeconomic research with important ramifications into multiple domains of investigation including the relationships between technological and organizational innovation, the vertical and horizontal boundaries of the firm and the role of institutions. Indeed, it is our general conjecture is that the nature of business organization, their competences/ capabilities and their strategic orientation – embedded as they are in specific national institutions – are crucial not only for the performance of individual firms but also for the competitiveness and growth of whole nations and regions.

These are indeed the topics which the **Dynacom Project** has addressed. And, at the risk of immodesty, we would like to claim significant advances in many of these areas.

It would be futile to try to provide a detailed account in this Final Report of the of all individual contributions. Rather we shall, first, sketch a general interpretative framework and, second, flag out a few particularly relevant theoretical developments, empirical findings, particularly relevant and controversial issues and policy implications stemming from the Project.

For convenience, our presentation shall be divided into three parts, focused upon the nature of corporate competences, including the firm -, sectoral and institutional specificities (Section 2.1), the patterns of competence accumulation (Section 2.2), the theoretical implications of a competence/ capability perspective on the theory of the firm (Section 2.3). (The distinction is however largely artificial in that most contributions consider aspects of more than one of the foregoing domains of analysis). Finally, in section 3, building on the relationships between competences and various indicators of organizational performances, we shall outline a few "diagnostic" consequences for the European economy together with some major policy implications.

The **Dynacom Project** happens to find parts of its scientific roots into a pre-existing international network, which emerged on our largely overlapping issues under a partly overlapping coordination team. The ensuing book, edited by G. Dosi, R. Nelson and S. Winter on *The Nature and Dynamics of Organizational Capabilities* (Oxford/ New York, Oxford University Press, 2000), owes its completion to the **Dynacom** "invisible college" and **Dynacom** coordination - even if none of its contributions owes financial debts or "deliverable" commitments to the present TSER project. As such, it witnesses - we believe - the richness of scientific externalities which might grow notwithstanding cumbersome institutional constraints.

In the following, when necessary, we shall refer to the set of the foregoing contributions, as “book” or “part A”. Conversely, the ensemble of contributions, including directly committed "deliverables" as well as complementary scientific investigations, shall be labeled as "Part B" - covering an even wider set of works materially sponsored to varying degrees by the **Dynacom Project**.

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3. NATURE, DYNAMICS AND PERFORMANCE OUTCOMES OF FIRMS COMPETENCES/ CAPABILITIES[1]

It is familiar enough that business firms and other organizations "know how to do things" – things like building automobiles or computers, or flying us from one continent to another. On second thoughts, what does this means? Is there not a sense in which only a human mind can possess knowledge? If so, can this proposition somehow be squared with the idea that organizations know how to do things? And if organizational knowledge is a real phenomenon, what are the principles that govern how it is acquired, maintained, extended, and sometimes lost?

Our focus here is on the particular forms of organizational knowledge that account for the organization's ability to perform and extend its characteristic "output" actions – particularly, the creation of a tangible product or the provision of a service, and the development of new products and services. The range of activities we have in mind is broad, embracing for example automobile manufacturing, brain surgery, identifying and developing new pharmaceuticals, putting on an effective art exhibition, and shipping a package across a continent. Pending a more thorough discussion of terminology, we identify the term "organization competences or capabilities" with the know-how that enables organizations to perform these sorts of activities.

In a first instance, let us just build on the idea that o*rganizational knowledge* is a fundamental link between some *collective pool of knowledge/ skills/ incentives opportunities, on the one hand, and the rates, directions and economic effectiveness of this exploration/ development/ exploitation*, on the other.

In turn, distinctive organizational competences/ capabilities bear their importance insofar as they can be shown to persistently shape the destiny of individual firms - in terms of e.g. profitability, growth, probability of survival-, and, at least equally important, the patterns of change of broader aggregates such as particular sectors and whole countries. [For a more in-depth dimension of organizational microfoundations of competitiveness and growth, cf. among others, Coriat and Dosi (1998a); see also below].

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[1] Many more details of the interpretation which follows may be found in the Introduction to Dosi, Nelson and Winter (2000)(A); Marengo et al (2000](B); Dosi and Marengo (1999)(B); Coriat [2000a (A) and 2000b (B)] upon which this report is partly based. For critical essays of the literature within **Dynacom** cf. Weinstein and Azoulay (1999)(B) and Bezza (1999)(B)

3.1. ORGANIZATIONAL COMPETENCES/ CAPABILITIES.

To be *capable* of some thing is to have a generally reliable capacity to bring that thing about as a result of intended action. Capabilities fill the gap between intention and outcome, and they fill it in such a way that the outcome bears a definite resemblance to what was intended.

In the behaviour of organizations, however, the most relevant intentions are often remote from the particular action and outcome. They may lie deep in the background of the specific actions that occur, which often come about in a variety of ways not involving intentions – including habitual responses of human beings and the automatic, physically determined responses of machines. The local telephone company intended to provide phone service in the sense that its executives, past and present, construed many of their own decisions in those terms – but the realization of a particular call is automatic. Its feasibility reflects an accumulation of equipment, individual skills, and organizational arrangements generated by a series of specific decisions that implemented and re-implemented the general intention to provide phone service – including a variety of arrangements that link the services of the provider of local service to other organizations in the global telecommunications system.

This example illustrates the typical situation: it is in the building of organizational capabilities that the role of intentionality is most reliably displayed; specific exercise may be intentional (as when an engineering firm build a factory or bridge to fulfil its contract to do so), but it may be also quite automatic (as in the phone-call example).

Although the phone call is a simple and familiar action from the caller's point of view, it is made feasible by the operation of an extraordinarily complex system. The system in turn is the product of a long and complex process of technological and organizational change, with associated investments in facilities and training – a process in which intentions to develop a (better) telephone system played a role that was important but intermittent and fragmented. The contemporary global telecommunications system was not produced through the execution of a coherent and comprehensive plan. In this case, and many others, the structure of capabilities

at the highest level reflects the outcome of a self-organizing, bottom-up process rather than realization of any comprehensive intention.

The distinction we make here – between the capability itself and the numerous instances of its exercise – parallels similar distinctions expressed in varying terminology about a variety of contexts. In particular, it parallels the distinction at the individual level between a skill and the exercise of the skill. In organizations, there is a distinction between the execution of high-frequency, repetitive daily business by low-level employees and the decision of executives about the development and deployment of capabilities (serving the French fries vs. opening another hamburger stand). There is a corresponding distinction at the individual level between the relatively tacit, subconscious, automatic, and highly-frequency character of exercise and the more intentional, deliberate, and intermittent processes involved in skill development and deployment (learning to drive or choosing the destination vs. the exercise of skill in keeping the car on the road). The parallels extend to learning processes; different processes are involved in the sort of learning that improves exercise than in original development of skill and capabilities. This parallelism presents an opportunity to use the individual realm as a metaphor to explicate the organizational, and vice versa.

It has been said that the mark of high skill in an individual is the ability to make some activity look easy when it is actually very difficult, and much the same point applies to organizational capabilities. The more polished the performance, the less attention gets directed to the innumerable hazards of failure that have been overcome, and the more the performance itself assumes a taken-for-granted character.

Also, performances that are commonplace, in the sense of being reproduced at high frequency, come to seem less mysterious and easier than accomplishments that occur only occasionally – although it should be obvious on reflection that frequency *per se* is no indicator of ease of difficulty, once the threshold question of feasibility is settled. (For example the more organizations succeed in making customer encounters simple and uneventful, the more the complex reality of capabilities tends to disappear behind the veil of familiarity).

3.1.1. Some Notes on Terminology

As already warned, we have kept so far a general equivalence between "competences" and "capabilities".

Indeed both terms "capabilities" and "competences" float in the literature like icebergs in a foggy Arctic sea, two icebergs among many not easily recognized as different from several icebergs nearby. Hence, it might be appropriate to survey these terminological flotilla and point out some distinctive feature of these diverse floating objects.

Following the discussion above, it should be clear that we think of “capability” as a fairly large-scale unit of analysis, one that has a recognizable purpose expressed in terms of the significant outcomes it is supposed to enable, and that is significantly shaped by conscious decision both in its development and deployment. These features distinguish “capability” from “organizational routines” as that term is used in organization theory and evolutionary economics – subject to the qualification that *some* organizational routines might equally well be called capabilities. In general, however, the notion of a routine involves no commitment regarding size (large routines are typically structured sets of medium-sized ones, and so on). It involves no presumption regarding evident purpose: one of the interesting things about routines is indeed that they are often found in contexts where nobody can explain what they are for except in the vague terms of “the way things are done around here”. And there is no presumption of deliberation or conscious choice; a flight crew probably does not choose its response to unexpected turbulence any more than a batter chooses to hit the dirt when the pitch appears to be coming towards his head.

On the other hand, the notion of a routine certainly does not *exclude* the possibility of conscious decisions about exercise. Hence, some routines may appropriately be called capabilities, if they satisfy the other criteria.

Capabilities involve organized activity and the exercise of capability is typically repetitious in substantial part. Routines are units or “chunks” of organized activity with a repetitive character. Hence, it is basically well said that “routines are the building blocks of capabilities” – although routines are not the *only* building blocks of capabilities. A marketing capability might require a customer database, for example,

which is neither a routine itself nor does it resemble a routine in the way that the working of complex equipment sometimes does. The database is, instead, a contextual requisite of some of the organizational routines supporting the capability.

Individual skills, in turn, are among the building blocks of organizational routines. What we commonly think of as individual skills are quasi-modular components of routines; their names are useful in expressing, for example, the idea that the role played by one skilled machine operator might well be played by another. But "knowing the job" involves knowing things that are relational – involving other participants – and organization-specific (Nelson and Winter, 1982, pp. 100-3]) That is why the skilled operator still needs to learn the job when joining an unfamiliar organization to operate a familiar machine – and why someone who is a perfectly adequate machine operator might nevertheless fail to learn the job. Some of the non-modular knowledge required is skill-like, regardless of what it is called – but these are skills that can be learned only through experience in the specific organization.

In our view, clarity would be served by reserving the term "skills" to the individual level and "routines" to the organizational level. "Routines are the skills of an organization" is a metaphorical truth not a literal truth.[2] In the existing literature, however, our proposed usage convention is violated in both directions. For example, Waterman *et al.* (1980) used "skills" for what we would prefer to call routines or capabilities, whereas Nelson and Winter (1982, p. 100) slipped into using "routines" at the individual level when they should have said "skills" or perhaps "constituent skills". Transgressions of this kind will no doubt continue but, we hope, not by us.

Consistent with this proposal, a useful meaning for the "skills of the organization" would simply be the collectivity of skills possessed by individuals in the organization, regardless of whether the skills are modular, organization-specific, or not organization-related at all. Then it could be said that organizational routines have the major function of coordinating the skills of the organization, i.e. of turning that collectivity of skills to useful effect.

Turning to another area of the concept flotilla, we find a cluster centered on "competence".

[2] The statement is in Nelson and Winter (1982, p. 124), and it is there introduced as a metaphor.

The notion deserves some detailed discussion also in that it appears in the very title of this Project - although in an expansive interpretation which makes it largely indistinguishable from the notion of "capability" discussed so far -.

In organization theory, the idea that an organization ends to be good at some particular thing (if anything) has long been referenced by the term “distinctive competence”. This term was introduced by Selznick (1957) in his classic work *Leadership in Administration.* In Selznick’s original discussion, however, the idea of distinctive competence seems to be at least as close a relative of the organization’s mission statement, or perhaps its “strategic intent” (Hamel and Prahalad, 1989) as of its capabilities. Selznick’s concern is with the infusion of means with shared ends: “the transformation of an engineered, technical arrangement of building blocks into a social organism”. He suggests, as other management theorists have subsequently, that a highly effective organization emerges when a leader helps the organization to transcend a merely technical understanding of its own functioning.[3] An indicator of the distance from the capabilities concept is Selznick’s reference to *standardized* building blocks; apparently it is the value-laden “transformation” and not the building blocks that account for the “distinctive” part. While Selznick (and others) may well be right to emphasize the importance of values, especially among the best organizations, capabilities theorists think the technical building blocks are often quite distinctive in their own right.

An influential article by Prahalad and Hamel (1990) popularized the term “core competence”. Only a brief encounter with the article is required to note four points: (i) that large corporations have multiple core competencies (five or six at a maximum, they suggest, not twenty or thirty – but not one, either); (ii) that competencies are fundamental to the dynamics of the firm’s competitive strength, lending strategic coherence to a string of new and improved products appearing over an extended period; (iii) that the competencies referred to are all areas of “hard technology” (if Procter & Gamble is properly thought to have core competence in marketing and distribution, and Carrefour and Wal-Mart in logistics, the authors don’t mention it); (iv) that while the relationship of competencies to large-scale structural features of the organization is a featured issue, the organizational aspects of the competencies themselves do not capture the author’s attention. Some of the subsequent discussion

of core competence seems to lose track of one or more of these points. The fact that the authors titled their article “The Core Competence of the Corporation” (note singular) may have contributed to a partial eclipse of point (i).[4]

The last two points noted above are much at odds with the concept of organizational capabilities, which need not to relate to technology and certainly have significant internal organization. If, however, we ourselves exercise the prerogative of simply ignoring a couple of points, we can move closer to the capabilities concept by focussing on the first two. We then arrive at the idea that a successful large corporation derives competitive strength from its excellence in a small number of capabilities clusters where it can sustain a leadership position over time. This comes very close to the concept of “dynamic capabilities” advances by Teece et al. (1997, p. 516): “we define dynamic capabilities as the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments”. [See also Teece et al. (2000)(A)] In areas of “hard” technology, the dynamic capabilities of a firm depend heavily on its R&D resources; in other areas that label may not be applied but analogous investments are made.

There is general agreement, however, that dynamic capabilities cannot be built simply by spending on R&D or making analogous investments. On the contrary – and to an increasing extent as the competitive pace quickens – coordination between R&D and other functions, and often with suppliers or alliance partners, is of the essence. Such coordination is needed, among other things, for effective identification and linking of technological options and market opportunities, and for identifying the strengths and weaknesses of existing resources relative to the requirements of a new product or process.

Thus the concepts of “core competence” and “dynamic capabilities” point in the same direction, being broadly concerned with the firm’s ability to carry off the balancing act between continuity and change in its capabilities, and to do so in a competitively affective fashion. We shall not advocate terminological purism and

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[3] Peters and Waterman (1982) were emphatic on this point, see esp. Ch.4

[4] The use of the singular in “core competence” encourages a conflation with “core business”. In practice, “core business” seems to have primarily a historical connotation: your core business is the one you were in before you started (or resumed) diversifying. Recommendation that a corporation retreat to its core business do, however, seem to rest on the presumption that some resources offering potential competitive advantage do remain there, current poor performance notwithstanding . And

remain content when no ambiguity arises, with analogical uses of "capabilities" and "competences" (as we did ourselves in the original **Dynacom** proposal and in several of our contributions!!).

However, after all these definitional *tour de force*, let us also propose for the future a narrower interpretation of the notion of competences which gives the latter a distinct meaning confined to a scale of observation intermediate between single routines and overall firm wide capabilities (as defined above), capturing "chunks" of *organizational abilities* identified in terms of performed tasks and knowledge-bases upon which they draw. It is a usage well in tune with Patel and Pavitt (2000)(A), Patel (1999)(B) Cantwell and Piscitello (1999a)(B) and a few other contributors to **Dynacom,** which might usefully become a sort of standard.

So, one might talk of *mechanical competences* to capture, together, ensembles of skills of individual members of the organization and, at the same time, directly organization-embodied elements of knowledge, routines, etc. - all aimed at the design production improvement of, say, machine tools. Note that, in this example, mechanical competences are not likely to fulfil the overall *organizational capability* of producing and effectively selling the machine tools themselves. Other *complementary competences* will be required to that effect, concerning e.g. electronic technologies, marketing activities, etc.

If one accepts this interpretation of *competences stricto sensu*, some important consequences follow.

First, in line with Patel and Pavitt (2000)(A) one may begin to distinguish different but complementary types of competences concurring to determine the overall capabilities of an organization. Patel and Pavitt, in this respect, single out some *distinctive* functional features discriminating between *background*, *core* and *niche* competences of an organization, emphasizing at the same time their interdependencies: "…in sectors making and improving complex products and production systems…, firms require the broad range of technological competences that unable them to stimulate and integrate technological improvements by their suppliers of materials, components, subsystems and production equipment…". Technological interdependence means that the notion of "focus" and "make or buy"

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there is a presumption that if you can't be good at your core business, you probably can't be good at anything else. See also below

applied in production and marketing activities, do not work in relation to technological competences" [Patel and Pavitt, (2000)(A), p. 330].

Second, in this context, one is always referring to organizational competences bearing that the "competence of company *x* in technology *y*" is something different from " the ensemble of the individual skills in technology y of all the members of company *x".*[5]

Having said that, it is useful to distinguish between what we shall call *technological* and *organizational competences* [similar distinctions are made in Dosi and Teece (1998), Coriat and Weinstein (2000) and Weinstein and Azoulay (1999)(B)].

The two types of competences are clearly overlapping in the empirical world. However, the distinction rests in that *technological competences* refer to shared pieces of scientific and technological knowledge and routines concerning essentially "the structure of nature" and "how to handle it", (turning a piece of metal into a particular structure, searching for a new chemical compound with certain functional characteristics or printing a circuit on a wafer of silicon are examples of the *genre)*. Conversely, we shall call *organizational competences* those shared pieces of knowledge and routines concerning the governance of coordination and social interactions within the organization and with outside entities (customers, suppliers, etc.).

So, while it is straightforward that a technological competence requires some organizational arrangements in order to be put to work, it is also true that fundamentally similar bodies of technological knowledge might be nested in and exploited by diverse organizational arrangements and coordination modes.

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[5] So the foregoing notion of competence, *stricto sensu,* escapes the analogy with the usage of the term with reference to individuals with a connotation of breadth rather than specificity – something closer to judgement than to skill. Eliasson (1990), for example, discusses the role of the "top competent team" in the firm – the *de facto* top management team – which involves making strategic judgements that are not readily amenable to analysis. Such decisions are informed instead by the experienced-based tacit knowledge of individuals and by the dialectical interaction within the team. This sort of competence relates not to a specific subject matter or task, but to an entire realm of highly consequential decisions that are difficult to get right, where small percentage improvements over judgements of average quality can be very valuable. The character of decision- making in this realm, and in contexts in which both competence (or vision) and capabilities play an important role, has been explored by Fransman (1994a, 1994b).
Without at all denying the importance of such "strategic competences", as a first approximation we choose to leave them out of our *narrow* definition of competences, one reason being the lower organizational stickiness of the former. [With some pragmatism, especially when discussing Project-based organizations: cf. Dosi, Hobday and Marengo (2000) (B)]; see also below.

Indeed a significant part of **Dynacom** is devoted to a) the exploration of the patterns in such diversities (even when holding strictly knowledge bases constant); b) the impact of organizational competence upon corporate performances; c) the role of organizational innovations; and d) the co-evolutionary dynamics between organizational and technological competences.

So, for example, one of the topics tackled in Coriat (2000)(A) is the organizational dimension of the change from "Fordist" to "Toyotist" organizational arrangements; Florida and Kenney (2000)(A) and Lorenz and Lazaric (1999)(A) study the degrees of "hybridization" which Japanese modes of corporate organization undergo when transplanted into different institutional contexts; Coriat (2000c)(B) discuss different pieces of evidence on the performances effects of diverse organizational arrangements and innovations thereof.

Notice that is plausible that the "intermediate" level of observation where competences are detected - "coarser grained" than individual routines but functionally more specific than overall capabilities - might be also where statistical proxies might more easily be found. Proxies of innovative output such as patents have long been used but one is beginning to explore a richer variety of data concerning technology (e.g. innovation counts, linkages with scientific advances, etc.), skills profile of the employees and modes of organizational coordination and reward mechanisms (e.g. from just-in-time to TQC to the modes of governance of internal labour markets, etc.).

On all these different angles of quantitative observation cf. Henderson and Cockburn (2000)(A), Pisano (2000)(A), Patel and Pavitt (2000)(A), Patel (1999)(B), Cantwell and Piscitello (1999a and b)(B), Breschi and Malerba (1999)(B), Grandstrand (2000)(B), Lhuillery (2000)(B), Coriat (2000-b)(B), Giarratana and Torrisi (2000)(B).

3.1.2. Technology and Organization

One way of reading in a common perspective an overwhelming majority of **Dynacom** contributions is as part of an ambitious effort to advance and systematically link the investigations of "what is inside the technological blackbox" - paraphrasing Rosenberg (1982) - and of "what is inside the organizational blackbox". In fact the analysis of the former has largely proceeded under the headings of the

"economics of innovation", studying the patterns of change in the knowledge bases underlying innovative activities and the related dynamics of "technological paradigms" and "regimes" [cf. among others Dosi (1982) and (1988), Freeman (1982) and (1994), Pavitt (1999), Breschi, Malerba and Orsenigo (2000)].

Conversely, competence/capability studies have been undertaken to a good extent with a strategic management orientation - especially in North America. In any case, to repeat, technological knowledge is to a significant degree *embodied within economic organizations* which are also major players in its accumulation and improvement. Mapping knowledge dynamics into organizational and industrial dynamics is therefore a priority area of research.

For sake of illustration, consider for example the response of an industry to the appearance of a technology that provides a new way of performing functions of central importance to the industry's activities. Such episodes can be identified on a very large scale - such as the replacement of mechanical and electro-mechanical devices by electronic devices in a wide range of types of equipment, and - on a quite smaller scale - such as the successive generations of displacement of larger disk drives by smaller disk drives in computers (Christensen and Rosenblom, 1995; Christensen and Bower, 1996; Christensen, 1997).

A common pattern in such episodes is that the leading firms in an industry often seem to react slowly to the challenge, with the result that leadership passes to some of the pioneers of the new technology. Sometimes a previously leading firm even fails to survive, or has a very close call. This pattern is, of course, illustrative of Schumpeter's discussion of capitalism's 'perennial gale of creative destruction', which he saw as the essential contextual feature for 'every piece of business strategy' (1950: 83-4).

One problem is to understand why this happens. Another problem is to understand why it *doesn't* happen - the pattern described is not universal, and the intuitive expectation that a 'bigger' technological change ought to make it more likely is not always confirmed. Among a number of explanations that are complementary and hence difficult to untangle, considerations related to the nature of the adjustment of firm capabilities needed to cope with the challenge have received increasing attention. [For different perspectives, cf. Tushman and Anderson (1986), Henderson and Clark (1990), Pavitt (1999)].

Certainly, technology-specific modes of knowledge-accumulation are likely to shape and constrain the ways "particular firms do particular things". Relatedly, the combinatories amongst different competences are likely to be product-specific and possibly sector-specific.

3.1.3 The “anatomy” of regimes of knowledge accumulation and their sectoral dimension.

The taxonomical exploration of technology specific patterns of knowledge accumulation – of which an early largely cited prototype is Pavitt (1984) – is far from over. Indeed, within **Dynacom**, one tries to advance our understanding both with respect to intersectoral differences and specific intertemporal patterns. Concerning the latter, see especially section 3.2 below. Regarding the former, Marsili (1999)(B) studies the diversity of innovation patterns across industrial sectors, attempting to identify a more refined taxonomy of *technological regimes*. Such regimes are based on industry-specific properties of search for technological improvements, sources of knowledge and nature of knowledge-bases. In line with previous taxonomic exercises such as Pavitt (1984), Patel and Pavitt (1997), Malerba and Orsenigo (1996), Dosi et al. (1995), Breschi, Malerba and Orsenigo (2000), it builds on two basic conjectures, namely, that, *first*, notwithstanding the importance of country-wide institutional factors, the properties of innovation processes are, to a significant extent, invariant across countries and specific to technologies or industrial sectors, and, *second*, some general properties of innovation processes shared by populations of firms might be identified independently of a variety of idiosyncratic behaviours observable at firm-level. Moreover, Marsili’s work analysis another crucial dimension discriminating across regimes and having to do with technological entry barriers, stemming from diverse modes of access to novel opportunities by entrants as opposed to (possibly cumulatively learning) incumbents. [The issue is studied also, from another angle, by Balconi (2000)(B): see also below]. From complementary perspectives, the differences across diverse regimes are further refined in Breschi and Malerba (1999)(B) with respect to the incumbents’ vs. entrants’ learning patterns, even within a broad single industry, i.e. electronics; and in Castellani and Zanfei

(1999)(B) when analysing the role of industry-specific factors (electronic vs. chemicals) affecting MNC's growth and diversification strategies.

3.1.3.1 *Corporate Specificities and Technology- /Industry- Specific invariances in competence profiles.*

At one, very fine-grained, level of observation, one observes fascinating idiosyncrasies in organizational capabilities: see in particular the first four papers (Part I) of Dosi, Nelson and Winter (2000)(A) which put a microscope on the particularities of capabilities and learning.

Narduzzo, Rocco, and Warglien (2000)(A) is concerned with two sets of capabilities developed and implemented by a cellular phone network company. One of these capabilities is for the installation of new stations. The other is for maintenance and problem-solving. The authors use the study of these complex examples of capabilities as an opportunity to explore the usefulness, limits, and meaning of the treatment of capabilities as bundles of routines. They conclude that, in their case at least, effective capabilities certainly do involve the mastery and use of certain routines, but also the ability to do particular and often idiosyncratic things that are appropriate to a particular context.

The company studied in this paper has different operations in different regions. The authors also explore the question of the extent to which capabilities, and practices, are company-wide, as contrasted with developing regional - or group-specific idiosyncratic elements. They conclude that the latter are important.

Argote and Darr (2000)(A) is concerned with the apparently humble capabilities in making good pizza in an economical way. One of their central questions is the extent to which learned capabilities are built into particular people, and the mechanism and extent to which capabilities can be regarded as organizational, in the sense that individuals can come and be replaced without erosion of the capability. They also are concerned with the extent to which new learned capabilities are transmitted and contained within an organization, in this case a set of franchise operations. A hallmark of the paper is detailed examination of the way knowledge is made organizational, and spread throughout the franchise.

Szulanski (2000)(A) also is concerned with the mechanism through which routines are made common across a group of related organizations, in this case the member banks of a bank group. The group of banks associated with Banc One has been expanded through acquisition. Banks become members of the group because of the significant financial success that group members continue to have, and because of a strong belief that success is due in good part to certain bundles of routines that are used in all Banc One operations. At the same time, the philosophy of Banc One admits that individual units should have a certain freedom to accommodate to the particularities of their individual circumstances. The study describes in elaborate detail the processes through which a new acquisition of Banc One system.

Flaherty (2000)(A) is concerned with learning and effective control in semiconductor manufacturing. In contrast with other technologies considered by other papers in Dosi, Nelson and Winter (2000)(A), semiconductors manufacturing is extraordinarily complex. There are many different processes involved, and each process, and the interactions across the various processes, easily can get 'out of control'. There is a major problem in assuring quality of the output. A central problem, therefore, in semiconductor manufacture is to be able to spot quickly production aspects that seem to be getting 'out of control', to diagnose and solve a problem can themselves be highly expensive in terms of lost production. Flaherty's study puts a microscope on these issues, and illustrates nicely the complexities that often are involved in organizational capabilities.

All the foregoing studies find an interesting complement in the chapters of Part II of Dosi-Nelson-Winter (2000)(A), concerned with dynamic capabilities. The firms under study are in industries where success in competition requires the capability to continuously introduce new products, and improve older ones, and to develop new production processes to support and accommodate these product changes. Pisano (2000)(A) and Henderson and Cockburn (2000)(A) are about firms in the pharmaceuticals industry. Appleyard, Hatch, and Mowery (2000)(A) is about firms in the semiconductor business. The capabilities studied in these chapters relate to performance in doing R&D, and the ability to learn and to solve problems more generally. Sometimes the orientation is toward the capability to learn how to learn.

Each of the studies looks at several different firms that have varied in their success in developing and implementing key dynamic capabilities. The studies are very much

in the tradition of studies in business strategy, in that they have as a principal purpose the identification of factors that have made for successful strategies. But these studies also add to our positive understanding of the key capabilities of firms in industries where innovation is a central aspect of competition. Thus they contribute significantly to the further development of a positive theory of the firm that can fit into an evolutionary theory of industrial competition and development.

In each of the studies, the dynamic capabilities under examination are defined at a relatively broad level: the capability to develop manufacturing processes to produce new pharmaceuticals (Pisano, 1991), the R&D capabilities to design profitable new pharmaceuticals products (Henderson and Cockburn, 1994), the capability to implement new process techniques in the semiconductor business [Appleyard, Hatch, and Mowery (2000)(A)]. Each of the authors sees the broad capabilities in question as consisting of a collection of more narrowly defined competences, and effective routines, brought together through mechanisms and organizational structures that influence how they work as a whole. Thus Henderson and Cockburn refer specifically to component competences, and architectural competences.

In each of the studies, the authors provide evidence of a combination of explicit and articulated, and tacit and sometimes subconscious, elements. Thus the firms involved are able to articulate broadly the strategies that lie behind the capabilites they are employing, or at least present a theory or a myth about that.

On the other hand, in each of the studies it is apparent that the key capabilities involve bundles of routines which are strongly tacit in nature. And one comes away from reading these studies with the perception that, in none of the cases, did the firms involved completely understand what they were doing, at least at a relatively fine level of implementation (as such a healthy antidote against “cartesian” views of strategies !). Rather, firms appear to differ – well in tune with a basic premise of evolutionary theories – partly of choice, partly by chance and partly by history and context.

3.1.3.2 *Competences/ Capabilities in Multi -technology, multiproduct, firms*

Together with in-depth studies focused on small sets of enterprises, the **Dynacom** project has pursued a parallel effort to identify more “bird eye” invariances in the

nature of competence/capabilities – common to specific sectors, institutional arrangements, countries, technologies.

Modern corporations are typically *multi-competence* entities – in the sense that in order to do whatever they do they generally embody and combine diverse technological and organizational competences (cf. the definitions above) -, and they are often *multi-product*, *multi-capability entities*, too.

A few contributions to **Dynacom** attempt indeed to interpret the observed patterns in the former domain (with regards to both technological and organizational competences) and also try to map them into their actual activity especially with reference to the product diversification profiles. Within these endeavours, Patel (1999)(B) studies the patterns of technological diversification (as such a reasonable proxy for the distribution of technological competences) in nearly 500 large technologically active firms based in Europe, Japan and the USA.

The main findings, include the following:

- increasing technological diversification has become a more common phenomenon in the 1990's amongst firms in all product groups and nationalities;
- as a group, *increasing diversifiers* have expanded the volume of their technological activities, have much higher than average proportion of these activities in areas of high technological opportunity, and have increased their market share;
- on the other hand refocusing firms have a low proportion of their technological activities in fast-growing areas and have seen a decline of their share of technological activities. Their market share in all product groups has declined;
- at the firm level, there is a statistically significant positive relationship between increasing technological diversity and growth in the volume of sales and patenting.
- amongst the technologies that are becoming more important are both the (so-called) "high-tech" areas and the more "traditional" technologies.

The findings indicate that despite the emphasis, especially in the consultancy literature, on "refocusing" as a business strategy, large firms are becoming *more diversified in terms of their technological competencies* in the 1990's, and this process has gone hand in hand with growth in their volume of sales.

Further corroborating evidence comes from Piscitello (1999)(B) who (i) studies the patterns through which large firms move in space of technologies and products over time, trying to highlight the differences in diversification patterns followed by European firms vs. their US and Japanese competitors: and (ii) attempts to develop a methodological framework, based on a matrix representation, for the analysis of the many-to-many relationship between technological competencies and products. (Again, the evidence draws on a large panel of the biggest European, US and Japanese firms over the period 1977-1995).

The analysis highlights the processes through which large firms grow by diversifying their technological competences and, through that, also their product range. [For previous studies mainly concerned with the technological side of the process, cf. Granstrand et al (1997) and Pavitt (1998)].

Contrary to “common wisdom”, not much evidence is there of “return to the core”, “refocusing and specialization”, etc. Rather, the picture is quite blurred. Certainly, there appear to be a quite widespread process at work of “creative accumulation” in technological competences coupled with the dynamics of product diversification. Interestingly, amongst US firms variability in products diversification profiles is not accompanied by any pronounced trend while only European and Japanese firms seem to generally reduce the number of their diversified activities. When crossing the geographical dimension with the sectoral one, it emerges that US firms happen to be on average the most diversified – with a decreasing trend in pharmaceuticals, chemicals and coal & petroleum and an increasing in all the other sectors -. EU firms show an increasing business diversification in office equipment, aircraft, food, chemicals, rubber and plastic products and mechanical engineering.

Note also that business diversification reveals an increasing trend towards service sectors, particularly for European and, even more so, for US firms.

Concerning the profiles of technological diversification, *first*, the evidence appears to corroborate the conjecture that *the domains of technological diversification tend to be broader than those of diversification in production* [Pavitt (1998), Patel and Pavitt (2000)(A), Piscitello (1999)(B)]. As such, all this suggest that multiple internal competences are necessary even to simply sustain absorption and integration of technologies and products generated outside the firm [Cohen and Levinthal (1989)].

So for example car-producing firms embody competences in plastics, even if they do not produce plastic products, just to be able to integrate the latter into an automobile.

Second, while there is evidence of the existence of *pervasive* technological competences – *new* and *old* (such as mechanical competences) –, even "specific" ones appear in multiple capability profiles: hence also one should not take too literally the distinction between "general purpose" and "specific" technologies [Piscitello (1999)(B)].

Third, one tends to observe a growing complementarity between competences traditionally associated with innovation and production in manufacturing, on the one hand, those related to services, on the other.

A highly complementary angle to study competences in multi-technology corporations is by explicitly focussing upon *corporate innovation systems*, as Granstrand (2000)(B) does. The analysis of a number of technology and management issues such as technology acquisition, technology diversification, internationalisation of R&D, IP management and commercialization of new technologies is undertaken on a comparative basis over a sample of corporations in Japan, Sweden and USA.

One tends to observe relatively coherent (and diverse) corporate systems, whereby in-house R&D is managed together with a mix of external technology acquisition strategies, with various contractual forms. Product case studies further show that external technology acquisition is associated with technology diversification into increasingly costly new technologies. Moreover, data at corporate level highlight a strong impact of technology diversification on R&D expenditures and corporate sales. A breakdown of corporations into strategic groups show that diversified "multech" corporations grow faster than other corporations, while "focused" corporations display a sort of "second best" strategy for growth. However, in order to realise growth through diversification it is of vital importance to gear technology management towards reaping economies of scale, scope and speed through coordination, conflict resolution and technology transfer. These all represent – as Grandstrand (2000)(B) discusses – new challenges to traditional in-house R&D management practices.

Indeed, when comparing managerial capabilities and other features of corporate innovation systems, one observes clear nation-specific features, especially Japanese ones. To a considerable extent the latter developed during a catch-up stage, but a

challenging issue is the extent to which they are “stage-specific” and possibly dysfunctional to “frontier” technology management, or, conversely, whether they are conducive to innovation also in the “forging ahead” stage. The evidence from Grandstrand, subject to some qualifications, is inclined toward. The latter conjecture - for example with regards to the organizational arrangements fostering “integrative” capabilities between research and other organizational activities high up in the hierarchical ladder -.

(The degrees to which other Japanese organizational practices have some sort of “universal” efficiency is also discussed by other studies concerning their international diffusion: see below, section 3.2).

3.1.4. Individual Skills and Collective Competences/Capabilities

Fundamental questions in the interpretation of the nature of organizational competences/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 (Clearly, the questions have far reaching implications also in terms of organizational *learning*: see below section 3.2).

In order to highlight some major underlying issues let us dramatize two alternative views. [A more detailed discussions is in Weinstein and Azoulay (1999)(B)].

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 H. 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). From a quite different angle, also visions of "Hayekian" ascendency come to a similar "individualistic" reduction of organizational knowledge: given diverse and socially distributed pieces of knowledge the central task of the economy is to assure the coordination amongst multiple agents embodying diverse and complementary skills. It is in a similar vein, albeit from a different tradition, that, for example, Grant (1996) defines a firm as a *knowledge integrating institutions* and emphasizes the organizational task of integrating specialized, people-specific competences.

Here, one of course is far from denying the importance of individual skills as constituents of the broader organizational competences/capabilities.

However, largely in tune with an alternative, *collective view,* of organizational knowledge, let us suggest that competences 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." (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 behaviours (a germane discussion is in Cohen et al., 1996).

Here, as well as in a few other domains of organizational theory, the hard challenge for the analyst is to identify approximate but relatively robust discrete types of organizational arrangements mapping them into distinctive competence/ capability profiles (see also below section 3.3) It is an exercise that one has begun to undertake in Coriat and Dosi (1998a) – trying to spot the distinctive features of “Fordist” and “Toyotist” organizational arrangements – and has continued within **Dynacom**. (The implication in terms of learning processes are discussed below, in section 3.2).

3.1.5 Organizational arrangements and competence profiles: some discrete types, from “traditional” industries to complex products and systems.

Coriat [2000] (A) studies the specificities of the “Toyotist” model of production organization precisely on the grounds of both *diverse routines* and of diverse *combination thereof*. Moreover, it is shown there, the routines prevailing within the “Toyotist competence” a) call for a different distribution of individual skills (as compared to e.g. “Fordist” organizational patterns), and, b) while providing a specific, relatively coherent, organizational of work reflect also equally specific governance structures, modes of control and compromises regarding conflicting interests.

The analysis of the Toyota System [cf. also Fujimoto (2000)(A)] abundantly illustrates the properties that routines as "programmes" for coordinated action draw upon a set individual skills whose presence is obviously necessary condition for their implementation. In turn, the elicitation of particular repertoires of action is constrained and shaped by "meta-routines" governing information distribution and information processing, allocations of tasks and decisional power. In that, to paraphrase Warglien (in Cohen et al., 1996), routines and the related competences have an *"architectural dimension"* going all the way from the physical layout of manufacturing artifact to the allocation of work individually or by teams, vertical or horizontal coordination, just-in-time programmed from downstream or upstream, etc.

Car production – studied by Coriat (2000)(A) and Fujimoto (2000)(A) – as well as many other manufacturing activities display distinctive, firm-specific, slowly changing organizational architectures - with a well identifiable distribution of routines and competences.

But what about other activities such as those associated with the design and production of Complex Products and Systems (CoPS) whereby organizational arrangements tend to be much more "plastic" and project-specific?

Dosi, Hobday and Marengo (2000)(B) and Coriat (2000a)(B) studies these activities, trying to identify the underlying "combinatories" of competences. In order to do that the former work analyses the distribution of problem-solving abilities and of governance mechanisms associated with diverse institutional arrangements within and between firms. These topics are studied from a different, complementary, angle also in Coriat (2000c)(B) who suggests the notion of *relational competence* – as a particular instance of organizational competences (cf. above, section 3.1.1) – enabling the coordination and building of problem-solving complementarities across diverse organizational entities (e.g. different firms, public agencies, etc.). Moreover, Coriat suggests a typology of governance structures, nested on different distributions of a) competences, b) property rights, and c) authority relations.

A few **Dynacom** studies also highlight the *double nature of routines* [Coriat and Dosi (1998a)] – as both devices for problem-solving and mechanisms for monitoring and command . So, for example, both Fujimoto (2000)(A) and Coriat (2000)(A) study the "control" side of the Toyota system - including "visual control", self-monitoring and other control devices – and their evolution over time.

The “double nature” of organizational practices is also one of the main topics of Coriat (2000a)(B) who also argues that diverse institutional architectures, in the case of Complex Product and Systems (CoPS), do not only entail diverse form of authority relations (cf. above) but also different *levels of distributions of relational rents* (i.e. rent accruing to agents holding crucial relational competences in the networks of CoPS designers and producers).

A quite different but equally interesting domain of investigation, in Balconi (2000)(B) concerns the competence and underlying distribution of skills in a rather wide ensemble of sectors – including “supplier dominated”, “scale intensive”, “science based” ones [in Pavitt (1984) terminology]. Traditionally, they had been largely unaffected by Taylorist/ Fordist electromechanical automation but have recently been deeply transformed by electronic automation technologies and measurement instruments.

The nature of the required individual skills, has profoundly changed. People no longer “do” things, but control that things are done correctly by automatic equipment. In controlling, they must exert some judgement and their ability in assessing anomalous situations is based both on some formal education (computer literacy included) and on the experience acquired on the job. In that terms proposed in the paper, their tacit knowledge is complementary to a codified knowledge base. The discretionality they enjoy is however limited, since the responsibility to solve demanding problems is shifted to distinct engineering personnel.

The flattening of the hierarchical ladder and the broadening of the tasks assigned to shop floor workers appear to be to a large extent a consequence of i) the elimination both of most manual repetitive tasks and of tacit-skills-requiring ones; ii) the increasing reliability of equipment; and requires iii) higher education levels of the workforce.

The famous pins of Adam Smith’s example are currently made by an automated manufacturing line so that one single worker suffices to control both the smooth running of the equipment and product quality, undertake some machine set-up and make some preventive maintenance. The ensuing division of labour amounts to a division of functions amongst workers with very different types of skills. At one extreme in the knowledge ladder – above the controller, just described -, specialist white-collars are assigned the conception of products and of manufacturing cycles.

At the other extreme, below the controller, unskilled labourers carry out ancillary services, such as moving objects and cleaning.

Compare the skills distribution in the new (electronically automated) competence profiles with the older (non-automated or, partly electromechanically automated) ones. Skills of the production workers are much less specific than they used to be, as they are grounded on more general knowledge. For workers it is easier to be multiskilled and for firms it is often more profitable to rely on a multiskilled workforce. Inter-sector mobility of workers has become less demanding as well, in terms of the time and difficulty of acquisition of "local" new knowledge. (Note also that the number of this type of production workers tends to shrink).

Conversely, at the higher extreme of the knowledge ladder, organizational competences rely upon the complex, difficult-to-acquire, skills of expert problem-solvers and new knowledge creators (indeed, *more complex* and more difficult to acquire than in the previous regime).

3.2 PATTERNS OF LEARNING AND COMPETENCE ACCUMULATION.

In acquiring and adapting their competences/capabilities over a period of time, organizations are doing something that can reasonably be called organizational learning. Here again there is a large literature embracing a wide range of specific intellectual ambitions, methodologies, and techniques. There are books 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 thus the large literature of quality management 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

[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).

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), and Von Hippel and Tyre (1995), and in the laboratory [see Cohen and Bacdayan (1994) and Egidi (1995), among others].

However, it is fair to say that organizational learning is still another large but foggy sea.

Let us thus begin with some notions on organizational learning and then move to some empirical evidence on the processes through which firms acquire, build, modify and lose their competences/capabilities.

3.2.1. Organizational Learning

The two alternative archetypes of organizational knowledge which, in section 3.1.4, we called 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 infecting new members who have knowledge the organization did not previously have".

Conversely, while not denying at all the importance of the foregoing learning modes, at least a few of the **Dynacom** contributors share the "collective view" and attempt to disentangle – both in theory and from organizational evidence - the patterns of change of some sort of *collective intelligence* which organization embody: see, in particular, Levinthal (2000) (A), and Marengo et al. (2000) (B) on the theory side; Narduzzo et al (2000) (A), Fujimoto (2000) (A), Coriat (2000) (A), Dosi, Hobday and Marengo (2000) (B) for empirical investigations, Warglien (1999)(B) 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 individual learn;

- shape the efficacy by which individual skills are exploited and contribute to the overall performance of the organization (see also section 3.3, below, on *interdependences* and *complementarities* as key organizational features);
- affect the rates at which individual skills and broader competences are diffused throughout the organization.

Given all that, the "collective view" also adds that – as there is an intrinsically organizational dimension of organizational knowledge (cf. also section 3.1, above) embodied in the routines, hierarchical structures, culture of an organization -, so, dynamically,

- 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).

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)(A)].

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 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 [for discussions on such a vexed debate cf. Dosi, Marengo and Fagiolo (1996), Pavitt (1987) and *Industrial and Corporate Change*, 2, Special Issue, (2000)], *codificatio*n -

also in the form of archives, documents, training practices, etc. – imperfectly *deals* with the *persistence organizational knowledge well beyond the mobility of organizational members*.

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 competences 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 labour, in action patterns, etc. without any dramatic change in the technical competences 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, when holding strictly technological knowledge roughly constant. In turn, this bears far-reaching implications in terms of comparative assessment of e.g. "the Japanese firm" vs. "the American firm", etc.

IV. Organizational learning is ridden with path-dependencies whereby incumbent competences 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 learning 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 specialization, "way of doing things", hierarchical arrangements, action pattern [cf. Levitt and March (1996), Cohen and Sprull (1996) Levinthal (2000)(A), Cantwell (2000), Marengo et al. (2000)(B)].

Incidentally, note also that assessment of the degrees of path-dependencies of organization learning bears again, importance consequences for the comparative

diagnostics of the diffusion of particular organizational forms e.g. between Europe, the USA and Japan. Without any path dependency, when observing a given diffusion pattern one may safely talk of “laps” and “leads” across regions and countries. However, the picture is much more blurred when path-dependencies matter, since some organizational innovations might yield superior performances in some context and given a particular history might not do so along other institutional and organizational paths.

3.2.2. Patterns of Organizational Learning and Competence Accumulation

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 conflict 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 competences and organizational knowledge. Having said that, a crucial but still largely unexplored question *is how organizational innovations occur*.

More specifically, one may distinguish two “ideal types” of learning processes, namely, first, *internal learning processes vs*., second*, acquisition of external competences and organizational models*. Needles to say, the real world displays varying combinations between the two modes. It applies to technological learning (Cohen and Levinthal, 1989), and, equally so, to organizational innovation. However, it is useful to distinguish some specificities of each archetype.

Let us begin with internal learning and notice that, as far as organizational competences are concerned, one hardly find 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, strictly “credit assignments” of successes and failures to submits of the organization [Argyris and Schön (1996), Sproull (1981) and Levinthal (2000)(A)].

Path-dependence looms large throughout.

The problem associated with the acquisition of external practices and competences 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 whereas one can maintain that there are identifiable, relatively invariant, organizational models that are undergo interorganizational diffusion.

Moreover, both "internal" and "external" forms of organizational learning entail subtle links with organizational structures. So, for example, as Marengo (1992) 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, as Marengo (1992) puts it, "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" (p. 19).

3.2.3. Accumulation of Technological Competences

Consider all the foregoing discussion as a sort of tentative roadmap in the large and foggy ocean of organization learning. Given that, let us flag some contributions of **Dynacom** research on several of these topics, beginning with learning processes which primarily concern the accumulation of *technological* competences and then move to some evidence on the even foggier domain of organizational innovation.

3.2.3.1 *Patterns of interaction between firm-specific competences and location-specific attributes.*

The interaction between firm-specific and distributed (but location-specific) knowledge is studied from complementary angles by Castellani and Zanfei (1999)(B) and Cantwell and Piscitello (1999a)(B). The basic idea of the former is that multinational firms' acquaintance with local contexts is a key asset increasing their

ability to understand user need and to tap into local sources of application-specific knowledge.

These context-specific competences interact with generic firm-wide ones in determining the strategies of knowledge accumulation, investment and networking with local firms.

The authors on the ground of a novel data set on international operations in which the world largest electronics and chemical corporations were involved in 1993-97, examine how multinational experience affects inter-firm linkage creation. Remarkable similarities and differences emerge across industries in this respect. First, *specific multinational experience*, measured by the extent and nature of a firm's presence in a given country, appears to positively impact on commitment intensive international operations, such as mergers and acquisitions, in *both* electronics and chemical industries. This result is consistent with a "knowledge based view" of the firm (combined with a "dynamic transaction cost" approach). Second*, generic multinational experience*, measured by the extent and nature of a firm's global operations, positively affects the creation of more "exploratory", non-equity linkages, in the electronics industry *and not* in the chemical industry, highlighting also the importance of paradigm-specific knowledge in shaping internationalization strategies.

Cantwell and Piscitello (1999a)(B) study – again for a large sample of world top firms – study the relationship between competence accumulation and internationalization strategies. While a good percentage of innovative activities in still undertaken at the home base (with the noticeable exception of some small European countries, such as the Netherlands), one observes processes of internationalization of research aimed primarily at "tapping" locally generated opportunity, rather than exploiting existing ones.

The international networks of MNCs now contribute positively to their technological diversity, by drawing on the locational differentiation of innovation across the sites in which the MNC operates, and thereby reinforcing regional and national systems of innovation. In a complementary study [Cantwell and Kosmopoulou (2000)(B)] one shows also how the internationalization of corporate technological development depends upon the competitive strength of nationally-owned firms in an industry (which encourages outward investment but may deter inward investment by foreign-owned firms in the same industry), and upon the importance of localised vertical

linkages in innovation in a country (which may deter internationalization). Cantwell and Piscitello (1999b)(B) investigate also the geographical spread of MNC networks for innovation within Europe, whether formed by European-owned or non-European-owned firms, paying particular attention to the relative attractiveness of locations for the technological development of foreign-owned firms, at a regional (sub-national) level within Europe. Amongst the results one finds that, first, diversification in new locations is increasingly becoming a mean by which firms extend their technological base and capabilities, since internationally dispersed development of technology might be a source of competitive advantage.

Second, and relatedly, the experience acquired in a specialized activity in one location is likely to create *intra-organizational* technological spillovers that can be passed on to the other parts of the multinational company.

Third, as far as the locations themselves are concerned, these patterns, other things being equal, are likely to *increase* asymmetries between "central", "intermediate" and "peripheral" regions, due to location-specific dynamic increasing returns. And a somewhat similar effect is likely to apply to firms themselves. So, for example, as Cantwell and Piscitello (1999b)(B) argue, European firms originating from the major centers for their industries (e.g. the leading German chemical companies) are able to create cross-border European networks to diversify their corporate technology base, and while continuing to develop the principal technologies for their industry mainly at home, they can source related technologies in the appropriately specialised regions. As a result of such strategies of corporate European integration by the leading European MNCs, intermediate and lower order regions are able to deepen their established patterns of technological specialisation, since the new research facilities of capable foreign-owned MNCs not only access the region's existing local skills and expertise, but locally build upon them and enhance them. However, since higher order regions attract a greater diversity of foreign-owned MNCs, the impact of MNC technological development within these regions is to widen their pattern of technological specialisation, and to reinforce the general tendency for technological activity to geographically agglomerate in these areas.

A further implication, which brings into focus the effects of cross-border MNC development on smaller and more localised (non-multinational) European firms, is that the kinds of technology spillovers which occur between firms within regions are

likely to differ between lower order and higher order regions. In intermediate regions spillovers are typically intra-industry or at least involve a common set of broad technological fields, and hence reinforce the established pattern of specialisation (such as within motor vehicle and related engineering in the West Midlands or Piemonte). Conversely, in higher order regions spillovers occur much more in fields of technology that are common to many industries, such as in general mechanical processes, information and communication technologies, or new materials, and the existence of these kinds of localised network externalities increases the attractiveness of such regions for foreign-owned corporate technological development in general. The availability of localised technology spillovers within regions in turn increases the potential for foreign-owned affiliates to acquire an independently technologically creative role within their international corporate groups, to which they are connected (among other things) by means of cross-border knowledge flows.

Yet another angle of investigation concerning the patterns of accumulation of technological competences is with reference to the role of collaborative agreements and collaboration-related policies. The analysis by Giarratana and Torrisi (2000)(B) utilizes a large database of European electronics firms. The study does confirm the importance of collaborative ventures of various kind as a mechanism of technological learning. Interestingly, however, the evidence shows that effect is greater when collaborations involve non-EU (mostly American) partners, while EU-sponsored collaboration do not appear to exert any significant influence upon innovative capabilities. The sample of firms does include the largest European firms only: hence may reasonably argue that EU policies have had mainly an impact upon *diffusion* of competences to the weaker and smaller partners of the collaboration. In any case, such an evidence ought to send significant warnings about the efficacy of European technology policies concerning the *advancement* of the international technological frontier.

3.2.3.2. *Discontinuities in knowledge-bases and corporate capabilities: the case of drugs and biotech*

General conjectures put forward in different fashions in Dosi (1982) and Freeman (1982), and refined by several students of technology and organizations thereafter, are a) that the nature and patterns accumulation of organizational capabilities are intimately related with the underlying *technological paradigms,* and b) that discontinuities in the latter might entail also significant changes in the required corporate competences and performance profiles.

These conjectures are amongst the topics explored by Orsenigo, Pammolli and Riccaboni (1999)(B) with reference to biotechnology and the drug industry.

Biotechnology is a major new technological paradigm which has been deeply transforming the nature of the relevant competencies and of the learning processes in various industries, particularly in pharmaceuticals. The pharmaceutical industry used to be - and to a large extent still is - one of the sectors where Europe enjoyed relative and in some cases absolute technological and competitive advantages. However, over the past two decades these advantages have been partly eroded. US companies have clearly taken the lead in innovation and sales. Within Europe, British firms have shown a remarkable performance, whilst the position of the German industry - which has been an absolute world leader for almost a century - has been deteriorating. Whilst there is a considerable debate about the reasons and the extent of this decline, a wide consensus appears to exist on the consideration that this (partial) decline is linked to the joint working of two main factors: a series of big technological shocks and a series of large institutional shocks (ranging from the introduction of tighter regulations in the process of approval of drugs, to policies of cost containment of health expenditures, etc.). Orsenigo *et al.* explore how these shocks (and especially the former ones) have impacted on different firms and national industries.

It has been argued [see, for example Henderson (1994), Gambardella (1995), Henderson, Orsenigo and Pisano (1999), Pammolli (1997)] that the emergence of a new knowledge base in the pharmaceutical industry, based on biology rather than on chemistry, has led to profound transformations in the procedures underlying drug discovery and in the organization of the innovative process within firms and among

firms and other institutions (like University laboratories). The different response of both individual corporations and national industries to these changes is certainly a major part of the explanation of the aggregate trends of competitiveness in the sector. Two issues are particularly challenging.

First, the new knowledge base has a distinctive scientific nature and therefore it is, in principle, abstract, to a good extent codified, and – absent the establishment of intellectual property rights – largely accessible by everybody. This makes the case of pharmaceuticals somewhat different from cases of organizational transformations driven by changes in more tacit competences such a with engineering knowledge. Moreover, there might be somewhat of a puzzle here. Given these properties, how is it that firms and national industries reacted so differently to the ''molecular biology revolution''?

Second, another distinctive feature of the recent evolution of the pharmaceutical industry has been the emergence of a dense network of collaborative relations between various types of firms (new specialized entrants, large established corporations, universities, etc.). What does explain this ''organizational innovation'' and what are the variables driving the dynamics of the network over time?

One can find in the literature widely different interpretations of the nature, motivations, structure and functions of these networks, ranging from more sociologically oriented approaches to economic explanations based on (various mixes of) alternative theoretical backgrounds, e.g. transaction costs, contract theories, game theory and competence-based accounts of firms' organization. In turn, these interpretations generate widely different predictions about the evolution of collaborative relationships over time [Barley, Freeman and Hybels, (1992); Arora and Gambardella (1994); Gambardella (1995); Powell, Doput and Smith-Doerr (1996); Orsenigo et al. (1999)(B)].

For example, with reference to the case of biotechnology, collaborative relations have been often considered as a transient phenomenon, bound to decrease in scale and scope as the technology matures and as higher degrees of vertical integration are established in the industry (Pisano, 1991).

In a rather different perspective, Orsenigo et al. (1999)(B) emphasize the role played by scientific knowledge in pharmaceutical research and the emergence and evolution of networks. In this vein, collaborations represent a new form of

organization of innovative activities, which are emerging in response to the increasingly “formal” abstract nature of the knowledge bases on which innovations draw [Arora and Gambardella (1994), Gambardella, (1995)].

According to this approach, the innovative process can be represented as a sequence going downstream from science to marketing, whereby division of labor can occur at every stage of the process.

Collaborations are likely to emerge, with a large (and possibly expanding) number of entities interacting with each other, generating an intricate network within which organizations might specialize in particular technological areas or stages of the innovative process.

Relatedly, the complex and interdisciplinary nature of relevant knowledge bases in pharmaceutical R&D tends to make technological innovations the outcome of interactions and cooperation among different types of agents commanding differentiated competencies and complementary resources [Orsenigo (1989); Pisano (1991); Orsenigo et al. (1999)(B)]. The structure of the network and the position of agents within it is thus instrumental determining agents' access to relevant sources of scientific and technological knowledge and together innovative performances [see also Shan et al. (1994); Walker et al. (1997)].

Orsenigo et al. suggest that the formation and subsequent evolution of the network of R&D alliances can be interpreted primarily as an adaptive response to the emergence of a radically new knowledge base within the industry, that is molecular biology. This paradigm discontinuity did not only simplify the search space by providing more general theories. It also led to an explosion of the search space, significantly deforming it. Firms – both large established companies and innovative entrants especially at the research end – may often master only fragments of the knowledge relevant to generate new chemical entities aimed at novel therapeutical targets. The growing innovative opportunities, the branching of knowledge into increasingly specific and uncertain directions and – especially in the ‘90s– the appearance of “transversal” technologies, have led to the generation of a wide variety of search trajectories, which however come under two broad families of exploration and technological advance.

The first patterns has involved a trajectory of increasing specification of biological hypotheses. The second has been progressing towards the development of "transversal" techniques to generate and screen compounds and molecules.

In both cases, established R&D-intensive pharmaceutical firms have been able to absorb the new knowledge by interacting with new entrants. In fact, the expansion of the network has been driven mainly by the entry of new agents embodying new techniques. The network has taken a distinct hierarchical structure, with different firms operating at different levels of generality, which has been perturbed but not broken by transversal techniques.

Given such a resilience of the "international oligopolistic core" and its ability to adjust to the new competence requirements, it appear also that European (in particular *continental* European) firms have lost some of their innovative edge, possibly due to also to less rich opportunities of tapping local scientific advances.

3.2.4. Inside the blackbox of organizational learning

So far we have discussed those Dynacom contributions focusing primarily on the patterns of technological learning and competence accumulation, while however largely neglecting the detailed nature of intra-organizational processes. Conversely, the latter are central to the investigation of Narduzzo, Rocco and Warglien (2000)(A), Argote and Darr (2000)(A) Szulanski (2000)(A) and Warglien (1999)(B).

3.2.4.1 *The evolutionary Dynamics of Intra-Organizational Projects*

Warglien (1999)(B) explores the idea that the dynamic processes through which firms accumulate and diffuse competences are evolutionary process. Of course, the idea links up with literature on adaptive complex systems, which has much emphasized that evolutionary processes not only shape the dynamics (composition) of populations of agents, but may indeed shape the internal processes through which agents learn and adapt [Holland (1975), Axelrod and Cohen (1999)]. (See also below, section 3.3). Similarly, cultural evolution theories have stressed that social systems accumulate an diffuse the results of individual or group experimentation and learning through processes that may be modeled as proper evolutionary dynamics

(Cavalli-Sforza and Feldman, 1989). Finally, there is now a pretty large stream of research in organization theory suggesting that there may be evidence for intra-firm “Darwinian” cycles of mutation, selection and spread of fittest variants (for a short review see Warglien forthcoming).

One of the contributions of Warglien (1999)(B) is to explicitly model such internal processes and look for empirical support to evolutionary views of the dynamics of firm competences through the analysis of a longitudinal case study. In particular, the paper reconstructs the intra-organizational evolutionary dynamics of design competences in a large European microelectronics firm, over a time span of about 20 years (1973-1993).

In the case study analyzed in the work, design competences can be meaningfully related to the processes embedded in products’ design. This provides a simple key for the research design, helping to single out a population of units carrying such traits (the population of product design projects) and suggesting to analyze the long term dynamics of such population.

The study has two main empirical parts. The first one can be properly labeled as “ecological analysis”, while the second one is more directly concerned with evolutionary issues.

The first part is an analysis of selective dynamics in the population of projects. This part brings two essential results on density and age-dependence. Density-dependence is generally acknowledged as the most fundamental property of populations subject to selective dynamics. Warglien shows that density-dependence characterizes the growth of the population of projects, affecting both the birth and the death process.

Age-dependence is a more problematic feature: in the context of microelectronic devices design, it can be interpreted as resulting form the contrasting effects of obsolescence (positive age dependence) and inertia and cumulative inter-project learning (negative age-dependence). The study shows that even in short life-cycle industries such as microelectronics the latter factors do matter.

After establishing the existence of selective pressures the work deals with the evolutionary dynamics of competences.

First, the paper shows that the rates of innovation have waveform behavior over time, and affect the risk of early mortality of new projects. This suggests that there

are “Schumpeterian” internal cycles of regulation of the exploration/exploitation trade-off within the firm. Warglien proposes the application of a new metric of evolutionary activity (mutuated from research in the artificial life domain) to gain further insights in the regulation of such trade-offs. Such metric highlights the existence of processes of learning to diffuse new design competences. Finally, the paper shows that the analysis of competitive dynamics between competences supports a Lotka-Volterra like modeling strategy.

Besides these research results, this study has some potentially relevant implications for the management of innovation. Broadly speaking, the results obtained point to the necessity of managing competences in a dynamic perspective which emphasizes the control of the parameters regulating evolutionary processes, rather than looking at single projects. I suggest that the ability to tune the evolutionary process is a genuine dynamic capability of the firm, affecting its long term success.

First of all, the study reveals a need to govern the selection process. Data reveal a strong impact of crowding effects over project expected mortality rates. The sources of project mortality are not only external to the firm, but also relate to bottlenecks in internal resources and the decision making process.

Second, managing patterns of evolution requires a careful tuning of the exploration/exploitation trade-off. The portfolio of projects should comprise at any time a balanced set of new traits, which present high risk but also higher development potential, and well-established traits that provide resources for supporting the cost and the risk of exploration and stability and reliability in the relationships with market niches. However, the key point is that organizations need to perform simultaneously more exploration of new solutions *and* more exploitation of the results of former explorations. Reconciling these needs implies governing the diffusion process of successful new variants in order to turn quickly new discoveries into profitable businesses. As Warglien shows, generating novelty does not warrant that novelty will successfully diffuse within the population of projects. Furthermore, the capability to absorb novelty into the population seems to vary with time, and is subject to learning effects.

3.2.4.2. *Duplication, transfer and international adaptation of organizational practices*

The international transfer of particular organizational practices is important in its own right and also in its bearings for the institutional specificities of organizational forms: e.g. to what extent can Japanese practices be successfully exported – even within the same company – across national/ institutional boundaries? And, conversely, to what extent do they undergo some "hybridization" due to local context condition?

Florida and Kenney (2000)(A) study the case of Japanese car-manufacturing transplants in the USA. Their basic argument is that these transplants have effectively transferred and to some degrees replicated key organizational forms and capabilities at both intra – and inter-organizational levels.

Lorenz and Lazaric (2000)(B) address a similar question and study Japanese transplants in the UK and France.

The investigation has two unique figures: first, they aim at the statistical universe of the transplants, and, second, add variance to their observations by comparing two institutionally rather different host countries. The study concerns characteristics of the organizational structures, work practices and human resource management (including training, internal careers, wage policies).

This comparative approach allows to draw more robust conclusions regarding the impact of local context conditions on what is transferred. A quantitative appreciation of the transfer of the work practices to the transplants is presented in Table 1 .

Table 1: Organizational Practices of Japanese Affiliates.

	Percentage of European Affiliates Involving more than 33 % of their Employees in the Practice	
Practice:	UK	FRANCE
Job Rotation	35	41
Quality Circles	29	18
Self-Managing Teams	27	25
Employee responsibility for quality control	75	73
Multi-disciplinary Project Teams	20	14
Just in time production	45	27
Number of respondents:	55	22

(N.B. None of the above percentage differences are statistically significant in Chi-Squared tests.)
Source: Lorenz and Lazaric (1999)(B)

The results show that Japanese style business practices are being transferred, but that local context conditions result in modifications relative to the parent firm. Thus Japanese affiliates never look exactly like their parents. “Hybrid organization” is an appropriate term to characterise their European affiliates. The significant differences observed concern the composition of skills on teams and the role of the supervisor or team leaders. Interviewees familiar with conditions in the Japanese parent firms invariably describe teams as learning organizations, in which the supervisor’s or team leader’s principal role is that of a trainer and a technical problem-solver. Japanese supervisors have a deep and thorough knowledge of the product, and this allows them, in co-operation with operators, to resolve most quality related problems without the intervention of engineers. Supervisors often lack this sort of expertise in the UK and, to a lesser extent, in France.

These differences in the way knowledge is developed and distributed in teams appear to be tied to specific features of each nation's system of professional training and to the way “*careers” are structured in each country*. Consider, for example, Britain with its deep social cleavages between manual operators and employees with

technical qualifications. There one finds also a strong anticipation that acquiring a formal technical qualification is the first step in a career progression leading away from the shop floor. Consequently, it proves difficult to retain technically trained employees in employment on the shopfloor. In France, this poses less of a difficulty. If anything, the problem in France concerns school leavers, with a technical degree such as the BTS, who are 'parachuted' into positions of supervisory responsibility without the necessary on-the-job training which forms the basis for good problem-solving skills.

At a more theoretical level, these observations point to *the way that routine practices connected to problem-solving skills are embedded in social and institutional context that matters*. The link between "external institutions" (mainly the education system) and problem solving devices implemented at the shopfloor level is thus highlighted (providing also further support to the notion that routines go well beyond any purely cognitive dimension, but need to be defined with reference to social context where they are introduced.

Note here that according to the authors, while their results point to *significant differences between the payment systems* of the affiliates in Britain and France relative to their parents, these differences do not appear to be connected with the ability of the Japanese MNCs to transfer their methods. This is not to say that payment systems do not matter for competitive performance. In fact, if a very robust correlation is found between the use of contingent or variable pay, which links compensation to various measures of performance, and the use of Japanese style business practices. However, the exact form these takes is influenced by local context conditions. (For example, Law plays a big role in France, much bigger than in the UK). However, there seem to be different ways of putting in place a system linking compensation to performance that respects local norms and law.

Another point regards the methods used to transfer the organizational knowledge and the routines. The study exhibits quite extensive use of human carriers of knowledge, reaching down to the lowest levels of the hierarchy. It is quite common for Japanese multinationals to bring over to Japan groups of operators from France or the UK at the time of the introduction of a new model. Similarly, it is quite common to send teams of Japanese operators over to the overseas affiliates. This practice distinguishes Japanese MNCs from their US or European counterparts. It points to

the crucial role played in the process of “On-the Job-Training” practices and of the transfer of know how through “direct” learning. Despite this efforts, and because the same conditions of training cannot be completely “transferred”, one may observe that *…”operators are not involved in problem-solving and continuous improvement activities to the same extent as their counterparts in Japan. Local team leaders and supervisors often lack the necessary training and experience to impart these skills to operators.”*

Finally, the study suggests that despite *“the labour market institutions of the two countries differ in important respects”* - a fact that *explains “some differences in emphasis*”, - … *“Japanese multinationals operating in Britain and France have experienced comparable degrees of success in transferring their work practices. This ability to combine Japanese style work practices with different national human resources systems points to a surprising universality of Japanese organizational forms*”, other readers of the same data might well be more cautious in their conclusions. However the evidence does support the idea that Japanese practices have a powerful "invasion potential" vis-à-vis institutional contexts different from those where they emerged.

3.2.5. The Role and limits of the "Markets for organizational competences": the case of consultancy firms

We have thoroughly argued above that both competences and capabilities (cf. the distinction made in section 3.1 above) a) bear partly *tacit* features, and b) have a collective dimension irreducible to the sum of individual skills. Given that, what is there to be transferred via straightforward market transactions? And more specifically, what are the central objects of the transaction involving consultancy firms? Some facets of an answer to this question are discussed in Garcia (1999)(B).

In brief, our conjecture is that the objects of transaction are primarily the following:

(i) Archetypes of quite standardized organizational protocols.

This is the case of rather codified templates for ensembles of routines such as "team work", "just-in-time", etc.

Firms "buy" these "way of doing things" as sorts of generic organizational

technologies, which -rightly or wrongly - are deemed to be quite universal and "superior" organizational arrangements.

(ii) More specific procedures generally associated with proprietary devices and software.

This is the case of e.g. training and software packages for information processing and support to decision-making (from the management of client portfolios all the way to modes of access to e-commerce and EVA techniques for financial management).

(iii) "Meta competences" and diagnostic capabilities.

The "upside" of the difficulties in decomposing organizational competences/capabilities (cf. also section 3.3., below) is that they contribute to the "uniqueness" of each organization and its differential economic performances. The "downside" of the same phenomenon is the endemic ambiguity in the relation between organizational traits and organizational actions, on the one hand, and performances, on the other. Consultancy firms, or at least some of them, tend to specialize precisely in the diagnostics of such links - based also on their ability to observe multiple instances of the same basic practices across firms, across industries and across institutional contexts, and of "benchmarking" particularly successful ones.

(iv) External legitimization of internal managerial choices.

In many respects it is the "political" counterpart of the foregoing point : a purported "diagnostic" ability is put to the service of corporate management, which by itself might have faced too big a resistance in the implementation of strategies which it had in any case already chosen (typical examples are layoffs, downsizing, "lean and mean" oganizational re-orientation, etc.)

(v) Selling "visions", keywords and fads.

How much fad-paddling there is amongst the "competences" of consultancy firms is an issue too difficult to discuss here: Garcia (1999)(B) rather cautious view tends to suggest that there is *some*, inextricably intertwined with the other objects of transaction mention above.

Come as it may, consultancy firms - the evidence appears to suggest - are both a) a fundamental vehicle of diffusion of "generic" organizational practices, and b) a crucial actor in the codification of such practices themselves (in fact diffusion is made possible largely by codification). Conversely, on the acquirer side, what one is getting is not only the adaptation of an archetypal protocol, but with it also the "crystallization" of a set of social practices, implicit decision biases, forms of authority relations and mechanisms of learning.

Given that, a challenging and open question concern the importance for the European economy of the fact that the overwhelming majority of international consultancy firms are likely to carry with them a North-American birthmark in the "organizational archetypes" they supply.

3.2.6. Patterns of organizational innovation: an assessment of some preliminary evidence.

A few **Dynacom** studies are aimed at opening the "blackbox of organizational change", trying to

a) identify it main current patterns : cf. in particular the critical discussions in Coriat (1999)(B),(2000b)(B) ; see also Lorenz (2000)(B) and Ichniowski et al. (2000);
b) explore the possible relationships between organizational forms and *technological* innovation : cf. Lhuillery (2000)(B), suggesting a positive answer, grounded on the evidence from a large sample of French firms;
c) study possible *direct links between organizational innovations and corporate performances even when explicitly neglecting technological innovation :* cf. again Coriat (1999) and (2000b)(B), Lundvall and Christensen (1999).

At a birdeye view, what one observes across both sides of the Atlantic are significant tendency departing from a system of work and labour- management relationships characterized by "tightly defined jobs with associated rates of pay, clean lines of demarcation separating the duties and rights of workers and supervisors, decision-making powers retained by management, and the channeling of communications and conflicts through formal chains of command and grievances procedures. Current workplace innovation seek greater flexibility in work organization, cooperation between labour and management, and workers

participation in the decisions and financial wellbeing of the company" (Ichniowski et al., 2000,p.2).

However, at a closer look, one sees also relative diverse trajectories of organizational change, both across the Atlantic and within Europe itself. As discussed in detail in Coriat (2000b)(B),

(i) the process of change tends to display more a series of piecemeal adjustments of the 'traditional' model rather than the transition to an 'alternative' model;

(ii) there seem to be a significant divergence between a trajectory primarily aimed at *numerical flexibility* of the workforce and another one emphasizing *functional flexibility and more plastic mobilization of skills and competences within the organization* ;

(iii) low degrees of diffusion of organizational innovation, notwithstanding the evidence suggesting positive correlations with economic performances (for similar findings on the US industry, cf. Ichniowski et al., 2000).

3.3. PROBLEM-SOLVING AND COORDINATION-GOVERNANCE: ADVANCES IN A COMPETENCE-BASED PERSPECTIVE ON THE THEORY OF THE FIRM

On purpose, we have organized this **Dynacom Report**, so to speak, "bottom-up", building upon what we believe are complementary elements of "value added" along diverse threads of empirical analysis. A highly complementary endeavour of the coordinators, however, has been to induce persistent feedbacks with theoretical advances. Here, "theory" is given a broad span - *as it should be* - ranging from "appreciative theorizing" (i.e. history-based, largely qualitative generalizations) all the way to formal modeling inevitably implying some sort of daring "reduced form" abstractions.

At a reasonable cost of marginal arm-twisting vis-à vis some **Dynacom** contributors, we are prepared to claim that the Project has also made significant advances concerning evolutionary theories of economic change, and, deeply related, competence/capability perspectives on the theory of the firm [henceforth CP, in line with Dosi and Marengo (1999)(B)].

3.3.1. Evolutionary Economics and Firm Capabilities

A fundamental proposition in evolutionary economics 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, to say nothing of the large-scale differences that separate the chemical firm, the automobile manufacturer, the mass retailer, and the hospital. 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 behaviour patterns gives the market selection process something to work on; because the pattern persist, the market's selection and promotion of successful ones has significant systemic consequences over time.

Research on capabilities advances the evolutionary economics agenda in four significant ways. *First*, it provides concrete examples and specific empirical evidence that illustrates and supports the view of firm behaviour taken in evolutionary theory. The analysis of firm capabilities illustrates one very fruitful way of conceptualizing the elements of continuity and idiosyncrasy that are central to the evolutionary view of firm behaviour. To the best of our knowledge, no student of firm capabilities has ever proposed that firm capabilities often change radically in short periods of time, except perhaps by the outright acquisition of another firm that already possesses different capabilities. Rather, the emphasis is on the accumulation of capabilities and the fact that the options for further development at each point of time are sharply constrained by the heritage of the past.[7]

The *second* contribution involves the relationship between capabilities and organizational routines. Routines play a central role in the formulation of evolutionary theory offered by Nelson and Winter. In their introductory discussion, they noted that much business behaviour is not routine within the ordinary meaning of that term, but then remarked '(The point) …. is that most of what is regular and predictable about business behaviour is plausibly subsumed under the heading "routine", especially if we understand that term to include the relatively constant dispositions and strategic

[7] These patterns of accumulation are well illustrated by Miyazaki (1995) and Patel and Pavitt (1998a).

heuristics that shape the approach of a firm to the non-routine problems it faces' (1982:15).

The story of the development of capabilities in a firm is very much a story of the shaping role of 'relatively constant dispositions and strategic heuristics' that provide an element of continuity that extends even over time spans long enough for radical change to accumulate in the firm's specific performances. Thus, the capabilities discussion relates specifically to a realm of behaviour infused with intentionality, conscious deliberation, planning, and expertise - as contrasted with the quasi-automatic character of performance of low-level operating routines. And it shows how these elements of intelligence and intendedly rational calculation not only coexist with, but give expression to, the historically grounded uniqueness of the individual firm.

The *third* contribution is closely akin to the second. Precisely because the development of capabilities also includes elements of intentionality and deliberation, the capabilities discussion provides a bridge between the predominantly descriptive concerns of evolutionary theory and the prescriptive analysis of firm strategy. Accurate description requires acknowledgement of the role of intentionality; likewise, sound advice must be founded on an accurate characterization of the system the decision makers are guiding. Thus the two areas of inquiry are mutually supportive, notwithstanding the substantial difference between their focal concerns.

Evolutionary economics has long been identified with an emphasis on the role of institutions in economic life, and this long-standing connection has recently been revitalized (Hodgson, 1988 and 1993). The narrower but still extensive set of institutions that shape a nation's science and technology resource and, generally, innovative abilities is another area of institutional and policy concern that has a long-standing connection to evolutionary economics.[8] It is hard to review the history of the aircraft industry, or of computers, or biotech, or many other industries, without getting the distinct impression that something more is going on than the exploitation of the 'given' production functions of firms. Evolutionary economists view firms as building their capabilities in an institutional and policy context, and the exploration of the connections to those contexts remains very much on the research agenda (Metcalfe, 1994).

Last but not least, *fourth*, evolutionary theories of economic change finally begin to meet institutionally embedded analyses of incentive governance.

Within any organization, capabilities, in principle aimed to 'solve problems' in the broadest sense - ranging from carrying a passenger across the Atlantic to more purposeful activities of search for new drugs or new machines - come anyhow together with specific mechanism governance of potentially conflicting interests and incentives. Indeed, the links (and, over time, the co-evolution) between organizational capabilities and governance structures is another major field of inquiry ahead [for some hypotheses and empirical interpretations cf. Coriat and Dosi (1998a); Weinstein and Azoulay (1999)(B) and Coriat (2000)(A)].

3.3.2. Firms Capabilities and Strategic Management

As many observers have noted, the past decade or so has seen a marked swing in the attention focus of scholars and practitioners interested in business strategy. Among the aspect of strategic doctrine that now capture attention, issues surrounding the quality of firm capabilities now loom very large. A number of factors, have contributed to this development. On the academic side, there is an element of the familiar phenomenon of the swinging pendulum of attention: the concerns with capabilities followed a period in which strategy research had been re-energized by economic concepts drawn from industrial organization economics and focused primarily on the firm's relation to its competitive environment. As often happens, one of the truths discovered in this research programme was that its orienting ideas were not as fruitful in illuminating the key issues as had been hoped. The quest for the sources of competitive advantage turned back toward the internal workings of the firm, and in particular to the development of Edith Penrose’s idea (1959) that the profitability and growth of a firm should be understood in terms of its possession and development of unique and idiosyncratic resources. 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 “leveraged”, and what considerations prevent the elimination of the gap between the cost of the resources and the market value of the output produced.

[8] On the germane field of 'national systems of innovation' see Lundvall (1992) and Nelson (1993).

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. 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 example of the sorts of resources they see as sources of competitive advantage.

Another recent theme in the strategy literature is the idea that the most distinctive role of the business firm in the economic system is the way it brings 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 (1994)].[9] As with the notion of resources, this discussion converges with the capabilities discussion in proportion as the knowledge is conceived as know-how embedded in the organization's activities, as opposed to passive, library-like stocks in the heads of participants.

There is, however, much more to the rising concern with capabilities than simply the swinging pendulum of scholarly interest. One important background fact (in the USA) is the stock market's skepticism toward unrelated diversification, which has been manifested quite consistently for at least fifteen years (even if one always argues that this phenomenon itself is a scholar-induced fad!). Episodes like Sears Roebuck's 1992 retreat from its strategy of diversification into financial services, and the broadly similar evolution at American Express in 1993 and after, illustrated the power of the market to "jerk the chain" of wandering CEOs and force a retreat to the "core business"[10]. That being the case, it is unsurprising that managers and consultants became inclined to focus more on the relatively concrete and specific issues affecting the individual firm's competitiveness in particular markets. Another impulse in the same direction was provided by the rising concern with American manufacturing vis-à-vis Japanese competition in the early and mid-1980s.

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[9] For an earlier discussion with similar emphasis but cast in terms of reforming the theory of production, see Winter (1982)

[10] For a more detailed discussion of the relationship between capabilities and diversification patterns, see Teece et al. (1994).

So far has this trend progressed that Michael Porter of Harvard, a long-time leader in the strategy field who is active in both the academic and consulting segments, has recently felt compelled to enter an objection in the form of an article title “What Is Strategy?” beginning with Section I: “Operational Effectiveness Is Not Strategy” (Porter, 1996).

It remains to be seen whether this assessment will do much to diminish the prevailing interest in capabilities-based competition.

Although the discussion of capabilities issues has been quite extensive in both the business press and the academic strategy literature, the fund of solid empirical research that is specifically on the strategic aspects of the subject has accumulated rather slowly.[11] As result, much of the discussion has remained at a relatively high level of abstraction. The **Dynacom** works, we believe, have contributed important insights helping to operationalize CP in the strategic domain.

In particular Teece, Pisano and Schuen (2000)(A) present an ambiguous attempt to conceptualize different forms of competence and relate them to both organization theory and strategic management. A general premise, common to the many **Dynacom** works, is that distinctive governance modes, which do not replicate either pure market arrangements or any “nexus of contracts”.

Given that, the authors identify the specificities of each firm in terms of (a) *organizational processes* (including their operating routines), (b) positions (broadly defined to cover their specific assets, their location along the value chain, and their relationship with suppliers and customers), and (c) paths (i.e. their patterns of change in the former two sets of characteristics). A theme which they emphasize – common also to most of the other **Dynacom** contributions – is the stickiness over time of distinct organizational capabilities and, thus, also the constraints which the past learning history of the organization puts upon the degrees of discretionality of strategic management.

This perspective on organizations and organizational learning clearly shifts the focus of analysis from either product positioning or “clever strategizing” to the

[11] For 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). The discussion in Robert Grant’s excellent textbook illustrates the appearence of these ideas in the business school curriculum (Grant, 1995, ch. 5]

processes of problem-solving and organizational governance, and, dynamically, to competence-enhancing strategies.

Within such a general perspective let us just signal here what we consider a particularly novel angle of observation promisingly linking analytical and normative dimensions, - namely Warglien (1999)(B) - on intra-organizational dynamics of projects. We have already mentioned some of its interpretative implications. From a normative point of view, it points at the crucial importance of some sort of *meta-competence*s attempting to "carefully tune the exploitation/ exploration trade-off", whereby "the portfolio of projects should comprise at any time a balanced set of new traits which present high risk but higher development potential, and well established traits that provide resources for supporting the cost and the risk of exploitation…" (Warglien, *ibid*.). Note that this perspective on intra-organizational knowledge dynamics involves a major "re-thinking of traditional management tools such as team staffing and nobility, incentive policies and information storage and retrieval – conceptualizing them as tools for setting the parameter of intra-firm dynamics" (i*bid*).

More specifically, in such a context, the management of a *variety* of *exploration trajectories* implies a view of an organization as an "artificial ecology" – borrowing from Levinthal (2000)(A) – wherein managers look somewhat like contemporary bioengineers, trying to "fine tune" ex-ante the discovery of new traits and ex-post test and select amongst them (Indeed the analogy is chilling, were one to extrapolate the rates of managerial success to the biological domain!).

3.3.3. CP on Organization Theory, in the Broader Context of Contemporary Theories of the Firm.

It is worth comparing the CP on the theory of the firm with the "orthodox view – which for brevity we equate to the "orthodox" agency theory (OA henceforth) and transaction cost economics (TCE henceforth).[12]

Given the growing number of detailed accounts of CP and germane views of organizations, such as "resource-based" theories, one can effort to be particularly telegraphic [more in the just cited Dynacom works, in Nelson and Winter (1982) and also in Dosi and Marengo (1994), Kogut and Zander (1992 and 1995), Nelson

(1991), Teece and Pisano (1994), Teece et al. (1994), Madhok (1996), Conner and Prahalad (1996), Leonard-Barton (1995), Winter (1988)].

The phenomena the theory addresses prominently feature heterogeneity among firms and the sources of persistent competitive advantage. For this primary purpose, it elaborates a theory of the nature of the firm whose perspective departs quite significantly from standard Agency views but also from the Coasian one. First of all, firms are not seen exclusively as *loci* of coordination, but also, and equally important, as *loci* of creation, implementation, storage and diffusion of productive knowledge (cf. Winter, 1982). Second, an relatedly, the very existence of firms is not considered in terms of a departure from the original state of nature in which coordination is carried out entirely by competitive markets, but in terms of their being the primary *loci* of the process of division of labour, i.e. of the creation of those separable units which competitive markets might (or might not) coordinate efficiently. Equivalence between markets and organizations might well hold (lacking transaction and bureaucratic costs) for a given state of division of knowledge and labour, but it does not hold if the latter are themselves dependent upon the organizational structure [more on this "anti-Coasian" perspective in Marengo (1999) and Marengo et al. (2000)(B)].

In addition to this inquiry in the sources and consequences of heterogeneity, CP attempts to interpret both the vertical and horizontal boundaries of the firm (cf. Teece et al., 1994); it investigates the properties of different forms of internal organization; it tries to establish the sources of differential performance among firms; it analyses the processes by which particular organizations became what they are (i.e. the underlying evolutionary processes).

As a first approximation, and notwithstanding the limitations discussed in Coriat and Dosi (1998 a), it tries to accomplish the above tasks by focussing on organizations as repositories of problem-solving knowledge as distinguished from sheer information and by studying some salient properties of knowledge accumulation and the ways the latter co-evolve with organizational structures and practices (including, of course, routines but also managerial heuristics and strategies).

Organizational specificities and persistently different revealed performances, are interpreted also on the grounds of path-dependence in knowledge accumulation and inertial persistence of organizational traits. Bounded rationality, in its broadest

[12] This part of the report is largely based on Dosi and Marengo (1999) (B), Coriat (2000b) (B).

meaning, is the norm. Its general sources include the "complexity" and procedural uncertainty associated with problem-solving procedures [cf. Dosi and Egidi (1991), Marengo et al. (2000)(B)] and the intrinsic "opaqueness" of the relationship between actions and environmental feed-backs, so that it is seldom obvious, even ex-post, to state how well one did and why (cf. March, 1994).

The analysis is, or ought to be, undertaken both in terms of comparative properties of different organizational forms (a methodology deeply shared with TCE) and modal learning processes (almost entirely absent from TCE), properly accounting for initial conditions and for their embeddedness into broader institutional set-ups, such as those governing the markets for labour, finance and products.

In CP, as discussed with several original insight in Levinthal (2000)(A), organizational competences and capabilities are partly a collective property of ensemble of organizational routines and learning heuristics (and also, 'cultures', 'visions', and strategic orientations) and provides an appealing theoretical framework for their analysis.

Key features in this respect are the notion of (a) *complementarity* and (b) *interdependence* among organizational routines and complementary assets. A crucial consequence concerns what one could call the *'competitiveness diagnostic'* of corporate performances: precisely because of the (non-linear) interrelatedness in the contribution of the various organizational traits to overall performances, 'credit assignments' is a difficult exercise.

Relatedly, in terms of organizational learning, 'local' exploration and adjustments are likely to be rule, since otherwise one is likely to lose any grasp on the relationships between causes (i.e. changes in organizational behaviour) and effects (i.e. changes in relieved performances). But a fundamental corollary of all this is also that organizations are likely to end up *(quasi)* stuck into local peaks of the 'fitness landscape', using Levinthal (2000)(A) and Marengo et al. (2000)(B) terminology (i.e. roughly speaking the mapping between organizational traits and 'competitiveness'), with low probabilities of exploring radically diverse organizational arrangements.

It is useful to provide a sort of "bird-eye" comparative assessment among CP, TCE and the orthodox view of agency (OA) where by the latter we mean the whole class of interpretations grounded on equilibrium contracting with fully rational far-sighted agents under asymmetric/incomplete information.

In table 2. we highlight some major distinguishing features.

Table 2. Orthodox agency, transactions costs economics and competence perspectives: a comparative appraisal**.**

Dimensions of analysis and theoretical building blocks:	**Orthodox Agency**	**Transaction Costs Economics**	**Competence (and Evolutionary) Perspectives**
1. Problem-solving/ cognition/knowledge	No	Not so far (but see Williamson, 1999a and 1999b)	Yes (central dimension of analysis)
2. Incentive governance	Yes (central dimension of analysis) via equilibrium contracting	Yes, possibly via organizations as substitutes for equilibrium contracting	Not much, so far [but see Coriat and Dosi (1998a), Coriat (2000) (A), Coriat (2000a) (B].
3. Behavioural microfoundations	Perfect, farsighted rationality	Bounded rationality with "farsightedness"	Bounded rationality (usually with some 'myopic' attributes but also unexploited innovation potentials)
4. Organizational behaviours	Strategic (in the game-theoretic sense)	Cost-economising	Driven by routines, heuristics, etc.
5. Learning	No	Not so far	Yes (central dimension of analysis)
6. Unit(s) of analysis	- strategies - allocation of information - allocation of property rights	Transactions	- elementary 'bits' of knowledge - routines and other elementary behavioural traits
7. Non-economic dimensions of organizations	Not as original dimensions	No	Power, trust, identity-building, etc.

In order to emphasise the differences, consider first a major divide concerning the primary dimensions of analysis, which in the case of both OA and TCE regard essentially incentive governance, while CP focuses on the problem-solving

dimensions of organizations. In a nutshell CP's "primitive story", which finds ancestors in the work of Herbert Simon as well as multiple streams of organization theory, carries a good deal of "cognitive" emphasis, while it tends to censor (as a first approximation, which is ripe time to overcome!) all governance issues which arise from potentially conflicting interests, opportunism, etc.. Williamson (1999a and 1999b) is certainly right in reminding us that, taken at face-value, that primitive story implies a utopian view of actors as benevolent cooperators.

On the other hand, the same epistemological status can be also attributed to the primitive story which is implied by both OA and TCE, whereby one censors the fact that organizations essentially carry complicated procedures to do complicated things such as producing airplanes, shoes, transportation services for people and goods, etc. and that they do it more or less well for reasons which are partly independent from sheer incentive alignment issues. Thus, in the OA and TCE "utopia", the implicit *ceteris paribus* assumption is that organizations naturally possess, in their "optimal" form, the knowledge required to carry out such complex tasks and, moreover, that this optimal knowledge in itself is independent from the actual organizational structure. The members of the "utopian" organization depicted by OA and TCE are not actually engaged in acquiring and implementing the knowledge necessary to do the complex things actual organizations do, but are only engaged in playing among themselves devious games of cheating, hiding, double crossing, etc.

Needless to say, the crucial issue beyond the caricature is what kind of empirically robust propositions each view is able to generate. In this respect, one of the basic tenets of CP is that the whole domain of accumulation and social distribution of knowledge cannot be reduced to a sheer matter of either incentives or property rights allocation. Witness on that, the ample literature on the economics of innovation and organizational learning already mentioned in the foregoing sections trying to establish a few "stylised facts" on the patterns of learning at the level of firms, industries and countries, which may be hardly interpreted as equilibrium responses incentives or to property rights distributions.

Having said that CP is beginning to tackle the "grand" research programme, sketched Coriat and Dosi (1998a), building on classic insight such as those from March and Simon (1993), whereby evolutionary, competence-based theory of the firm begin to take on board incentive alignment issues and more generally the

political dimensions of organizational arrangements: amongst **Dynacom** contributions, see in particular Coriat (2000a)(B) on the arrangements governing *both* knowledge distribution and political leverages in Complex Product Systems.

In parallel, advances are being made in the development of a formal theory of organization as problem-solvers. Within **Dynacom**, see in particular Marengo et al. (2000) (B), where we study analytically the ways different patterns of division of labour shape and constrain search processes in high dimensional problem spaces. Examples of such search processes are all those problems requiring the coordination of a large number of interdependent "elements" whose functional relationships are, to a good degree, opaque to the organizational members themselves.

Here by "elements" we mean elementary physical acts - such as moving one piece of iron from one place to another - and elementary cognitive acts - such as applying inference rules. Relatedly, problem-solving can be straightforwardly understood as combination of elementary acts leading to a feasible outcome (e.g. the design and production of an engine, the discovery and testing of a chemical compound, etc.).

In this perspective, one presents a quite general formal framework enabling the exploration of the problem solving properties of diverse patterns of division of labour and routine-clustering practices, ranging over a continuum that notionally spans from totally decentralised market-like mechanism to fully decentralised coordination processes.

Moreover, diverse organizational forms map into diverse

I. problem *representations*;
II. problem *decompositions*;
III. task *assignments*;
IV. *heuristics* for and *boundaries* to *exploration* and *learning*;
V. *mechanisms for conflicts resolution over interests*, and, equally important, over *alternative cognitive frames* and *problem interpretations*.

With respect to these dimensions, to repeat a telegraphic caricature we are rather fond of, one might think, at one extreme, of an archetype involving complete, hierarchical, ex ante representations, precise task assignments according to well defined functions/ tasks, quite tight boundaries to exploration – “learning” being itself a specialized function – and, if all that works, no need for ex-post conflict resolution.

The opposite extreme archetype might be somewhat akin university departments, with a number of representations at least as high as the number of department members, fuzzy decompositions, little task assignments and loose boundaries to exploration, fuzzy conflict resolution rules, etc.

Clearly, Taylorist/ Fordist organizational forms tend to be nearer the former archetype, while e.g. the design and production of complex product Systems are more alike the latter. However, at a closer inspection, one begins to identify a set rich of discrete types of organizational arrangements, and with that also diverse learning patterns.

4. COMPETENCES AND ORGANIZATIONAL PERFORMANCES: SOME "DIAGNOSTIC" CONCLUSIONS AND POLICY IMPLICATIONS.

Within **Dynacom**, the analyses of competence profiles and patterns of organizational learning have often come together with a few, admittedly preliminary, explorations of the impact of competences themselves upon *technological and economic* performances and of broader policy implications.

In the following we shall discuss some of them. In particular, in order to highlight a few policy issues stemming from our study it is useful to place the findings of **Dynacom** in the context of the broader picture concerning comparative patterns in science, technology and competitiveness. This is what we shall succinctly do in the following [(drawing also on the results of the other TSER Projects: cf., in particular, Fagemberg, Guerrieri and Verspagen (1999) and Edquist (1997)].

A *caveat* is required: some of the policy issues raised by **Dynacom** and related studies are both quite crucial for European policies and also quite controversial (indeed, even within the **Dynacom** team, different researchers draw diverse conclusions from the considered evidence!). Hence, rather than offering any full-fledged policy recipe, here we shall just flag some problems to be addressed and, possibly, the dilemmas involved.

4.1 COMPETENCES CAPABILITIES AND CORPORATE PERFORMANCES

First, several studies - including Pisano (2000)(A), Cockburn and Henderson (2000)(A), Patel and Pavitt (2000)(A) - add original insights on the powerful effects of competences and capabilities (cf. our earlier discussion) upon corporate technological performances, measured by different proxies of innovative outputs (e.g. innovations, patents, etc.).

Together, a complementary evidence is beginning to emerge concerning systematic links at firm level between *organizational* competences and *organizational* innovations, on the one hand, and *technological* innovation, on the other. See the evidence from national surveys discussed in Coriat (1999) and Coriat (2000a and 2000b) (B); the elaborations on a large sample of French firms by Lhuilery (2000)(B);

cf. also the study by Lay, Shapira and Wengel (1999) on the correlation between patterns of introduction of innovative organizational methods and rates of introduction of new products in the German machine tool industry.

Second, as discussed in detail by Cefis (1999)(B) both the innovation - and profitability profiles of firm tend to display high degrees of persistence over time.

The analysis of the joint distributions gives a very similar picture: firms which are systematic innovators and earn profits above the average have a high probability to keep innovating and earning profits above the average, as well as firms which are occasional innovators and earn profit below the average have a high probability to remain in the initial situation. Interestingly, the mobility in a firm's relative position with respect to the average profitability does not appear to be correlated with the firms relative position in the innovation dimension, in the short run. However, firm's relative position in the innovation dimension does matter in the long run: the probability to earn profits above the average, in the long run, is higher if a firm start as a "systematic" innovator rather than an occasional one.

Third, a few **Dynacom** contributions have begun to explore the impact of specific organizational arrangements and *organizational* competences (*narrow* sense, cf. above) upon diverse indicators of economic perfomances of business firms: cf. in particular the diverse sources of secondary evidence critically discussed in Coriat (2000c)(B),and the statistical analyses in Lhuillery (2000)(B) and Gambardella and Torrisi (2000)(B).

So, for example, the latter paper shows the positive impact upon the market valuation of firms of both their 'technological' and 'relational' capital (notwithstanding the inevitable roughness of the statistical proxies).

Moreover, as shown by several elaborations on national surveys - discussed in Coriat (1999), (2000b)(B) - the introduction of a large ensemble of organizational innovations (including just-in-time, organizational provisions from 'cross-projects' team work, reduction of hierarchical layers and a few others) appear to exert in general a positive influence on the competitiveness of firms, both in terms of production costs and non-price factors (e.g. product quality, market responsiveness, etc.). If anything, the puzzling aspect in all that is the relatively slow pace of diffusion

of seemingly 'superior' practices (a phenomenon also emphasized in the case of the US by Ichniowski et al., 2000) and their piecemeal, partial and local penetration even within a good deal of firms which do adopt them.

There appear to be multiple complementary 'retardation factors'. Some have to do with the uncertainty and gestation lags associated with future improved performances. Others relate to 'political' conservatism within any organization whenever innovations bring about also changes in hierarchies and power distribution. However, more fundamentally, *organizational forms are carriers of history*, paraphrasing David (1994): in particular, a history of problem-solving experience and, together, of governance arrangements, industrial relations, authority mechanisms, salary profiles. Organizational innovation tend to disrupt the 'epistatic correlation' across these traits, as argued at length in Levinthal (2000)(A). [See also Marengo et al. (2000)(B) and Dosi and Marengo (1999)(B)]. In our view, also this is one of the underlying causes of the relatively low degrees of diffusion of new organizational practices and their 'timid' patterns of adoption in Europe, which often only scratch the surface of older organizational forms: cf. the evidence discussed in Coriat (2000c)(B). This latter review of various comparative studies also highlights the influence of the institutional context - *in primis*, the systems of economic-wide labour relations - upon the patterns of diffusion of organizational innovations. In this respect, circumstantial evidence seems to suggest that comparatively more institutionally structured labour relations (with powerful mechanism of collective labour representation, effective Business Associations, etc.), as present in many central/northern European countries, have been indeed a factor conducive to faster and deeper diffusion of novel organizational practices [cf. the studies cited in Coriat (2000c)(B)].

4.2 FROM COMPANIES TO SECTORS AND COUNTRIES.

The "diagnostic" aspects of the works from **Dynacom**, as well as from other complementary studies, bear profound implications not only in terms of strategies and performances of individual firms, but - we suggest - also for the sectoral, national and regional patterns of innovation, competitiveness and growth. Moreover, they relate both to the mechanisms of generation of innovative opportunities, the

organizational arrangements through which opportunities are economically tapped, and their effectiveness.

One way of organizing the discussion of such implications is with reference to the so-called “European paradox”, which claims a purported European scientific and technological strength comparable with the US and Japan but lower abilities in translating it into its economic exploitation in terms of competitiveness and growth (for a discussion cf. Andreassen et al. (1995), including Coriat's and Dosi's contributions therein and ESRC (1997)] and more recently Muldur (2000)].

Indeed, our evidence allows an assessment of some of the issues underlying such a 'paradox' [(cf. among others, Marsili (1999)(B), Breschi and Malerba (1999)(B) and Orsenigo et al. (1999)(B)].

First, note that not only Europe is significantly weaker in terms of scientific “frontier” output in rapidly advancing fields like ITC, but this weakness is also reflected in a relatively weak technological output. (See Dalum et al., 1999). So, for example, Breschi and Malerba (1999)(B) show that European weaknesses in electronics technologies based on the weaknesses of both the core and the fringe of European innovators emerges. As far as the core is concerned, in electronics Europe does not have a big core of numerous large competent companies that span over mature as well as new technologies. In this way, big projects on broad technologies, the continuous opening of windows on new technologies and the pursuit of multitechnology initiatives that requite the integration of different complementary technologies may be unpaired. As far as the fringe of innovators is concerned, Europe is characterised by a too high entry of small firms specialized in mature technologies. The problem here is not entry but survival. Most of the new innovators are not able to become continuous innovators and do not survive as innovators for long. Even those that survive are unable to widen their specialization, and move from mature to emerging technological fields.

Second, in a sector of historical European lead such as pharmaceuticals, the transition to a different, more directly science-based, search paradigm [cf. Orsenigo et al. (1999)(B)] has led to a weakening of the European technological and competitive positions (especially with regards to continental Europe).

These worrying evidence primarily concerns, to repeat, many activities based on biotechnologies and electronics/information technologies (and notwithstanding remarkable exceptions such as mobile telephony: see also below).

Conversely, Europe tends to maintain a position of relative strength in 'older' activities and technological paradigms (which can be characterised by low *but also by high innovative opportunities*) including mechanical engineering, complex capital goods, transport equipment, chemicals and a few others [for more detailed analyses see Archibugi and Pianta (1992), Fagerberg, Guerrieri and Verspagen (1999), Fontagné et al. (2000), and Marsili (1999)(B)].

Given the patterns of technological strength and weakness of the European economy - *which often largely match the technological competences of the major domestic firms* (cf. Patel and Pavitt, 1998b) -, a first fundamental question concerns the effectiveness of the science and technology system in generating an expanding pool of knowledge and innovative opportunities. A second and equally crucial one regards the institutions and organizational arrangements which bridge the dynamics of innovative opportunities with their economic exploitation, most often by business firms.

Let us start with the former.

4.2.1. Strength and weaknesses of the European Science and Technology system and Competence accumulation in European firms.

It has not been among central purposes of **Dynacom** to investigate the “pure research” side of the so-called “paradox”. However, our evidence supports some of the pieces of the interpretation discussed in Pavitt (2000a and b) and pointing at worrying structural and policy weaknesses of the European research system.

First, consider the European scientific output. In general, European scientific productivity, evaluated in terms of European *expenditures* for basic research is roughly at par with the US (possibly even marginally higher: cf. European Union, 1997).

However, the *overall scientific* productivity of EU-15 continues to be on average significantly lower than the when measured in per USA (by around 40%: cf. OST, 2000). And it remains lower by more than 10% even by comparison with the EU

countries with higher productivities (i.e. France, Germany, Benelux, Scandinavia and UK). These two opposite facts are indeed easy to reconcile: the gap in public expenditures for R&D between the US and EU-15 is of the order of several hundred billion dollars in favour of the former (Muldur, 2000).

Perhaps more revealing are the differences in the various scientific disciplines (OST: 360). EU-15 has its strongest publication performance compared to the USA in the well-established disciplines of chemistry and physics, whilst the strongest US performance is in the recently established disciplines of molecular and cellular biology, biomedical engineering, and informatics. As we shall discuss below, these are the very disciplines that are at the basis of the US strengths in biotechnology and ICT, and their development has been strongly supported by large-scale Federal funding.

Second, the *R & D performance of businesses* in EU-15 has been declining since the early 1990s relative to those in the USA, and the decline has been particularly marked in electronics (OST, 2000, p. 364]. But trends have been uneven, with decline in the larger countries (France, Germany, Italy and UK), but growth in Scandinavian countries which have also emerged as world leaders in mobile telephony.[13]

The reason usually given for such a decline are inadequacies in technological entrepreneurship in European business reflected in low investments in R & D. In certain cases - such as British electronics and automobile companies in the 1970s and 1980s - this was certainly the case. For other European countries, any entrepreneurial inadequacies must have emerged only in the early 1990s, since their business R & D expenditures had been growing more rapidly than those in the USA during the previous twenty years.

There is another possible explanation of the changing trends since then, namely that European firms are performing an increasing share of their R & D outside their home country, and more specifically in the USA. The analysis by Cantwell and Piscitello (1999a)(B) shows that this is indeed the case. The major companies in most of the EU-15 countries have been increasing the foreign share in their R & D activities, and at a faster rate in the 1990s. At least a third of European-based large firms' R & D is

[13] EU countries in general have been relatively stronger in telecommunications than in other fields of ICT. See Tijssen and van Wijk, 1999

now performed outside their home country, of which about 20% in the USA and 14% in other European countries. It is not possible at this stage to assess the degree to which this shift in the location of corporate R & D can explain the stronger performance of business R & D in the USA, since US-based businesses have also been increasing the foreign share in their own R & D. But there is increasing evidence that foreign corporate R & D no longer is a simple support function for foreign production, but a deliberate search to learn about foreign skills and knowledge [Niosi (1999), Cantwell and Piscitello (1999b)(B), Castellani and Zanfei (1999)(B)].

Recent studies by Dalton et al. (1999) and Florida (1999) show that this is particularly true of foreign corporate R & D in the USA, which increased from about 9% of the US total in 1987 to nearly 15% in 1997. In the pharmaceuticals and biotechnology sector, the foreign share was as high as 49%, in communications it was 20%, and in computers and office equipment only 2%. At least two-thirds of the foreign R & D was performed by European firms[14], who have a very powerful position in the pharmaceutical sector. Although part of this foreign R & D serves the traditional function of modifying products and practices to the requirements of the US market and regulatory regimes, its major purpose is to gain access to high-quality technical staff and developing links with the technical community. This is particularly true of firms involved in biotechnology, but also holds for those in electronics.

As a consequence, foreign corporate R & D is located mainly in regions where such talent in concentrated, sometimes in business R & D laboratories (e.g. Detroit for automobiles, New Jersey for chemicals and pharmaceuticals), and sometimes in universities. Co-operative research with US universities is the rule rather than the exception, and they are also a common source of recruited technical staff. The main fields for such co-operation are biotechnology and ICT, and the main regions California (Berkeley and Stanford), Massachusetts (MIT) and the Research Triangle Park in North Carolina[15].

These data tend to confirm that the strength of US academic research is one of the factors causing European firms to increase the share of their research performed in the USA, particularly in pharmaceuticals and related biotechnology, and also in ITC. Our point, drawing upon Pavitt (2000a and b) and earlier works of Freeman (1982),

[14] About half, when Swiss firms are excluded.
[15] Other universities identified include Princeton and the Universities of Colorado and Washington.

Dosi (1982), Rosenberg (1982), Hughes (1990), among others, is that large-scale US government funding has helped create this state of affairs (below we shall mention some implications for EU policies for funding R & D).

In the past, the academic disciplines of electrical, chemical and aeronautical engineering were pioneered in the USA. More recently, we have seen the development there of research and related post-graduate teaching in biotechnology and ICT-related engineering subjects.

The amount of resources matters, too: it has been estimated that the resources devoted to academic research in the life sciences in the USA are 50% bigger than in Europe (Ballantine and Thomas, 1997).

A similar pattern of funding of high quality and long-term fundamental research, from a plurality of Federal sources, emerges from a recent study of earlier developments in US computing and software engineering (Computer Science and Telecommunications Board, 1999).

By comparison, European policies appear to continue on an established trajectory too often conforming with the old philosophy "too little, too late, with too many strings attached…". This has been true for past national policies toward electronics and biotechnologies [cf. Dosi (1982) and Orsenigo (1989)] and it continues to largely hold for European R&D policies. In fact, the latter institutionally embody further constraints and compromises concerning 'cohesion' and 'equity' (e.g. between big and small firms, big and small countries, the North and the South, etc.). On these grounds, the findings by Giarratana and Torrisi (2000)(B) on the disappointing effects of EU-sponsored research agreements upon technological competences of European firms should not come a total surprise.

In fact, historically, objectives of intra-European integration and homogeneization could have justified the complexity of the allocation mechanism and the mix of diverse criteria which have informed EU policies.

At this stage, one wonders whether a more direct focusing on criteria of scientific quality might not be desirable if not altogether necessary.

4.2.2. Institutional Differences in the mechanisms of knowledge exploitation.

Given the foregoing features of knowledge-generation in *science-based activities*, a related, although conceptually distinct, issue regards *the mechanisms of appropriability*, and in particular the width, depth and length of coverage of *Intellectual Property Rights*. It is an issue that - as known - has come to the forefront of the policy debate following a marked extension of the IPR coverage by US legislature and practice since the '80s - which has come to include a good deal of knowledge on life forms (genes, etc.) and of software artifacts.

Whether increases in private appropriability of innovations yield monotonically increases in the long-term propensity to innovate remains quite controversial. (For a rather skeptical view, see for example Dosi, 1997). However, it is straightforward that increases in appropriability, other things being equal, do increase a) the rents accruing to the innovators themselves, and b) their ability to attract financial investors [as the US case indeed shows: cf. Orsi and Moatti (2001), among others].

Here, one finds indeed a policy dilemma with far-reaching implications for Europe. One option is of course 'to go the American way', imitating the whole set of American IPR institutions. The alternative - which a few, although possibly not all, of the **Dynacom** researchers subscribe - favours, on the contrary, distinct European institutional arrangements, centered on *open science,* and relatively tight boundaries to what can become a rent-yelding asset (no matter whether the rent goes to a private agent or a public organization such as a university). The subscribers to this view do so not only on the grounds of ethical and political reasons - as important as they are - but also on sheer economic grounds. In the long-run, too much/too wide an appropriability of single pieces of knowledge which contribute to the development of complex products (think of a new drug with a new therapeutical target, of a piece of telecom equipment, etc.) are likely to hinder the innovation process altogether. But, then, were one to take the '*open science route'*, the need for remedies to the weaknesses of the European Science System - discussed above - becomes even more urgent.

Certainly, it is hard to think of a more damaging condition than the *status quo*, squeezed between half-hearted attempts to imitate the US, bureaucratic rigidities

and meager budgets for public science, 'directives' of the European Commission and 'resolutions' of the European Parliament….

4.2.3. Competence, capabilities and their institutional roots.

As the **Dynacom** studies make abundantly clear, diverse sectoral systems of innovation and production are grounded in equally diverse combinations of competences and organizational capabilities. (Indeed, 'sectoral systems' are precisely the central issue of an ongoing TSER research coordinated by Franco Malerba).

In turn, a general conjecture that one is beginning to explore is that such competence/capabilities are *institutionally embedded*, in two different senses.

First, institutions - such as those governing scientific research, workforce training, labour relations, etc. - are instrumental in the generation and maintenance of organizational competences.

Second, sector-specific combinations of corporate competences, organizational structures, strategic orientations find varying degrees of matching/mismatching with the broader institutions in which a company operate. Hence, one is beginning to investigate also the interpretative value of some notion of *institutional comparative advantage,* which might render a given location conducive to a certain activity not as result of any 'physical' endowment and not even as a result of the sheer amount of knowledge generated in that location but primarily owing to of the locally dominant organizational arrangements governing e.g. labour mobility, finance, corporate governance, etc. If the 'ways of doing things' display some invariances specific to each activity (e.g. making steel, or designing/producing luxury cars, or searching for a new monoclonal antibodies, etc.) irrespectively of the nation where they are undertaken, then one may observe 'comparative advantages' due precisely to the institutional characteristics of that location which, so to speak, 'make it easy to do that particular thing in that particular way' in that particular place. [On all these points, cf. from different angles, Soskice (1996 and 1999), Amable (2000), Hanke (1999), Coriat and Weinstein (1999), Dosi (1999)].

Indeed, Soskice (1996 and 1999) and Hanke (1999) have begun to compare, among other countries, the US and Germany findings remarkable symmetries.

Whereas the US tend to display comparative advantages in activities characterized by science-based 'disruptive' innovations, Germany finds its points of strength in activities displaying more cumulative patterns of innovation, based on intensive intra-organizational learning. In turn, the authors suggest, each of the two broad patterns is supported by 'matching' institutions' in the financial and labour markets.

A loosely complementary evidence, this time concerning the European Union as a whole, highlights a widespread bias of European exports in favour of *high quality products* (where 'quality' is measured by unit prices within each product category): 'high' and 'medium' quality production makes up for more than the double of the total European foreign surplus in manufacturing trade (with the 'low' category accounting for a significant deficit) (Fontagné et al., 2000). Note also that this pattern does not apply to the US trade profile - even neglecting the structural presence of an overall trade surplus in the European case and growing overall deficit in the US case -.[16]

Come as it may, these pieces of circumstantial evidence, together with some of the works reviewed in Coriat [(1999), (2000b)(B)], and a few sociological investigations converge to the view that most European nations have distinctive institutional arrangements conducive to support a wide range of organizational capabilities, especially in 'older' technological paradigms, often relying on cumulative knowledge accumulation and on a highly skilled workforce.

A few European points of strength in ICT such as manufacturing automation and Telecom (especially mobile communications) are also revealing a more general lesson whereby ample opportunities for innovation and competitiveness are generated at the interface between 'old' and 'new' competences. Moreover, as the case of mobile phones highlight, a decisive role has been played by "the joint effort between (public) telecom service providers, telecom regulators and private firms", showing "how public-private cooperation at the institutional level may be a decisive factor in enhancing the competitiveness of European firms" (Dalum et al., 1999, p. 123).

[16] On the relative 'quality profile' of European exports, see also Jansen and Landesmann (1999), who however find wide intra-European differences.

4.3. Is there any 'one best way'? Some final policy remarks.

Certainly, one general lesson of this research is that one can hardly identify “one best way” to accumulation of organizational competences and competitiveness. Rather, the research has begun to make some painstaking inroads toward the identification of some sort of “combinatorial exercises” amongst scientific, technological, and organizational arrangements conducive to microeconomic competitiveness. However, the absence of any invariant “best”, does *not* mean that “anything goes”. On the contrary, all across the wide range of institutions, organizational arrangements and policies, one may identify both some necessary conditions and some “combinatorial constraints”.

Begin with 'pure research' domain.

As discussed in Pavitt (2000a and b), the experience of the USA shows that government support of high quality academic research has far reaching positive economic consequences, in both creating technological and economic opportunities and providing the skills and knowledge to attract high-tech businesses. High quality academic research in itself is a necessary but not sufficient basis for technological dynamism (Florida, 1999). But there is evidence that the direct practical usefulness of the results of 'pure' academic research is extending beyond molecular biology and biotechnology (Mowery et al., 2000).[17] This experience, and the above comparisons with Europe, strongly suggests that similar policies in Europe will help redress the balance of technological performance in its favour in future. However, this will require major changes in the priorities and practices in the science and technology policies of the EU.

The first major change at this level is that the strengthening of high quality academic research should become one of the principle objectives of EU policies. EU funding of academic research should complement and compete with national sources of funding, and not replace them, for the following reasons.

- The spread of the economic benefits of publicly funded research in Europe is extending increasingly across national boundaries in Europe, reflecting the long

[17] See, for example, in a range of fields, massive computing power now enables academic-based researchers to develop and test technical concepts through virtual prototyping, and thereby become an increasingly importance source of technology - based firms Mahdi and Pavitt, 1997; Koumpis and Pavitt, 1999.

term increase in Europe-wide collaboration and the growth in the establishment of corporate R & D laboratories of European companies in a number of European countries. A greater share of EU-wide funding of academic research would increase the alignment between the sources of funding and those benefiting from their results.

- The case for continuing EU funding of "near market" corporate R & D is weakening. Evaluations of past experience show that EU programmes are most effective in establishing networks, and accumulating science and engineering competencies (Peterson and Sharp, 1998).[18] Making high quality European academic research an increasingly important component of such networks and competencies will help establish a stronger basis for EU-based innovative activities.
- The US experience shows that pluralism in funding sources increases variety, and the likelihood that promising research will be supported.
- It also increases competition amongst both the founder and the funded, thereby both increasing quality. Connerade (2000) has recently pointed out that one of the major supposed benefits of the EU - competition on a Europe-wide basis - is denied in public research, since both funding and execution are mainly nationally based and protected. EU funding would create at least one element of such competition

Having said that, however, it would be a major mistake, in our view, to conceive the policy measures aimed at the (urgent!) improvement of the European Science and Technology System, drawing upon the fundamental experience of the US after World War II, as part of a naïve package to 'catch-up' *in toto* with a purported 'American model'. Rather, the tricky issue here is how to introduce changes which are not harmful to the 'relative institutional advantages' of the European socio-economic fabric. One example we discussed above regarded precisely the strengthening of research institutions *cum* 'open science'.

Another case to the point is the safeguard of the institutions (e.g. in labour relations) which support the accumulation of a distinct set of organizational competences.

[18] As the experience in mobile phones shows, establishing EU-wide standards is also widely appreciated by business practitioners.

Of course, one thing is the *generation* of new *scientific and technological* knowledge, and another is its economic exploitation - even if, as abundantly argued, the two processes are dynamically coupled. Indeed, a good deal of the **Dynacom** research has addressed that side of both processes involving primarily business firms, and the importance of their structures, strategies and organizational practices – in general, and in particular of European firms.

Let us just mention a few diagnostic issues ridden with normative implications.

Against a general background of increasing globalization, particularly in product markets and in foreign direct investment, one repeatedly notices nonetheless a continuing importance of company-specific organizational practices in managing the processes of charge. Together, institutional (often, but not always country-based) specificities appear to exert a powerful influence on organizational arrangements and on microeconomic performances [cf., among others, Florida and Kenney (2000) (A), Coriat (2000) (A), Fujimoto (2000) (A), Lhuillery (2000) (B), Lorenz and Lazaric (1999) (B), Coriat (2000c) (B)].

All this is intertwined with the deep modifications induced by new technologies and in particular ITCs upon organizational forms and skill profiles of the workforce. As, for example, Balconi (2000)(B) shows, ITC-based systems of control, that increasingly underlie manufacturing systems, lead to different forms of internal forms of corporate organization (flatter hierarchies), different industrial structures (vertical disintegration) and different workforce skills (high general levels of education, rather than specific artisanal skills). The results will be stronger competition from certain newly industrialising countries, and pressure for Europe to specialise in more knowledge-intensive industrial segments, with a greater emphasis on R & D and design activities.

Automation and codification of knowledge in sectors largely unaffected by the older “Fordist/ Taylorist revolution” is increasing the weight of fixed costs and, together, is fostering outsourcing and specialization (good sectoral cases to the point are steel and other metal processing industries, textiles, food processing and few segments of the mechanical sector). All this, Balconi (2000)(B) argues, engenders a sort of polarization across and within sectors depending on the relative importance of *cognitive entry barriers*.

The latter are high wherever problem-solving and new knowledge creation are central to the related production activities. Conversely, areas where innovation is mainly embodied in plants and equipment, the reliance upon the tacit knowledge of skilled workers has been falling, due to the codification of know-how and its embodiment into machine software: together “cognitive” entry requirements have fallen. Plant workers, machine suppliers, software developers and consultants – all activities where cognitive entry barriers are high – have increasingly developed capabilities enabling new “downstream” entrants to more easily acquire the knowledge needed to start production from scratch.

This divide also maps into deep changes in the international division of labour, progressively eroding traditional points of European strength – such as those based on tacit production skills – and, at the same time, challenging Europe to foster those segments characterized by a crucial content of problem-solving activities.

At a more normative level, one implication of our findings for technology policies is the need to take into account the increasing importance of a wide range of technologies - such as materials and instrumentation-, as well as "older" serendipitous competences - such as those in mechanical engineering and not just those related to computing and IT- .

As several **Dynacom** studies suggest, however, corporate (and most likely national and regional) performances are shaped by the interacting processes of technological *and organizational* innovation. With regards to the former, the project, we hope, has contributed to further advance our understanding of the patterns of technological accumulation - within and outside corporate organizations -, and with that also a hopefully better appreciation of the policy instruments aimed at the generation and exploitation of scientific and technological knowledge.

With reference to organizational innovation, a few **Dynacom** studies have begun to contribute to the painstaking exploration of the links between nature of the institutional context and patterns of organizational change - with that trying to give also a little bit more operational content to the *adagio* that the specificities of European institutions are not just a drawback but might be a major collective resource. Indeed, the major 'paradox' in the contemporary European scene might well be the fact that we significantly underestimate the potential for organizational innovation and competitiveness inherent in a few European institutions - including its

training systems, its representation mechanism, its patterns of labour relations -, clumsily trying to 'catch-up' with parts of an idealized 'American' model, while at the same time neglecting some crucial positive lessons coming from that very model - for example, concerning science-based competence accumulation.

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