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The evolution of local production systems: the emergence of the "invisible mind" and the evolutionary pressures towards more visible "minds"

Mauro Lombardi

Department of Economics, University of Florence, Florence, Italy

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Abstract

The aim of this paper is to propose an explanation of the changes of dynamic matching between systemic properties of local production systems (LPS) and characteristics of the competitive environment. An evolutionary sequence travelled during the last three decades by Italian LPS is identified and an explanation of long-term dynamics is based on how information flows and knowledge are structured within a local environment. The "traditional" pattern of interlocking behaviours of different agents is defined as cognitive architecture, which evolutionarily emerges as *invisible mind*. Evolutionary pressures lead new patterns of relationships and interlocking behaviours, which we define as a tendency for more visible "minds" to assert themselves.

Keywords: Information asymmetries and recurring interactions; Cognitive patterns; Adaptation; Distributed modularity; Cognitive architecture

1. Introduction

In the past two decades, the analysis of territorial agglomeration of firms and economic activities has been enriched by important theoretical and analytical contributions. Krugman (1991, 1996) analysed the factors on the basis of the industrial and urban localisation processes: (1) the development of particular conditions of the labour market (local accumulation of specialised skills); (2) the "thickening" of economic units capable of producing intermediate commodities and specialised services; (3) the creation of economic–productive contexts favourable to the spreading of knowledge. Porter (1980, 1998) put at the centre of his reflection the systemic nature of the "diamond", which is at the basis of the national advantage, emphasising the importance of the geographical concentration of clusters of firms. The competitive performance of the latter depends, in fact, on their capabilities of acting as "self-reinforcing systems". Arthur (1994) developed an analytical treatment of agglomeration economics, demonstrating—on the basis of important contributions by drawing on the theory of stochastic processes—two significant results: (1) an analysis of the economic–territorial processes in terms of static equilibrium is inadequate; (2) a theoretical schema is needed that assumes a plurality of localisation patterns, among which a Darwinian-type selection acts with lock-in and path-dependence phenomena. Other scholars have, instead, made in-depth studies of the dynamics through which spatial proximity favours the production and spreading of knowledge, thus feeding the virtuous circle that is at the basis of noteworthy industrial performances (Becattini, 1990; Becattini

E-mail address: mauro.lombardi@unifi.it (M. Lombardi).

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and Rullani, 1993; Amin and Wilkinson, 1999; Noteboom, 1999; Lawson, 1999; Belussi and Gottardi, 2000a,b; Tokumaru, 1999). In several studies on local production systems (hereinafter referred to as LPS) of small- and medium-size firms, two interesting theses are argued: (1) "collective efficiency", i.e. the competitive advantage of clustering firms, derives from the dynamic combination of external economies and joint action;[1] and (2) during the evolutionary acceleration phases of the Marshallian Industrial Districts (hereinafter referred to as MID), "systemic" entrepreneurs can play a fundamental role in the creation of new scale and scope economies (Bellandi, 1996).

In addition to the theoretical reflection synthetically cited, there is also a vast aggregate of empirical research (Dei Ottati, 1996; Pilotti, 1999, 2000; Corò and Rullani, 1998; Schmitz, 1999; Storper, 1989), from which have emerged characteristics and properties taken on by the LPS.

The aim of this paper is to pick up and develop a line of research, based on an evolutionary conceptual framework, with particular attention being paid to the cognitive aspects (Lombardi, 2000). We start with the results of a vast amount of theoretical literature and first of all the idea that "interlocking features of the collective order of an industrial agglomeration constitute essential foundation for regional economic innovativeness and competitiveness" (Scott, 1998, pp. 157–158). From the point of view here adopted that implies examination of LPS as systems of collective order[2] (Cooke, 1998, p. 16): their evolution is fostered and influenced by how information and knowledge flows are created and organised. We will try to explain the factors which cause the transformation of LPS from hierarchy[3] into a closer clusters of interfirm relationship, to the extent that new co-ordinating models and mechanisms between units distributed have emerged during the recent decades.

Following a cue by Wang and von Tunzelman (1998), the focus of this paper is on the third dimension of a production cycle,[4] that is, how information flows and knowledge are structured within a local environment so that production costs are reduced. This aim is pursued by examining the cognitive aspects of decision-making processes; indeed above all information and knowledge processing procedures have been considered, with explicit references to concepts derived from cognitive science.

To this end we employ a general theoretical framework, elaborated on the basis of the following pairs of concepts: (1) local system/external competitive environment; (2) systemic properties/environmental parameters (in other words, features of the inside environment and exogenous input); (3) endogenous/exogenous input of transformation.

The categories pointed out define a theoretical horizon within which the evolution of LPS can be described by means of an analysis of the dynamic matching between systemic properties and incentives from the competitiveness environment, while the changes in the "interrelatedness or systemic nature of economic activity" (Maskell et al., 1998, pp. 2–3) are analysed.

The argumentation unfolds as follows. In Section 1, the theoretical framework which is employed in the following analysis is explained. In Section 2, on the basis of the proposed theoretical framework, fundamental systemic properties of the traditional configuration of LPS are highlighted: in other terms they show self-organisation processes and can be defined complex adaptive systems depending on how information flows are organised (Propositions 1, 2 and 3). In Section 3 the following thesis is treated: discontinuities of competitive environment lead to changes of systemic properties of LPS; in fact, they transform from modular systems of distributed productive capacity into structures based on purposely-designed co-ordination structures. In the last section, a possible future evolutionary scenario is proposed.

[1] "Joint action" can be of two types: individual firms co-operating (for example, sharing equipment or developing a new product), and groups of firms joining forces in business associations, producer consortia and the like (Schmitz, 1999, p. 469).

[2] The concept of systems of collective order is proposed by Cooke (1998, p. 16) and profitably applied to the analysis of regional innovation systems in many industrial countries. The concept here is applied to a more limited territorial scale.

[3] Within which "network relationships (are) based on trust, reputation, custom, reciprocity, reliability, openness to learning and an inclusive empowering, rather than an exclusive and disempowering, disposition" (Cooke, 1998, p. 9).

[4] The other two being "the labour processes (how the labour force is constituted and co-ordinated) and capital processes (how the equipment is likewise)" (Wang and von Tunzelman, 1998, p. 810).

2. The evolutionary sequence of the LPS

Exclusively empirical researches on LPS do not exist, because these cannot be reduced to mere statistical collections of elements (Brusco et al., 1997, p. 37). In fact, they are complex entities within which social, economic, institutional and geographical factors are so closely entwined that the very definition of the unit of analysis is quite difficult.[5] However, defined, the systems of small firms share relevant features, even if it is necessary to remember that the "youngest" LPS (above all in southern Italy) sometimes show peculiar characteristics. The first fundamental element, which has been pointed out in many surveys,[6] is the discontinuity that occurred during the late 1980s and that was prolonged over the following decade. Unioncamere (1995, p. 24), for example, describes the transition of industrial districts from a "model of intensive growth to a model of extensive growth". The same study drafts a kind of "life cycle hypothesis" based on seven evolutionary phases,[7] which in turn are essentially connected with the transformation of the competitive environment. The concluding point of the analysis is the classification of clusters on the basis of the proposed scheme, which is also adopted by the research relative to seven hundred firms belonging to 15 industrial districts (Omiccioli, 2000). Following Porter's approach (Porter, 1998), Viesti (2000) points out an evolutionary path for Italian clusters (or industrial districts) by describing actual phases of competitive evolution. First of all, this author defines five basic conditions[8] for the birth of an industrial district. He then describes the role of "leading" firms during the transition to a real industrial district, i.e. the creation of fundamental factors for the formation of a local productive potential: (1) incentive for the diffusion of suppliers, thank to phase economies of scale which spur the division of labour among firms on the basis of an expansion of the market; (2) the formation of human capital, which is necessary for all phases of the production cycle; (3) spin-off activities; (4) the producing of demonstrative effects and, thus, incentives towards imitative processes at a local level.[9]

There can be different genetic processes on the basis of the LPS (Belussi and Gottardi, 2000a,b; Pilotti, 1999) and of the MID (Becattini, 1989; Bellandi, 1989, 1996; Dei Ottati, 1996):[10] (A) local accumulation of abilities and competencies in artisan units and an increase in the latter as a result of an increase in demand; (B) resorting to production decentralisation by large firms; (C) crises and break-ups in well-structured production entities, with the subsequent triggering of a growth in the population of firms at a local level. According to Viesti (2000), a cluster consolidates by means of three parallel processes: "an increase of the number of firms; larger division of labour among firms, thanks to more collaboration and commercial relationships; horizontal widening of the range of products, together with more intense competition" (Viesti, 2000, p. 37). Thus, the evolution of industrial districts hinges upon changes in the competitive scenario: the passage from searching for static economies of scale to dynamic economies of scale is crucial, as competition requires new competitive capabilities. Changes are so relevant that real discontinuities have occurred within LPS, as many surveys demonstrate, trough a decrease in the number of firms and employees within many local systems over the past two decades.

Whatever the genetic process, on which we shall not dwell in this work, it is possible to identify a sequence

[5] For local systems, and industrial districts in particular, the first definition of the unit of analysis from a statistical point of view was elaborated by Sforzi (1991). Recently, Cannari and Signorini (2000) suggested a different classification for the local production systems.

[6] Unioncamere (1995), Dei Ottati (1997), Viesti (2000), Signorini (2000), Belussi (2000), Chiarversio and Micelli (2000), Lazzeretti and Storai (1999), Tamberi (2001).

[7] The seven evolutionary phases are: phase specialisation, integrated system area, de-localisation, hierarchies based on internal growth, management consolidation and merges, hierarchies based on external growth, and new market strategies.

[8] These are: the existence of production factors and resources, pre-existing technological capability, the role of leading firms, the dynamism of a local demand, and appropriate institutional actions.

[9] It is worth recalling that, in some Italian areas, the development of local system occurs on the basis of the expansion of a pre-existent artisan (social) network within which competencies and skills have been accumulated, triggered by input stemming from local and external principals.

[10] In this paper, we shall use the concept of local production systems, basing ourselves on the general properties present in various typologies of local productive micro-universes. The choice is based on the concept of local systems (LS), composed of sub-systems (LPS, institutional infrastructures, cultural and political shared values, etc.). Different mixes of links between sub-systems and differences in the composition of each sub-system foster varied forms of LS.

of phases travelled by Italian LPS, even if with temporal cadences that are not completely homogeneous. In fact, it is possible to identify a morphological homogeneity between the different types of LPS, with changes that are connected to the emergence of certain factors, that have produced evolutionary stresses to the point of inducing similar responses.

There are essentially three phases that can be detected within the typical evolutionary sequence: (1) expansion; (2) standstill and transition; (3) resumption on the basis of new models of systemic functioning.

The first consists of a long growth period that at times is impetuous and of intense diffusion, in a limited territorial sphere, of entrepreneurial initiatives that are essentially based on "virtuous" combinations of three elements:

1. An accumulation of skills and techno-productive competencies on the basis of traditional production methods, thanks to high-frequency interactions among subjects or entities operating in local contexts. An important consequence of this is the progressive consolidation of local labour markets, on the inside of which the passage of persons from one firm to another has constituted a fundamental propulsive mechanism in determining two important aspects: (a) the enrichment and continual variation of skills and competencies; (b) the local diffusion of a techno-productive culture that is subject to incessant, incremental-type innovations.
2. Competitiveness partially based on price. The low barriers to entry and exit, widespread complementarities between competition and rivalry have nourished micro-behaviours oriented at the search for greater productivity and higher efficiency, with consequently low levels of costs. An important corollary of these dynamics has been: the creation of a division of labour among firms or local markets for sub-contractors, the offer of half-finished goods and stage production.[11] In this process, competition and co-operation are intense and at the same time entwined, because these have been nourished among other thing by the workers' mobility within the local techno-economic environment.
3. Capabilities of satisfying a fragmented and variable demand, for which response strategies to shock and exogenous stimuli were effective.

The three elements are common to LPS that have even non-marginal differences, if we think of the fact that MID prevails in Tuscany, as do other forms of LPS in the north-east.

The second phase of the evolutionary sequence began when the LPS underwent a standstill which interrupted a long expansion process. In almost all the areas considered, above all during the 1980s, there appeared discontinuities, both technological and also relative to demand and to the problems generated by a competitive scenario that has been made more complex and turbulent by the appearance of new sources of competitive advantage.

Scholars have described phenomena that are relevant for the purposes of our analysis (Dei Ottati, 1995, 1996; Corò et al., 1998; Guerra, 1998):

1. Internationalisation of the production cycle produces a reduction in self-containment (see Section 2).
2. The changes underway in international competition erode the base of the traditional competitive advantage of LPS, that are founded on an original combination of incremental variations and practical-manual knowledge (Corò and Rullani, 1998). At the same time, spatial proximity is always a less decisive element, since today the capacity to manage global information flows is progressively more important for firms.
3. There is an unprecedented increase in formal and informal groups of firms.[12]

[11] For example, the traditional division of labour among firms in Prato: "... in the industrial district there are two different kinds of firms: the 'final firms' which have direct connection with final markets, and 'stage firms' or subcontractors which specialise in one or a few production stages" (Dei Ottati, 1996, p. 49).

[12] From the studies previously indicated, precise structural trends can be clarified which dominate the current surveys of LPS: (1) in Prato, a progressive acceleration and an consolidation of the phenomenon of the formation of formal (vertical and horizontal) groups of firms occurred, with the reorganisation on more stable bases of inter-firm relationships that previously had been very much "looser" and less selective (Dei Ottati, 1996). In the Montebelluna sports system (Corò et al., 1998, pp. 118–119), the "organisational model of growth based on outdoor networks" became dominant, while alternative models of business growth coexisted. The creation of organised groups of units in accordance with two typologies also characterised the production areas of furniture (Guerra, 1998, pp. 170–174), ceramics (Bini Calza and Bosco, 2000), and chairs (Tamisari, 2000).

4. A period of transition is underway, from an almost automatic co-ordination to more conscious forms of government or of planned co-ordination, in order to deal with the new challenges that have arisen in competitive dynamics. In some areas of the north-east, there is a "hierarchical evolution of local networks" (Gottardi, 2000).

The events described have set off a transition process that is characterised everywhere by the following phenomena, even though not to same extent:

1. a reshaping of the local production potentials, with a reduction in the number of firms and employees;
2. an increase in the imports of components and half-finished products from other (domestic and international) LPS;
3. changes in the mixes of technologies used, raw materials worked, and goods produced;
4. the possibility for larger firms to acquire qualitative and quantitative flexibility of the production potential, thanks to computer-related technologies. In this way, some traditional systemic properties of LPS become obsolete and new success factors emerge, so the traditional set of competitive advantages are radically modified (see Section 3).

In short, the LPS have undertaken strategies of response and structural adjustment in answer to exogenous shocks: diversification and a rise in the quality of the products, restructuring of relations between firms, progressive internationalisation of the production cycle, changes in the division of labour and distribution of the competencies during the various production phases.[13]

Transformations have naturally been realised in accordance with differentiated degrees of intensity and extension, with consequently different results in terms of the breadth of the production apparatus and of employment.

[13] For example, the changes in firms typologies are directly connected with the formation of the groups: in Prato, the final firms accentuated the separation process between specialised functions (commercial, financial, co-ordination), while there occurred a growing technological differentiation between the stage firms. A multiplicity of types of firms can be identified in Montebelluna (networks, specialised sub-contractors, complementary units) and in the furniture area (groups with leaders, small autonomous firms, specialised suppliers, and sub-contractors).

Another point to consider is the profound change in the competitive environment: the competitiveness based on factors other than price has become always more important; first of all the presence on the markets depends not on reactive behaviour respect to shocks, but rather it depends on anticipatory strategies capable of "endogenising" the demand, in the sense of assuming its changing parameters of behaviour by means of a system of information flows to the point of integrating physical and informational input dynamically and interactively.

A fundamental implication of the transformations described is the following: the information flows and the data processing change as a result of the fact that the interaction circuits and operational feedbacks come about on a larger scale than the local one, and are connected to changes in role and function of subjects and production units. A change in the techno-organisational configuration of LPS is, therefore, closely linked to new information and physical flows.

On the basis of the analysis made, we can synthesise the recent evolution of LPS as follows:

1. the formation of hierarchical networks of firms with significant leadership phenomena;
2. changes in the division of the labour and in the techno-productive configurations;
3. new types of interactions with the markets and therefore of both the mechanisms of acquisition and processing of the data and also the formulation of strategies.

3. The evolutionary dynamics of the traditional LPS: the emergence of the "invisible mind"

After describing the evolutionary sequence, we shall develop the analysis to identify fundamental factors for an explanation of long-term dynamics. To this end, it appears useful to start from an identification of the basic properties, i.e. the distinctive characteristics of LPS as systems. Here, we have adopted the methodological approach, based on the concept of system. We start from the operational definition of system, elaborated by Ashby,[14] since it allows us to give a first

[14] Ashby (1952, p. 15) defines system as "any variable selected set of variables".

representation of aggregate behaviour of a richly connected set of entities.[15] Since all objects (above all, social phenomena) can be represented by means of an infinite number of variables, an investigation must have as its starting point a selection of the relevant elements in accordance with a particular point of view, that has been made plain ever since the beginning. Subsequently we will sharpen the analysis by applying a precise concept, largely employed in different scientific fields: (1) The complex systems are "composed of different interacting sub-systems" (Ruelle, 1992, p. 95). (2) The complex systems are "made up of a large number of parts that interact in a non-simple way" (Simon, 1962, p. 468).

In particular we will develop the idea of the centrality of information, tightly connected to specifiable structural relations, i.e. interactions between agents and entities which exercise functions: "Organised systems are characterised by structural relationships that require *information* for their specification" (Wicken, 1987, p. 40). We would also like to enrich this approach by means of analysis of the typology of interactions and the role of many subjects in processing different types of information. Applying this theoretical framework to LPS implies that those are viewed as input–output systems, composed of sub-systems (productive units), carrying out activities within the various phases of the production cycle, which in turn can show different degrees of territorial dispersion.

Following the proposed theoretical framework we choose some representative variables of LPS:

1. boundary conditions;
2. types of interactions among components;
3. the typology of information flows.

As far as point 1 is concerned, one of the most important boundary conditions is the sense of belonging to a community of agents (individuals and firms) who operate in a given territory following more or less explicit rules of behaviour, like trust, loyalty, reciprocity, reputation. Shared values are then at the basis of the sense of belonging, which allows scattered people to behave as a community or self-organising network, cluster, etc. within which rivalry, emulation, imitation (Kash and Rycoft, 2000), competition and co-operation co-exist and proliferate.

From this it follows that there are widespread micro-behaviours that are oriented at those values and, at the same time, are subjected to different types of changes as a result of the incessant cognitive exchanges between local agents. Other boundary conditions are the existence of barriers to entry, in the sense that for a series of reasons it is very difficult for outside firms to be installed within a given context, while a complete fitting up can be realised only after long interactive dynamics with local subjects. The phenomenon described is a consequence of the prevalently endogenous nature of the training process for an LPS, and is evidently connected with the capacity to be inserted within the fabric of stable relationships characteristic of a local system on the whole.

As far as point 2 is concerned, the LPS is distinguished by what Simon (1962) defines as "higher frequency dynamics", due to the interactions between local agents, while there are "lower frequency dynamics", due to the interactions with outside subjects. In the preceding paragraph, we have referred to the intense competitive dynamics and to the co-operation between entities operating in the micro-universe. The high intensity of the localised interactions therefore constitute an important variable that is representative of the LPS.

As for point 3, which is logically connected to the previous point, we must keep in mind that the typology of the information flows is relevant. Information referring to a system may in general be separated into system information, that is inherent in its basic structure (Langlois, 1983, p. 594), and parametric information, that refers to its operational parameters, that is, to the performance of tasks in a given environment. The information hierarchy is, therefore, a constituent element of any sort of system, and has as a general validity the principle that information is neither an entity nor an object, nor a set of homogeneous units subject to selection. Rather, it is "inherently relational, a mapping between two or more sets of events .... Information, if it properly maps to the internal states of a system, can selectively trigger sets of behaviour" (Buckley, 1983, p. 602).

In the cases of LPS, the distinction between the two types of information is sufficiently defined, on the

[15] The analytical path here proposed aims at giving concrete content to a quite abstract theoretical framework, being aware of the need to distinguish between "a conceptual and a real system" (Cooke, 2001, p. 953).

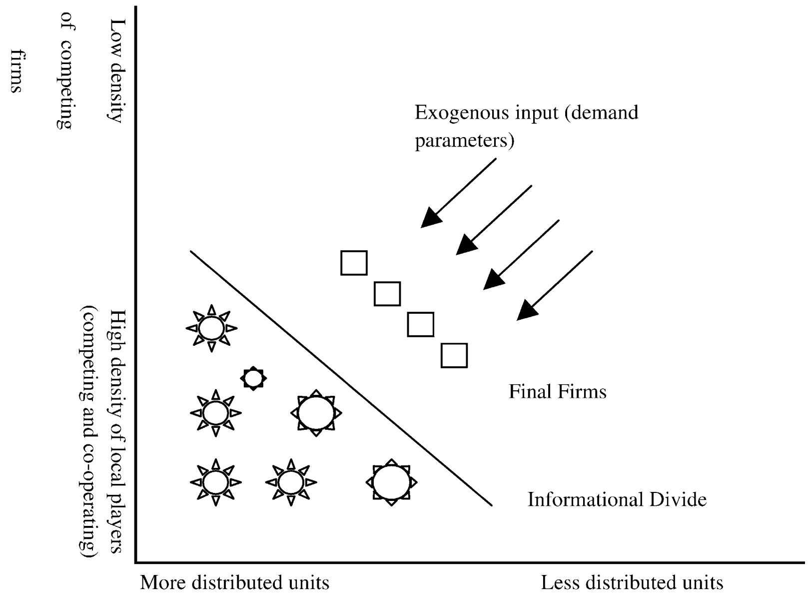

Fig. 1. *Final firm* (FF): entities which possess hidden information. *Informational divide*: exogenous input are unknown within LPS. *Filtering agents* (FF) spread only operational parameters, that is characteristics of materials and components of the good to be produced.

basis of a precise taxonomy of agents: (1) final firms (see notes 5 and 7), de facto "transducers" of signals extracted from the market and, thus, possessors of hidden information; (2) static firms, routine producers, satellite firms; (3) system integrators, like the final firms and the local institutions which perform relevant systemic functions, like the production of social and collective services or public goods in general.[16]

Only final firms have a knowledge of the markets: the existing opportunities; their predictable trends; characteristics of the demand. The general model is depicted in Fig. 1, where the horizontal axis shows the density of local economic space on the basis of the number of the different types of competing entities and the vertical axis depicts the degree of agglomeration of production entities. The information flows unfold as follows. Final firms acquire information by means of four types of activity: (1) exploration of opportunities in different markets; (2) acquisition of information about possible demand input; (3) experimentation of relationships with external operators and local agents; (4) interpretation of signals stemming from markets and other agents (buyers, representatives).[17] In this perspective the final firms are strategic agents:[18] the data by them acquired is not shared with other local agents. Thus, this data is "hidden information" for the LPS and is transformed into operational parameters, i.e. into the characteristics of materials and components of the goods to be produced, for activation of the local productive potential, thanks to the development of localised high-frequency interactions occurring in the course of the specification process of these parameters. In Figs. 2 and 3 (the axis are the same as in

[16] This is a general taxonomy. Further types of agents can be picked out thanks to the analysis of each LPS.

[17] Information, exploration, experimentation, interpretation are considered essential ingredients of a strategy within a complex horizon by Lane and Maxfield (1997).

[18] The term is employed with reference to the concept of strategy proposed by Chandler (1987, pp. 48–49): "A strategy can be defined as the determination of the fundamental goals and long-term objectives of a firm, the choice of action criteria, and the type of allocation of the resources necessary to implementing the objectives". The extensive use of the concept is aimed at capturing the role of the final firms in determining the guidelines for activating the local production apparatus and the distribution of labour among the various units.

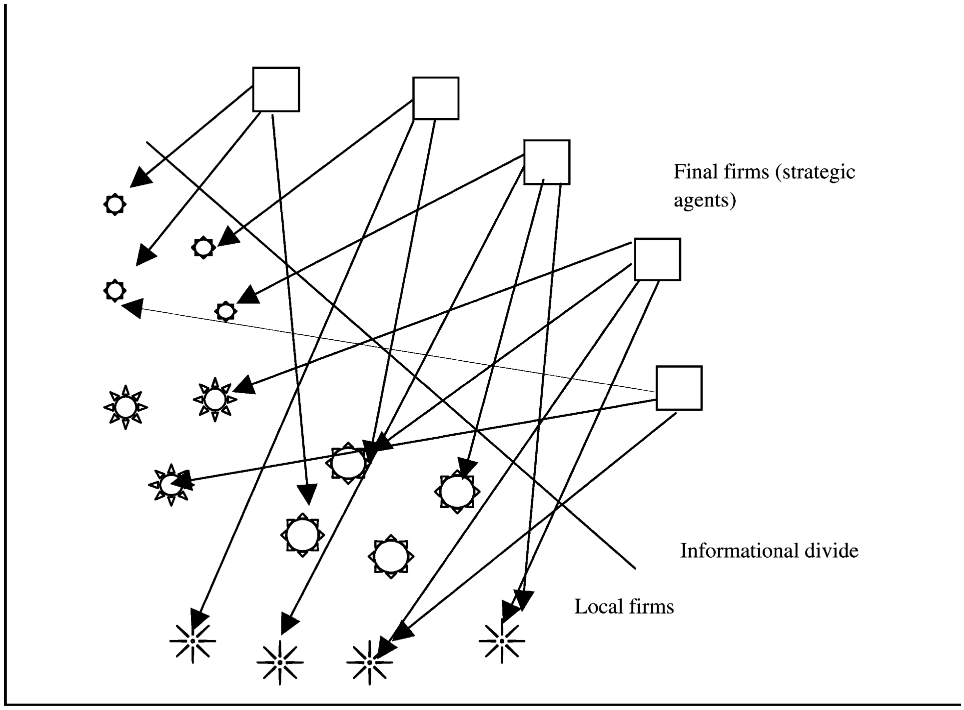

Fig. 2. Market information (hidden) is transformed into orders for specific production phases on the basis of multiple and sometimes overlapping links between final firms and locally distributed units.

Fig. 1), we look into the activation of a LPS and the multiple interactions among local agents.

Three information-flow levels thus exist: the first follows the markets, and is controlled by filtering agents (i.e. the strategic agents); the second concerns the techno-productive dimension, and derives from incessant exchanges of information and knowledge of a practical–professional type (also within loose "teams" of firms); the third includes the dynamics of costs and productivity, and is the result of previously-indicated processes of competition and co-operation.

The existence of a close association between the second and third points does not prevent each one of the two from having a multidimensional nature, because both derive from distinct dynamics of many internal components. We shall skip the third point, which has been widely dealt with in the studies previously indicated, in order to dwell on the second one.

At this point it is worth picking up an approach proposed by Richardson and subsequently developed by Maskell (2001). The first introduced the distinction between similar and complementary activities.[19] This distinction has been enriched by the latter thanks to the concepts of horizontal and vertical dimension of the clusters. The horizontal dimension comprise phenomena as co-localisation, intense exchanges of information, variation of knowledge, imitation and reciprocal monitoring, comparing, processes of selection of superior outcomes. The vertical dimension, based on "knowledge about product and market opportunities", implies information asymmetries among agents with heterogeneous knowledge endowments.[20]

It must be underscored that learning (by means of imitation, monitoring, comparing) happens within the

[19] "Activities which require the same capability for their undertaking I shall call similar activities" (Richardson, 1972, p. 888). "I shall say that activities are complementary when they represent different phases of a process of production and require in some way or another to be co-ordinated" (Richardson, 1972, p. 889).

[20] From this point of view LPS can be considered similar—on a smaller scale—to regional clusters, which are "repositories for industry specific skills" (Enright, 1999).

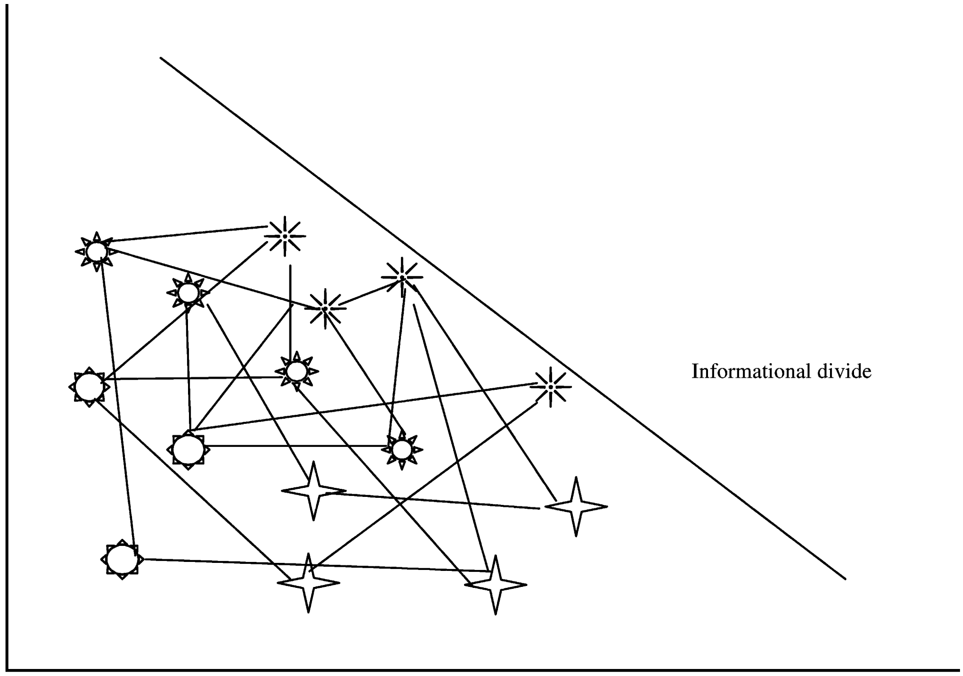

Fig. 3. A look within LPS: the phase parameters, that is how to produce particular goods or half-finished goods matching the demand requirements, are the results of a locally distributed dynamics, based on the creation and diffusion of technological knowledge inside the local environment.

horizontal dimension, even if it shows characteristics which would be worthwhile analysing in greater detail. Before developing this theme, we can synthesise the results of the analysis with Proposition 1.

Proposition 1. *Within traditional LPS there are information asymmetries between strategic agents* (*final firms*), *which possess basic* (*hidden*) *information, and widespread interacting units, which develop and exchange techno-productive information*.

A growing number of authors (Lawson, 1999; Maskell and Malmberg, 1999; Becattini and Rullani, 1993; Belussi and Gottardi, 2000a,b) have made a close study of information and data processing within the LPS, pointing out—within the environment of the spatial agglomerations of firms and industries—the fundamental role both of tacit knowledge and the repeated interactive circuits between tacit knowledge and codified knowledge (in the wake of the contribution by Nonaka and Takeuchi, 1995). The results of this literature are important, and can be further developed in the light of the concepts of technology, technological paths, and technological systems[21] within which LPS are necessarily inserted.

From this point of view this concept is important: "Technology in-use is an amalgama of artefact, knowledge and organisation" (Fleck, 2000, p. 257), while the "couple artefact-activity ... is a dynamic ensemble of the artefact with the immediate set of human activities that sustain the use and development

[21] There is a huge amount of literature on these themes: Dosi et al. (1988), BijKer et al. (1987), Carlsson and Stankiewicz (1991), Tushman and Rosenkopf (1992) are essential references. More recently, Stankiewicz (2000) distinguishes four technological regimes (craft, engineering, architectural, research). For the aim of this paper the craft regime is particularly interesting: "crafts are generally viewed as traditional technologies. They evolved slowly through the piecemeal accumulation of experience. In a craft regime, technology development is typically gradual. Chance and serendipity thus play a large role .... Technology accumulation and transmission are centred around the learning and passing on of the procedural knowledge and skills. That kind of knowledge is predominantly tacit and requires face to face interaction to be effectively transferred" (p. 238).

of the relevant technology". Following this perspective "technological information ... is embodied in techniques—coherent bodies of knowledge which instruct agents how to engage in production" (Mokyr, 2000, p. 64). On this basis, it is legitimate to consider that, in general, information asymmetries are inevitable and, at the same time, that communication processes are essential.

The described phenomena can be conceived following an interesting theoretical approach by Lane and Maxfield (1997, p. 174), who introduce the concept of the agent and "artefact space": "We use 'space' to denote a structured set. For agent and artefact space, the set consists of all the agents who are involved in some industry activity and the artefacts are the thing these agents design, make or exchange, while the structure is provided by the various kinds of relationships that exist between these agents and artefacts". We can extend the concept by considering that the levels of information flows, previously pointed out, constitute fundamental dimensions of the agent and artefact space. Indeed LPS are typical examples of co-evolving behaviour of *n*-entities: in general, the end of co-evolutionary dynamics could be chaotic, ordered or at the edge of the chaos; in the case of LPS the long duration of high frequency of interactions among agents produced recurring patterns of actions and convergence on ground values. Indeed the consolidation of local communities are possible only if the set of agents are able to construct "symbiotic" relationships and communication devices. Talk, traditions and templates, patterns or moulds as analysed in particular self-organised systems (Turnbull, 2000) are fundamental components of communication processes. So cognitive aspects and mechanisms which can act in both tacit and codified knowledge are relevant for the construction and the permanence of the agent and the artefact space within LPS.

Thus, it is important to inquire how the recurring interactions among agents produce ordered co-evolving behaviour. The starting point is the high intensity of local and bounded interactions: "stage" or phase firms (see note 11) and local producers have to solve technical problems to match the final demand requirements, by translating them into phase parameters.

We have seen that the LPS is a techno-organisational configuration based on a peculiar division of labour among units. The production apparatus is characterised, in fact, by widespread specialisations, thanks to the existence of a "multiplicity. . . of different nuclei of specialised know-how and approaches to production and innovation" (Bellandi, 1996, p. 358). Active rivalry and spatial proximity favour interactive dynamics which can trigger off an "original combination of ideas about products, processes and markets" (Bellandi, 1996, p. 358). A main system can be identified within this multiplicity of nuclei of competencies (Bellandi, 1994), that are professional and entrepreneurial, around which the process of division of labour among units with different degrees of specialisation is developed. The production cycle of goods (textiles, clothes, knitwear, shoes, chairs, etc.) is therefore highly decomposable, and the degree of decomposability is clearly connected to the intensity of the interactions.

The explanation of how a set of entities can give coherent responses to exogenous impulses seems well founded if we adopt an evolutionary framework in describing the cognitive processes within the LPS.

Human brain "is (an) adjuster, not (a) calculator" (Margolis, 1987) and human beings are "patterns seeking", whose evolutionary bases lead them to "seeing something, rather than nothing" (Margolis, 1987, p. 39).

If knowledge is "the capacity to extrapolate patterns" by recognising similarity and "relating them to a learnt tacit background" (Nightingale, 1998), the cognitive processes are founded on the activities of "tuning of patterns and cues" (Margolis, 1987, p. 71). Analogously, within local techno-productive processes, by which knowledge is developed, interacting n-entities continually try to tune decision-making patterns with patterns of exogenous impulses. In this way firms and individuals belonging to LPS develop and adapt their competencies by means of sequences of patterns and exogenous cues, transmitted by filtering agents (strategic entities). These latter act like binding agents, who behave as key sources of information flows: indeed, within the general constraints set by the basic information (previously called hidden information) localised interactions develop during problem-solving activity. In the information circuits within LPS, above all in the one concerning the specification of parameters, the high-frequency interactions between productive units and subjects take place within the framework of a given technological system. Interacting entities, which share values and intensely exchange information, can produce recurring patterns of behaviour only if they are able to recognise "similarity spaces" (Nightingale, 1998) inside the artefact and the agents space. So they have to make wide use of the representational structures that are at the basis of the communications processes of tacit and codified knowledge.[22]

Important contributions drawn from cognitive science (Minsky, 1974; Karmiloff-Smith, 1992; Margolis, 1987) show that specific mechanisms are in operation during the cognitive processes, and the problem of the representation of knowledge in a structured form cannot be eliminated: the Minsky frames,[23] Karmiloff-Smith's representational redescriptions (1992),[24] and the cognitive cycle on which the "pattern cognition" of Margolis is based, describe dynamics based on complex and entwined sets of tacit and codified knowledge. The problems indicated are the subject of growing interest also in the economics literature (Denzau and North, 1994; Noteboom, 1999), to indicate the importance of analysing the structures essential to an understanding of whatever information processing system. The case in point, that is LPS, is particularly important from this point of view, because within them the production of knowledge is at the basis of a regular cognitive division of labour (Belussi and Gottardi, 2000a,b) and of dynamic agglomeration economies (Malmberg et al., 1997).

We can synthesise the reflections made in this paragraph by pointing out the *systemic properties* and logic of the economic–territorial agglomerations considered. Three properties have been identified:

1. self-containment;
2. information hierarchy;
3. high-intensity of local and bounded interactions.

There also exists a general form of functioning for the system: from the external environment (markets) are extracted the signals (demand parameters), that are subsequently translated into general constraints from which the specifications produced by the internal environment drive. We are therefore dealing with a general adaptive logic which is expressed in a myriad of differentiated micro-behaviours: search for technical–productive solutions, widespread interactions by following certain rules (explicit and implicit). The overall coherence (that is the coherence with hidden information) is guaranteed by both the cogency of the system information and also by the necessary respect for the rules that are at the basis of the sense of belonging. In short, we find that macro-behaviours, expressed in adaptation, are realised thanks to sets of micro-behaviours centred on a limited variability.

The different types of information, and participation in numerous circuits, are at the basis of the division of labour at a local level, while the interactions between operational entities determine the formation of sufficient stable relations between different types of firms (final, stage firm, sub-contractors, subsidiary), i.e. regular patterns of interlocking behaviours.[25] Analogously, further aspects are characteristic of LPS, i.e. the functional differentiation between units belonging to the local context and the patterns of relationships which identify a complex organisation (Thompson, 1967). Thus, the result of the analysis is that Italian LPS are typical examples of the complex systems defined by Simon (see Section 2). This conclusion opens up a further perspective for investigation, centred on the analysis of the relations between the components of this system, starting from the "double environment" (internal, external) and from the adaptation of the latter to the former.

An important question then emerges that needs to be examined closely: how does the co-ordination between the different operating units take place?

[22] They are necessarily based on representational systems (frames, scripts, etc.) that represent the problems to be solved, with more or less cogent constraints placed on the search for values for the unknowns, i.e. for the parameters to be found for solving technical and productive problems.

[23] Frames are data structures that describe typical situations and are associated with different types of information, relative to numerous reference contexts. An alternative way to define a frame is to consider it an "aggregate of questions to ask regarding a hypothetical situation: specific queries to be raised and methods for dealing with them" (Minsky, 1974, p. 123). These representational structures are partly formalised in the human mind and partly contain "slots" to be filled in with continually renewed information.

[24] "The representational re-description is a particular process by which human beings show the capacity to generalise, to reason from the particular to the general, and to use analogy".

[25] The latter are considered by Weick (1979) to be the constituent elements of an organisational structure, a concept that we extend here to the local micro-universe. However, we find here relevant aspects of collective order (see Section 1 of this paper).

From the previous description of the techno-organisational configuration, it follows that the LPS is a complex system, viewed as a hierarchical set of nested systems, with the hierarchy founded on the typology of the information possessed and on the intensity of the interaction between components.

Within the complex systems, Simon (1962) distinguishes the decomposable ones, the final components of which are simple particles (as in gases), and the nearly decomposable ones "in which the interactions among sub-systems are weak, but not negligible" (Simon, 1962, p. 474). The local micro-universe of LPS is characterised by two different types of dynamics (that of higher frequency, inside the sub-systems; that of lower frequency is associated with larger systems, such as, for example, the outside environment), and can therefore be conceived of as a nearly decomposable system. In the case of LPS, it is legitimate the claim that the topology of the interactions between agents influences the aggregated regularity (technical standards, specifics of materials and products), and can reproduce in its own interior groups that are both very close (cliquish structure) or extremely loose (random links). This multiplicity of relations between units indeed favours the triggering of a decentralised industrial creativity, by means of a production cycle organised in such a way as to achieve a given objective by means of distributed tasks and functions. Therefore, the division of labour among units is nothing more than a "modularization" of the process, with production phases (or "stage" firms) developed in accordance with competencies accumulated on site and subject to a constrained variability.[26]

The modularity is an important characteristic of LPS: the production of final good is divided into stratified sub-components, which in turn have characteristics and parameters that are determined by interactive structures that are at times "cliquish" (Cowan and Jonard, 1999), in some other cases much more casual, and at other times relatively less free.

The decomposability of the production cycle into modules, carried out in relatively independent operating units, requires that the aggregate of the interacting agents and of the production units act as all one organisation in function of the objective, identified in terms of goods with determined characteristics and in required quantities. In this regard, we extend the thesis (Baldwin and Clark, 1997) relative to complex products divided into sub-systems: for a "nearly decomposable" system to function efficiently, there needs to be holders of "hidden information", with reference to the basic characteristics that each module must respect. At the same time, there must also be visible information concerning the rules and sets of behaviour to be followed so that the overall system reaches the objective. "Modularity is a general systems concept" (Schilling, 2000), and includes both a wide range of ways in which the components can be separated and combined, and also the intensity of the connections between them, in addition to the constraints placed on their operativeness. In traditional LPS, in fact, the existence of hidden information and visible information is noticeable: the former includes characteristics of demand, the typology of products, market trends; the latter comprises rules of behaviour, specialised know-how and technological knowledge that are diffused and continually renewed in determining specific parameters capable of satisfying the constraints imposed by hidden information. From this point of view, the role of the final firms as binding agents is essential. There exists a fundamental difference, compared to what is claimed by the traditional literature on the modularity of systems: in those studies, properties and rules of connection between the modules are determined "from the top"; in LPS, modular organisation is the product of the adaptive logic with respect to the market and to the constrained variability, nourished endogenously.[27] *Adaptation, distributed modularity and bounded endogenous variability* define an *evolutionary system*, which is benefit of a unifying centre, as it is evident from how the possessors of hidden information (final firms) perform the role of system integrators, i.e. the function of a general link between distributed modules. In this representation of LPS as evolutionary systems, the possibility of a further decomposition of the modules, consist-

[26] Within this perspective, phenomena of redundancy (Bellandi, 1994) and duplication and extreme diversification of competencies, in addition to a decentralised industrial creativity, can occur contemporaneously.

[27] With this expression, we refer to the on-site accumulation, diffused in a local sphere of specialised competencies and knowledge.

ing essentially of routines[28] grouped in an extremely variable manner, also takes on relevant importance in accordance with the evolution of the competencies and interactions between units and agents.[29]

Thus, the result of the analysis is that, in responding adaptively to the signals extracted from the market, the specification of the parameters inherent in the production cycle occurs by means of repeated feedbacks and reiterated cycles of exchanges between variable routines. We define this type of process as an *evolutionary emergence of parameters*. This means that selective dynamics occurs within a potential of available solutions, the dimensions of which depend on the activity of a search for technological and productive solutions, even if within the limits set up by hidden information.

The conclusion of the previous analysis is thus given by Proposition 2.

Proposition 2. *Systemic properties, evolutionary characteristics, and the particular mechanisms of distributed information processing lead us to define traditional LPS as selective systems, based on the evolutionary emergence of parameters*.

Within LPS, agents use sets of goal-seeking behaviour in the search—by means of interactions—for solutions to technical and productive problems. In this way, an extensive and heterogeneous network of specialised, functionally-connected routines has developed.

The previous analysis allows to enlarge the set of mechanisms and agents, which according to Enright (1999) satisfy the co-ordination requirements among entities belonging to "disintegrated structures". Beyond the mechanisms suggested by Enright (spot markets, short-term coalition, long-term relationship, vertical integration), we propose here the self-organising convergence between parameters, representative of the production phases. The convergence is fostered by the frequency and the intensity of interactions among agents exchanging different types of information.

By setting the local micro-universe in perspective, the techno-organisational configuration can be understood as a cognitive architecture, consisting of input and output units and of transformation functions characteristic of each of these. Competition and co-operation, spatial proximity and rivalry are complementary phenomena that are intrinsic to a system subject to endogenous and exogenous shocks.[30]

The cognitive architecture described, consisting of distributed competencies that are connected by means of the congruency of parameters, makes it possible to find an answer to relevant theoretical questions: how did it arise? In what forms is the co-ordination between sets of goal-seeking behaviour realised?

In comparing patterns or institutional structures which seem not to arise from the intentions of interacting agents, the scholars may in general make use of two types of explanations (Nozick, 1994). The first is formulated in terms of the *invisible hand*, and it is based on the idea of spontaneous processes that filter the evolution of the operating units, selecting them so as to arrive at a solution of equilibrium by means of reciprocal adjustments. The second seeks for and discover, behind apparently unintentional results, intentional designs (the so-called *hidden-hand explanation*). The cognitive architecture being dealt with here makes it possible to propose a different answer to the two questions. The presence of numerous complementary and apparently contradictory aspects (i.e. variability and stability) and of certain patterns of interaction derives from the fact that the nearly decomposable systems arise like a systematic and diffuse search, through trials and errors, for solutions to adaptive problems. The variability of the micro-behaviours is therefore functional with

[28] Here, routine is understood to be an aggregate of modules of competencies, performed by people who carry out activities and pursue objectives in a dynamic environment. The concept derives from the many definitions of *routine* put forward by scholars: "routine is a general term for all regular and predictable behavioural patterns of firms . . . " (Nelson and Winter, 1982, p. 14); *routines* are "patterns of interactions that represent satisfactory solutions to particular problems" (Dosi et al., 1991, p. 46), or "highly-programmed decisions" (Loasby, 1976, p. 81).

[29] The concept of an evolutionary system indicates a peculiar co-ordination structure within the terms defined by Malone and Smith (1988, p. 422): a "pattern of decision making and communication among a set of actors who perform tasks in order to achieve goals".

[30] Milsum noted that, "The dual processes of co-operation and competition (are) essential, concomitant but complementary aspects of such (living systems') hierarchical structures" (Milsum, 1972, p. 147).

(systemic) macro-behaviours; therefore, redundancy, noise, and random variations nourish a global stability in the answers. Distributed modularity is thus essential, because it enables a flexibility which, in turn, is fundamental in order to have a repertory of distributed competencies from which to draw for multiple solutions[31] available. The limits to the variability of the sets of micro-behaviour have a primary importance, since extreme flexibility would in practice prevent the solving of adaptive problems. The acquiring and processing of information and knowledge would be a task greatly superior to the computational power of any agent whatsoever, as the space of the search for alternatives to be evaluated would become extremely large (the so-called "combinatorial explosion").

Considering that the structure of LPS is the unintentional result of the adaptive dynamics, it appears stimulating to define its architecture as the *invisible mind* that derives from processes of self-organisation that have previously been described in terms of a selective system with an evolutionary emergence of parameters. With the expression "invisible mind" (Lombardi, 1991, 1992) we aim to give a synthetic representation of the self-organising dynamics of information processing within LPS acting as complex adaptive systems.

A dynamic intertwining between the physical transformation process of multiple input (chemical, electrical, optical) and the dynamics of data processing identifies the most complex product of natural evolution (the human mind).[32] A similar intertwining, with lower levels of complexity, characterises LPS, the representation of which as *invisible mind* synthesises the peculiarity of a repertory composed of changing competencies, that are organised in order to search for solutions to adaptive problems.

The thesis upheld leads to sustaining the following.

Proposition 3. *Traditional LPS are evolutionary systems, on the inside of which operates an invisible mind that co-ordinates the components of the local input–output matrix in order to respond adaptively to the impulses coming from the market.*

This type of evolutionary system allows us to enrich the classification of the input–output systems by Storper and Harrison (1991), who distinguish between atomistic producers, process producers, agglomerated network with mostly smart units, agglomerated network with some large units, dispersed network with some large units. In fact, LPS can be classified as agglomerated networks with stratified agents on the basis of the type of information possessed and the interaction processes.

4. Evolutionary pressures towards more "visible minds"

For decades, the adaptive "modularization" of LPS has been very effective; however, the empirical evidence presented in Section 1 points out the fact that relevant changes occurred over the course of the past 15 years. The analytical framework proposed in this paper makes it possible to explain the long-term dynamics. The image of the invisible mind denotes an evolutionarily-patterned architecture, the result of the double set of high-frequency (inside) and low-frequency (outside) interactions. The adaptive nature of LPS and the "bottom-up" procedure with which the specific parameters for components of the product are defined, explain how the continuous and reciprocal adaptations between units are particularly suited to environments subject to incremental innovations.

In analysing the industrial district, Brusco (1991, p. 32) claims: "As the district has neither a vertex nor a hierarchical structure, it is much more complex to introduce new technologies. Industrial district is characterised by a strong sluggishness. It proceeds by absorbing technology in a deep, personal, and creative way, but it is very difficult to move a vast amount of people, not only workers, but the entire competence of a community. Industrial district faces now the problem of how to acquire new technologies . . . ".

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[31] LPS showed the ability to timely respond to fragmented and variable demand and at the same time are able to introduce technological and bounded flexibility by redefining and mixing different competencies.

[32] The analysis made leads to the discovery of a really surprising analogy between LPS and the human mind, which is an evolutionary result that consists of "a set of evolved information processing mechanisms . . . . Many of these mechanisms are functionally specialised to produce behaviour that solves particular adaptive problems" (Tooby and Cosmides, 1992, p. 24).

A survey by Nomisma (1989) emphasised the problems caused by the links between information flows and dynamics of investment: since only specific units are owners of market information, while techno-productive information are instead widespread among many agents "the problem of technological innovation ... becomes extremely critical, because decisions to invest are made by agents bereft of market information .... A clear split between technological innovation and market knowledge then emerges" (p. 32).[33]

In fact, the search for solutions to technical and productive problems takes place inside the existing techno-organisational configuration: "the process of innovation from below" (Bellandi, 1996) implies gradual changes (in the inside environment) in adaptation to more or less stable constraints that derive from the market. Indeed, the peculiar system of information flows (see Section 2) indicates that this is a constrained variety: there is a micro-universe in ferment, but within the boundaries defined by exogenous variables, i.e. basic technological invariants and the characteristics of the final demand.

The myriad of reciprocal adjustments therefore makes a high operational flexibility possible, in the sense of being able to vary the quantity and quality of the goods produced within a range of possible and continuously-renewed solutions. The concept of "parametric change, that is, change of certain variables within a known framework" (Langlois and Robertson, 1995) is perfectly suited to this representation.[34] Parametric uncertainty thus constitutes the dominant property of the situation in which the invisible mind is emergent and has functioned very well. At this point it is appropriate to wonder whether the changes described in Section 1 are such as to cause profound alterations in the basic properties of the system.

The phenomena reported in Section 1 are present in different gradations in all LPS, which demonstrate very heterogeneous capacities for transformation. For example, Belussi and Gottardi (2000a,b) distinguish between static, evolutionary and strong evolutionary paths, followed by a certain number of LPS.[35] One fact is undeniable, however, in many realities, profound changes lead to an emergence of diversified strategies by units operating inside a localised production apparatus. Indeed, within today's competitive trend, radically new factors have become relevant.

Above all, turbulence in the market increases, and innovation dynamics centred on information and communications technologies is amplified. It is therefore difficult to extract signals from the market: not only are they numerous and ambiguous; they are also only partially consistent with traditional production capacity, as a result of the changes that occurred in the structure and dynamics of consumption at international level. In view of the situation, which is characterised by instability and fuzziness of demand, product differentiation strategies and a search for market stability without reducing production flexibility become fundamental. These objectives cannot be pursued by means of adaptive types of behaviour with reference to exogenous parameters, but require "aggressive" marketing strategies, together with the planning and scheduling of the production and logistic cycles (Ferrucci, 1999). These new aspects are accentuated by process and product innovations, which alter the speed and nature of traditional information flows, while many production materials become obsolete, notwithstanding the accumulation of localised know-how.

Evolutionary discontinuities have thus generated a mismatch between requirements relevant to competition and the traditional sectoral and crafts culture (Ferrucci, 1999). The macroscopic effects of this dynamics are manifested in the importance taken on by new competitive factors. These can be synthesised as follows: (1) product quality; (2) a shortening of the life cycle of goods; (3) a vertically-organised and specialised logistics system, in order to react promptly and

[33] Lanzara and Ferrucci (1997) underscore the low propensity of industrial districts to invest in new technology.

[34] "For example, it may be highly uncertain which grade of cloth or which style of tile will be demanded this season, but it is well known to all what it means to produce a grade of cloth or a style of tile" (Langlois and Robertson, 1995, p. 555). An analogous observation could be made in regard to the search for solutions within a given technological perspective.

[35] Belussi and Arcangeli (1998, pp. 422–423) propose an interesting typology of networks: the first are networks "characterised by a low degree of operational flexibility and by static incremental learning .... The second type of network exhibits, by contrast, the attributes of flexibility ('retractility' or 'reversibility'). Firms linkages are mobile. Firms develop learning capability focused on incremental innovations ... the third type of networks is an adaptive/flexible local system".

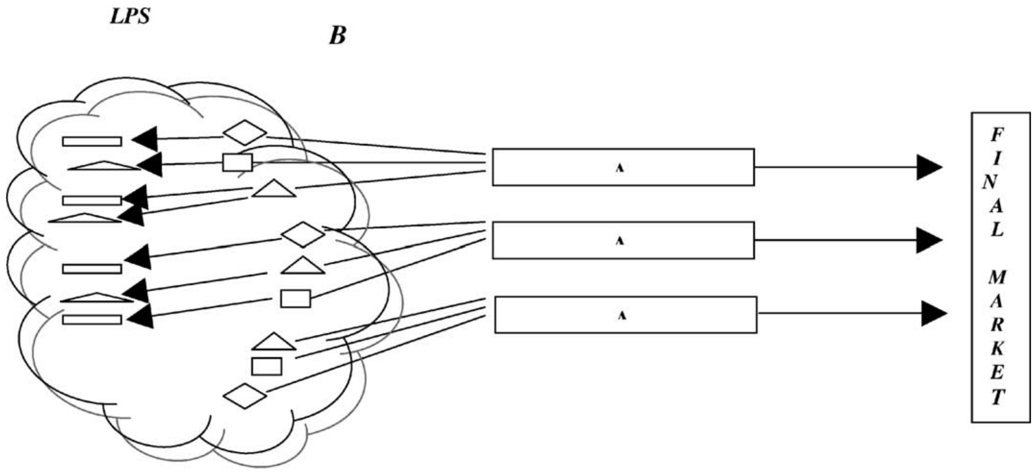

Fig. 4. (A) More integrated groups. Multilayered and verticalised LPS emerge. (B) Segmented techno-productive configuration. After evolutionary discontinuities selective processes reduce the numbers of firms and change the production cycle: (1) the informational divide tends to disappear; (2) local interactions are reduced; (3) more stable relationships are established.

flexibly to unstable demand.[36] Analysis of the implications of product differentiation strategies has revealed some interesting points (Ciappei and Mazzetti, 1996): producers must have an exact knowledge of customer requirements. Within an environment of high turbulence (i.e. of rapid and unforeseeable evolution), information related to industrial and final demand parameters cannot be filtered an transmitted: it is important to predict and anticipate potentials and threats stemming from the market, and then to react quickly. Ability to foresee and rapidity of reaction means that control of time becomes a fundamental factor, together with quality control. It follows that discontinuities in the competitive environment lead to conspicuous changes in information flows, introducing a new information asymmetry. In fact, asymmetry between strategic operators and the myriad of operating units changes, because the necessity for new strategies forces firms to realise more integrated production and logistics cycles.

The factors here analysed and the phenomena described in Section 1 evidently make the adaptive behaviour always more precarious, and challenge the systemic properties analysed in Section 2 (information hierarchy, self-containment, distributed modularity). LPS have, in fact, entered an era characterised by radical (technological, macro-economic) discontinuities, that is, an age dominated by "strategic uncertainty" (Langlois and Robertson, 1995), which requires a change in capabilities, competencies and, lastly, consolidated productive routines. In an period of radical discontinuities, adaptation and operational flexibility, as regards exogenous conditions and constraints, are not sufficient. Instead, it is necessary to mobilise resources and energies in order to make a basic redefinition of the patterns of interlocking behaviours. The distinction between outside environment and inside environment becomes more ephemeral, because of globalisation of information flows, while the trend towards the formation of vertical aggregations of units introduces profound changes in traditional techno-organisational configurations. Fig. 4 depicts the results of the competitive dynamics, which generates evolutionary pressures in the direction of the creation of a different architecture for the system, so that:

(1) it is less adaptive and more capable of anticipating events strategically;
(2) it contains co-ordination structures that are integrated and hierarchical arranged, in order to concentrate resources on new long-term objectives.

Therefore, cognitive architectures are needed that are suitable for the representation, accumulation and development of knowledge in environments that are

[36] We can define this factor as the control of a territorial network of sub-contractors (Viesti, 2000).

distinguished by high turbulence. We are confronted, therefore, by processes that transform the evolution of self-organised systems by favouring the emergence of components with purposeful organisational designs. The propensity to integration, i.e. to the more conscious strategic co-ordination between productive modules, represents—so to speak—a strong bias towards the construction of ordered architectures capable of rationalising physical and informational flows.

We can synthesise the conclusions of the analysis as follows.

Proposition 4. *Evolutionary pressures tend to change the basis elements for the emergence of complex adaptive systems, and favour explicitly-designed co-ordination structures, which can be defined—in cognitive terms—as visible minds.*

5. Concluding remarks

Evolutionary pressures tend to reduce the bases for the emergence of complex adaptive systems and to favour purposely-designed co-ordination structures. In other words, we are facing a process characterised by the joint presence on the one hand of distributed modularity, adaptation and limited endogenous variability, and on the other, of various forms of techno-productive planning. This type of evolutionary pluralism obviously challenges the self-organised nature of LPS. In fact, there are decision-making centres capable of drawing up strategies in profoundly different conditions from those synthesised in the representation of the "double environment". Above all, these centres organise sequences of arranged modules and no longer randomly distributed in the territory. In traditional LPS, there were strategic operators functioning as transducers of hidden information. At present, there is a consolidation of autonomous strategic centres that utilise local and outside competencies. A multiplicity of evolutionary hierarchies and cognitive architectures therefore emerges. In a world that, up until now, has been governed by an "invisible mind", there is a tendency for more visible "minds" to assert themselves.

This thesis also pertains to public intervention, as in the case of the creation of agencies specialised in favouring the adaptation of decentralised production systems to radical challenges (Bellandi, 2002). We must differentiate two possible roles for these agencies: (1) the exercising of systemic functions, in the sense of distributing public services and commodities (infrastructures, system logistics); (2) the strategic co-ordination of operators, through associations of firms, consortiums, etc.

In the first case, the self-organised nature can be reinforced and not contradicted. In the second, we are once again facing an evolution in decision-making centralisation, which alters the traditional systemic properties.

In the scenario described, at least two questions are presented to the reader:

1. Are we facing an irreversible transformation?
2. Can a given evolutionary path for LPS be hypothesised?

In regard to the first question, the following thesis appears to be valid: competitive evolution and the era of strategic uncertainty push in the direction of forms of centralisation, i.e. techno-productive structures and sequential and integrated cognitive architectures. The revival of competitive contexts distinguished by parametric uncertainty may, however, create biases towards a more self-organised dynamics. We can also hypothesise an evolutionary cycle of LPS based on recurring phases of more or less integrated organisation models, depending on: (1) the changing characteristics of the competitive environment; (2) the type of technological change; (3) the matching processes between LPS and dynamic environment.

As far as the second question is concerned, the most plausible answer is that it is indeed the nature of evolutionary systems that causes LPS today to take on a multiplicity of forms: new propulsive drives can be triggered on their adaptive capacities, but the specificity of new factors (competencies, localised interactions, shared values, etc.) could in some cases determine a dynamic reactivity, and in others problematic routes or stagnation. By mentioning the classification by Storper and Harrison (1991) again we can consider well founded this hypothesis: agglomerated networks with stratified agents (see Section 3) are becoming hybrid networks, within which different organisational patterns and governance structures coexist.

We believe that an analysis of the specific mixes of systemic properties possessed by the various LPS, together with the theoretical framework herein proposed, can supply the bases for formulating reliable forecasts.

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