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Spatial co-localisation of firms and entrepreneurial dynamics

The combinatory system view

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Abstract In this conceptual paper, I propose an interpretation of business dynamics in terms of the spatial co-localisation of firms—considered as an intelligent cognitive system—in a circumscribed area in order to form clusters of various types. I interpret clustering by adopting the methodology of multi-agent combinatory systems: that is, systems formed by collectivities of agents (firms) in which an internal feedback recombines the micro behaviours of the agents (localisation) in order to produce a macro effect (cluster) which, in turn, modifies the attractiveness of the area and conditions the subsequent localisations. I also present the idea that if a cluster has fitness advantages for new firms, then usually new entrepreneurs are formed within it and the cluster widens, due to the endogenous genesis of new firms.

Keywords Entrepreneurial dynamics · Combinatory systems · Co-localisation of firms · Clusters of firms · Districts

Exogenous and endogenous co-localisation

The objective of this study is to explain the phenomenon of co-localisation, understood as the dynamics of firms and of entrepreneurs, in two respects:

a) The *spatial dynamics* of firms and entrepreneurs; that is, the aspect of the *localisation* of the firms in a given area or territory, or even—in equivalent though general terms—the dynamics regarding the formation of *clusters* of firms or productive activities; I shall call this phenomenon *exogenous co-localisation*;

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b) The dynamics regarding the *density of firms* and entrepreneurs over a given territory; that is, the aspect regarding the *genesis* of new entrepreneurial initiatives, entrepreneurs or firms in a territorial context where there is already a cluster of entrepreneurs and productive activities; this phenomenon will be called *endogenous co-localisation*.

I interpret clustering by adopting the methodology of multi-agent combinatory systems: that is, systems formed by collectivities of agents that, by "combining" their micro behaviour, give rise to a macro behaviour and a macro effect which refers to the collectivity considered as a whole, and which in turn directs the subsequent micro behaviours.

Two basic assumptions: The firm as an efficient and as a rational agent

Despite the differing points of view from which the firm can be considered, for the purposes of a study on entrepreneurial dynamics I believe it is appropriate to introduce the *first basic assumption,* which considers the capitalistic firm as:

a. A *cognitive and viable economic agent* (Beer, 1979, 1981), in that we must assume that the organization carries out a cognitive activity aimed at giving significance to the environmental stimuli and translating these into information that is structured in knowledge and models (de Geus, 1997), in order to survive in a changing environment and maintain its identity in a long-lasting autopoietic process (in the sense of: Maturana & Varela, 1980; Mingers, 1994)
b. A *rational agent*, in that the cognitive activity is aimed at maximizing its *fitness*, indicated by a system of performance measures which express the entrepreneur's ability to maintain or improve the autopoiesis of the system-economic agent in a given area and over a definite interval of time.

We can thus also consider a *collectivity* of firms, whether or not these have similar or different structures, size, businesses and production, as a population of agents constituting a complex system (Holland, 1995; in the sense of: Axelrod, 1997; Mella, 2005).

To fully understand which performance measures most effectively express the fitness of the firm, we must agree on the minimum characteristics of survival.

If we define a *capitalistic firm* as an autonomous permanent *business* and *profit-oriented* organization (Williamson, 1993) that finances its economic processes with external capital in the form of equity and debt, we can introduce the following *second basic assumption*:

a) The capitalist firm is created and maintained over time only if the entrepreneur succeeds in developing a portfolio of businesses with sufficient economic efficiency to acquire and maintain invested the financial capital necessary to activate and continually renew the productive investment cycles that guarantee its autopoiesis;
b) This condition will exist if the firm is able to create a sufficient value for the shareholders to meet the expectations of the suppliers of the financial capital that guarantees its existence (Ruefli, Collins & Lacugna, 1999);

c) The overall fitness of the firm, which guarantees its autopoiesis, is revealed by productive, economic and financial *measures of performance* that denote the efficiency and effectiveness in the production of *shareholder value* in terms of return and capital gains.

Financial and economic performance and fitness (a short survey)

In order to achieve the conditions of survival, the choice of the optimal portfolio mix must be made based on the most sophisticated methods of economic calculation (Cornelius & Davies, 1997), which considers the three operational levels of every firm as operating systems for efficient transformation that carry out three parallel transformations:

a. A *productive transformation* of factors into production; this is a transformation of utility, governed by productivity and quality;
b. An *economic transformation* of costs and revenues into operating income; this is a transformation of value, governed by prices, and therefore by the market;
c. A *financial transformation* of risks, which transforms capital into returns and guarantees the maintenance of its financial integrity.

The *productive* choices to maximize value must adhere to the rules for maximizing *quality* as a fundamental variable in the selling price, and to those for maximizing *productivity* as a fundamental variable in the cost of production, by reducing the unit factor requirements by means of an efficient *production function*.

The *economic* choices must adhere to the following rules: (1) choose the businesses which guarantee the maximum profit margin, compatible with capacity constraints; (2) sell on markets while searching as much as possible for possible positions of dominance or monopoly, in order to influence prices and reduce the risks from competition (Doyle, 2000; Mc Taggart, Kontes, & Mankins, 1994; Rappaport, 1998); (3) acquire inputs from markets where competition exists, in order to reduce the purchase costs and the supply risks (Ashworth & James, 2001); (4) locate production and selling where knowledge is appropriate, labour costs are low and infrastructures are efficient; (5) choose businesses with the highest cost/investment ratio.

The *financial* choices must adhere to the following rules (Cornelius & Davies, 1997):

(1) Arrange the business portfolio so that $roe \geq roe^*$, where roe^* indicates the return on equity expected by shareholders;
(2) Choose the investment where $roi > 0$ and $roi > rod$ (*roi* and *rod* indicate the return on investment and the return on debt);
(3) Choose those businesses with $roi > roi^*$ and with *roi* max (roi^* indicates the objectives of *roi* necessary to achieve the objectives of roe^*);
(4) Choose the financing with *rod* minimum;
(5) If $rod < roi$, then increase debt (D) and reduce equity (E) to the level of invested capital (IC); thus, if it is necessary to increase IC, finance this with D if $rod < roi$;

(6) Substitute business A with business B if *roi*(B) > *roi*(A);
(7) Substitute financing H with financing K if *rod*(K) < *rod*(H).

If all these choices are correctly carried out at every level of the organization, the maximization of the *roe* is guaranteed, as indicated in the well-known equation (Modigliani & Miller, 1958):

$$roe = [roi + (spread\ \ der)],$$

where *spread* = (*roi* − *rod*) and $der = \frac{D}{E}$. *"roe"* is the most concise indicator of *fitness*, since if *roe* ≥ *roe**, assuming *roe** ≥ *ir*—where *roe** is the *fair* (satisfactory) *return expected* by the investor in equity capital (financial opportunity cost), and ir is the (expected) inflation rate for the stockholder—then the survival of the organization is guaranteed, since the firm is capable of producing a return that is sufficient to ensure the capital remains integral, both in monetary terms (preserving its purchasing power), financial terms (the financial return satisfies the expectations of the equity holders), and real terms (capacity to renew investments at the end of their cycle).

In fact, from *roe* we can derive other concise indicators of *fitness* that refer to the firm's ability to meet the return expectations of investors: the *economic value added* (EVA) and the *economic value of the firm*.

Third assumption: The firm as an explorative agent moving through an attractiveness landscape

The basic measures of financial and economic performance not only reveal how internal factors of strength and weakness can heighten or depress the reaction of the firm to opportunities, threats and risks, but can also be viewed as *spatial performance indicators* revealing how physical and social characteristics of a territory can support or inhibit the *fitness* of the firm or of a business acting in that territory.

The fundamental variables that influence the performance indicators for every area represent the spatial *factors of attractiveness* (positive), which increase the chosen performance indicator (supply and cost of labor, infrastructures, transport costs, availability of land and water, waste disposal possibilities, the presence of clients, materials and services, etc.) or those of *repulsion* (negative), which instead reduce the indicator (probability of conflicts, existence of corruption, etc.).

The values for the attractiveness factors in each area allow us to draw up the *fitness landscape* for the territory that is made up of the different areas.

We can then assume in principle that the enterprise is able to draw up a fitness landscape of the territory that can potentially be reached by its businesses, and can accurately determine (rationality assumption) the *factors of attractiveness* or *of repulsion* for each site and quantify these in economic terms (prices, costs, quantities, quality, etc.).

Then the firm chooses one or more *performance indicators* (operating income, return on investment, return on equity, economic value of the firm, etc.) and determines for each alternative site the value (measure) for this indicator (it can construct the business plan for each business and for each site); the value thus obtained for the various sites represents the *index of attractiveness* for the site. The

distribution of the *index of attractiveness* deriving from the chosen performance measure(s) for different businesses (or parts of them) in different areas represents the idea of a *function of attractiveness* for the territory, from which we derive an *attractiveness landscape* that guides the co-localisation decisions.

For example, by choosing as indicators of *fitness roe* and *roi* and their components, it is plausible that an area full of potential consumers and lacking in competitors is highly attractive, since it has potentially high revenue prospects, both in terms of quantity and price, and thus a high *roi*.

On the other hand, an area with a reduced tax burden would have, with all other conditions equal, a higher *roe* than others with a higher tax burden. An area with a high amount of pedestrian traffic could favor sales for a small retailer, while one with a large parking area could increase the fitness of a large retailer.

The formation process for the *fitness landscape* and the *attractiveness landscape* can be summarized in Table 1.

Column [1] indicates the different *areas* considered interesting by the firm or by one of its businesses. Column [2] includes the *factors of attractiveness* that characterize each area in relation to the type of firm or business. The vector [a_{11}, a_{12}, a_{13},...] represents the fitness landscape of area A_1. Column [3] determines the value of the chosen *performance indicator*, while [4] specifies, if possible, a *value of risk* (certain if $r = 1$; impossible if $r = 0$). The *index of attractiveness* for each area is determined taking into account P_i and r_i contemporaneously; the simplest way is by multiplying the two indicators. The vector [$P_i * r_i$], $i = 1, 2,...$, indicated in column [5] represents the *attractiveness landscape* for the areas of the chosen territory.

For a given organization, and in relation to the characteristics of the various areas, the attractiveness landscape will likely present "valleys" of moderate attractiveness, "peaks" of high attractiveness, or "pits" of repulsion (negative attractiveness), to be avoided if possible.

The assumption of the firm as a *rational agent* implies that the entrepreneur must be viewed as an *explorative agent*, continually seeking improvement in the conditions of fitness in all possible areas while following the following *optimal behaviour*:

– Explore all accessible territories and areas that can be reached by his productive, economic and financial processes;

Table 1 Process to determine the attractiveness landscape

[1] Areas of a chosen territory: (A_i), $i = 1, 2...$	[2] Index of attractiveness (a_{ij}), $i = 1, 2,..., j = 1, 2,...$, and fitness landscape	[3] Performance indicators (P_i) evaluated for each area based on the factors of attractiveness	[4] Indicators of performance risk (r_i) evaluated for each area	[5] Attractiveness landscape
A_1	[a_{11} a_{12} a_{13} ...]	P_1	r_1	[$P_1 * r_1$
A_2	[a_{21} a_{22} a_{23} ...]	P_2	r_2	$P_2 * r_2$
A_3	[a_{31} a_{32} a_{33} ...]	P_3	r_3	$P_3. * r_3$
A_4	[a_{41} a_{42} a_{43} ...]	P_4	r_4	$P_4 * r_4$
A_5	[a_{51} a_{52} a_{53} ...]	P_5	r_5	$P_5 * r_5$
...	... ...	...	...	...]

- Determine the most important *factors of attractiveness* or *repulsion* and evaluate these in economic terms by forming the fitness landscape;
- Translate the *fitness landscape* into the *attractiveness landscape*;
- Shape, update, and continually explore, looking to the future, the *fitness* and *attractiveness landscapes;*
- Choose the area(s) with the greatest attractiveness; that is, with favorable conditions for the increase in *roe* and *roi* (for example, the ease with which new businesses can arise, greater sales volumes, expectations for better prices and supply costs, greater productivity and public subsidies, high levels of social protection, stimulating environment, abundance of infrastructures, lower tax burden, etc.)
- Avoid the "pits" and attain the highest "peaks".

The thesis: The clustering effect is generated by the action of combinatory systems

Our thesis can be summarized as follows:

a) If we refer not to the dynamics of the single firm but to a *collectivity of firms*, which act as *explorative rational agents* continuously attempting to improve their *performance* measures and their *fitness*, we can consider such a collectivity as a *combinatory system* capable both of *co-localising* in a given territory by forming a *cluster* and of *generating* new enterprises;

b) The *co-localisation* of firms and the formation of clusters is basically generated from the action of two *combinatory systems*:

   - *Systems of accumulation*, which favour the exogenous genesis of clusters characterized by units from other territories locating in the same area;
   - *Systems of diffusion*, which instead favour the endogenous genesis and growth of a cluster in a particular area, characterized by units from within the area where a cluster already exists locating in the same area (typical of districts).

Before attempting to demonstrate this thesis, let us first of all observe that *clusters* of firms situated in limited areas are widespread in all contexts and in various forms (Albu, 1997), among which:

1. *Conglomerate clusters*, typical of industrial and commercial areas (Porter & Sölvell, 1998), which we normally observe at the periphery of cities, along the main streets, near a tollbooth, or around universities;
2. *Industry cluster,* composed of a group of business enterprises bound together by "*buyer–supplier relationships, or common technologies, common buyers or distribution channels, or common labour pools*" (Bergman & Feser, 1999);
3. *Specialist clusters*, or *districts*, typical of single-business or mainly-business industrial areas and *industrial* areas (Lorenzoni & Lazerson, 1999);
4. *Vertically-integrated clusters*, typical of a "filière" or pipeline, composed of independent firms which carry on different phases of a single process along the value-added chain;

5. *Vertically*- and *horizontally-integrated clusters* of firms, typical of *networks*, closely linked by inter-company ties in terms of supplies, manufacturing, and process (Hakansson & Snehota, 1994; Harrigan, 1985; Thorelli, 1986); the network represents an organized system forming a single productive entity that does not depend on joint-location but on the activities of all the firms in the social network, wherever they are located;
6. *Hub* or *constellation* cluster (neck or spider-web) joint-location, arriving or departing, which we observe when there are common facilities, a common supplier, or a common client in the centre of the web (Lorenzoni & Lipparini, 1999).

It is clear that clustering represents a general phenomenon that is not limited to the firm; but if the phenomenon of the clustering of productive units in the same area is so general, then it is clear that the *mass* appears to gain the *force of gravity* and generates *attraction*, representing *global information,* so that individuals are inevitably drawn in to increase the mass of the cluster as part of a positive feedback or reinforcing loop.

The tool: Combinatory systems

In plain words I define as a *combinatory system* any collectivity of *non*-interconnected *similar* agents (individuals or organizations)—which develop *analogous* micro *behaviours*—that operate in a given environment (locality, territory, geographical area, etc.) and that, consciously or unconsciously, act (exclusively or prevalently) on the basis of *global information* which they directly produce and update as the consequence of their micro behaviours.

The basic idea behind the theory of combinatory systems is that, on the one hand, the *global information* is a *macro effect* deriving from the *macro behaviour* of the collectivity as a whole, produced by the *combination* of the micro-behaviours of the agents (or their micro effects), hence the name *combinatory system*; on the other hand, the *global information* drives the subsequent micro-behaviours as a result of a *micro–macro feedback*, acting over a period of time and producing interesting forms of *self-organization, synchronization* and *path dependence* (Arthur, 1994) in the agents' micro behaviours (Mella, 2000).

The feedback arises from *necessitating factors*, which force the agents to adapt their micro behaviour to the system's macro behaviour, and is maintained by the action of *recombining factors*, which lead the collectivity to recombine the *micro* behaviour, or the micro effects, in order to produce and maintain the macro behaviour, or the macro effect.

Recognizing the existence of a micro–macro feedback and understanding the nature of both the necessitating factors and the recombining ones is indispensable for interpreting collective phenomena as deriving from a combinatory system (Mella, 2005).

In order for the dynamics of the combinatory system to manifest itself we generally require a casual *input*, which sets in motion the micro–macro feedback.

The most relevant classes of combinatory systems are:

1—*Systems of accumulation,* whose macro behaviour leads to a macro effect which is perceived as the accumulation of objects, behaviours, or effects of some kind; these can be described by the heuristic model below (Fig. 1):

- Necessitating factors: if you have to accumulate some "object" with others similar in nature (micro behaviour), look for already-made accumulations (global information), since this generally gives you an advantage or reduces some disadvantage (necessitating factor);
- Recombining factors: the environment preserves the accumulated objects or is not able to eliminate them, and maintains the advantages of the accumulation; everyone accumulates (macro behaviour) and an accumulation of some kind is created (macro effect);
- Micro–macro feedback: the larger the accumulation (macro effect or global information) the more incentive there is to accumulate (micro behaviours) objects (micro effects); the collective accumulation (macro behaviour) leads to an ever greater accumulation.

2—*Systems of diffusion*, whose macro effect is the diffusion of a trait or particularity, or of a "state", from a limited number to a higher number of agents of the system; the heuristic model is (Fig. 2):

- Necessitating factor: if you see that an "object" is diffused among the collectivity (global information), then it is "useful" for you to possess it or harmful not to possess it (necessitating factor), and you must try to acquire it;
- Recombining factor: the environment or the collectivity preserves the diffused objects and maintains the utility of possessing the "object"; the higher the utility or need to acquire the object for the individuals, the more the object will spread throughout the collectivity;
- Micro–macro feedback: a greater diffusion (macro effect or global information) implies a greater desire to acquire the object (micro effect); the single acquisition (micro behaviour) widens the collective diffusion (macro behaviour).

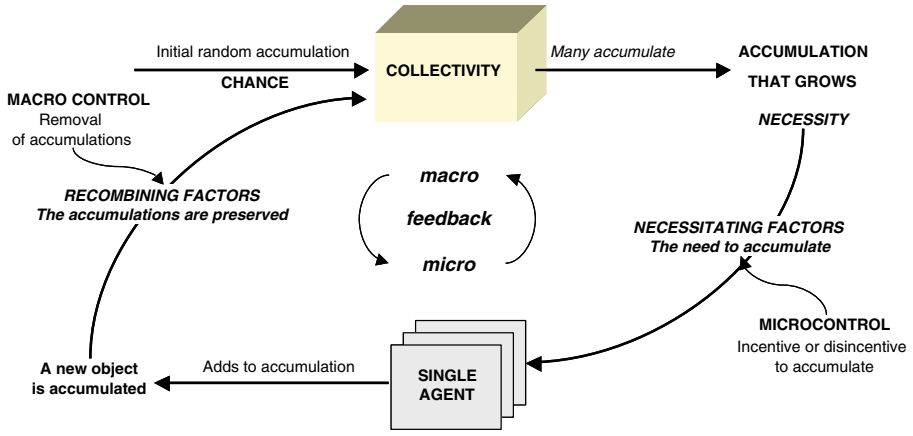

Fig. 1 Model of accumulation systems

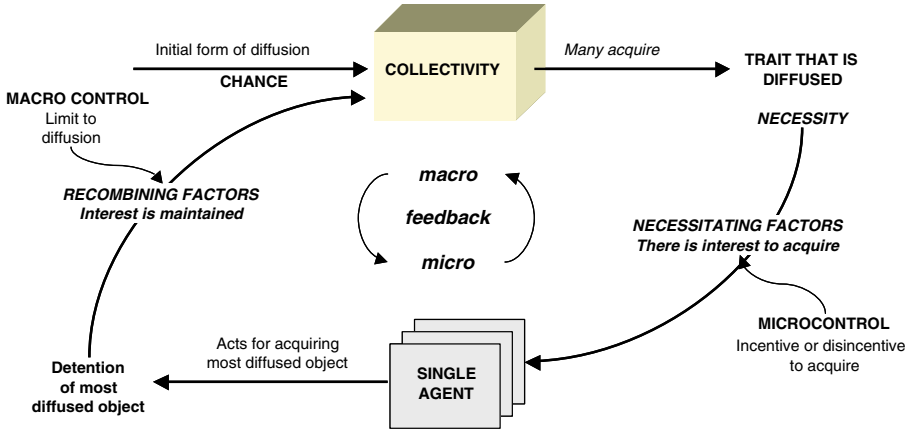

Fig. 2 Model of diffusion systems

A multi-agent model of clustering processes

In order to interpret (and simulate) *the joint-location process* according to the combinatory systems approach, let us present a general multi-agent model in which we imagine a territory as a lattice of regular adjacent cells of equal size (for convenience), each of which represents a possible location site for an economic agent.

From an abstract point of view, an agent *settles* in the territory if it occupies a cell.

A cluster is thus a *subset of adjacent cells* occupied by agents.

According to this model, an *economic cluster* may be interpreted as the effect of the gradual occupation of a territory by a certain number of intelligent agents jointly-located around an attracting nucleus.

If we consider a two-dimensional space, a surface, then the joint-location can be (Fig. 3):

1. *Horizontal*, if the occupied surface expands in a contiguous manner (ever larger commercial areas);
2. *Vertical*, if the units are superimposed on the same surface area (for example, skyscrapers);

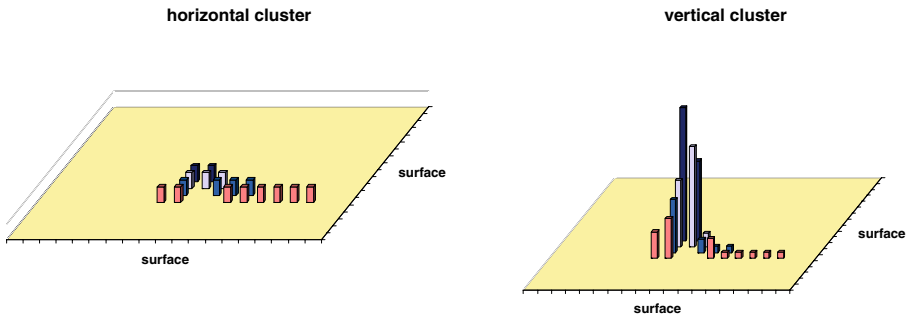

Fig. 3 Horizontal and vertical clusters

3. A *mix* of the two (cities whose buildings increase in height and grow in numbers).

We can represent the two typical clustering processes (Fig. 4) as follows:

a. *Exogenous joint-location*, if the clustering agents come from other areas external to the one observed;
b. *Endogenous joint-location*, if the units come from within the area where a cluster already exists, locating in the same area (typical of districts).

Let us assume that agents can evaluate their *fitness landscape* on the entire grid, so that each cell can be characterized by an *index of attractiveness* (or of preference, advantage, or probability) of occupation, and that the grid shows about the same attractiveness landscape for each agent. At first let us assume that the space is empty and does not reveal particular factors of attractiveness, so that the attractiveness landscape is flat (Fig. 5a).

Following the combinatory systems view, if a new agent is attracted to one cell then the *attractiveness landscape* is modified; the *attractiveness* of the occupied cell (for endogenous clustering) and/or that of the neighboring cells (for exogenous clustering) increases (usually non-linearly) and a *force of attraction* begins to act (Fig. 5b).

This means that now the grid has a certain number of adjacent cells with a higher *attractiveness* of occupation. A peak of preference forms on the grid.

If a new agent *is attracted* to this peak and locates in one of its cells, the *attractiveness of occupation* of the neighboring cells increases further and a *force of attraction* begins to form that derives from the (usually non-linear) increase, from the greater *attractivenessof occupation* of the cells.

For the sake of simplicity, in Fig. 5a we have assumed a field of equal preferences; in most cases, however, a territory presents different attractiveness for different zones; thus the normal case is the one represented in Fig. 5b: the location (figure at left) is the consequence of a field of preferences showing a peak over the territory (figure at right).

In any case, the phenomenon can start when "by chance" (or even by an "external decision") an initial cell is occupied and this initial settlement increases the index of preference for occupation of the neighboring cells.

The mass of a cluster of firms appears as *global information* that generates *attraction* for the new entry and for the elements already localized.

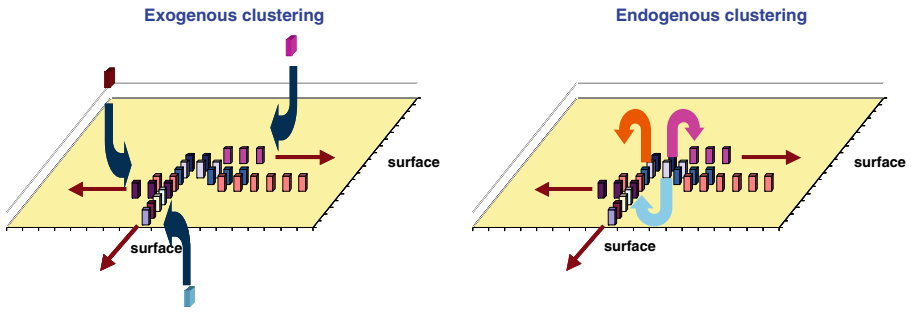

Fig. 4 Exogenous and endogenous clusters

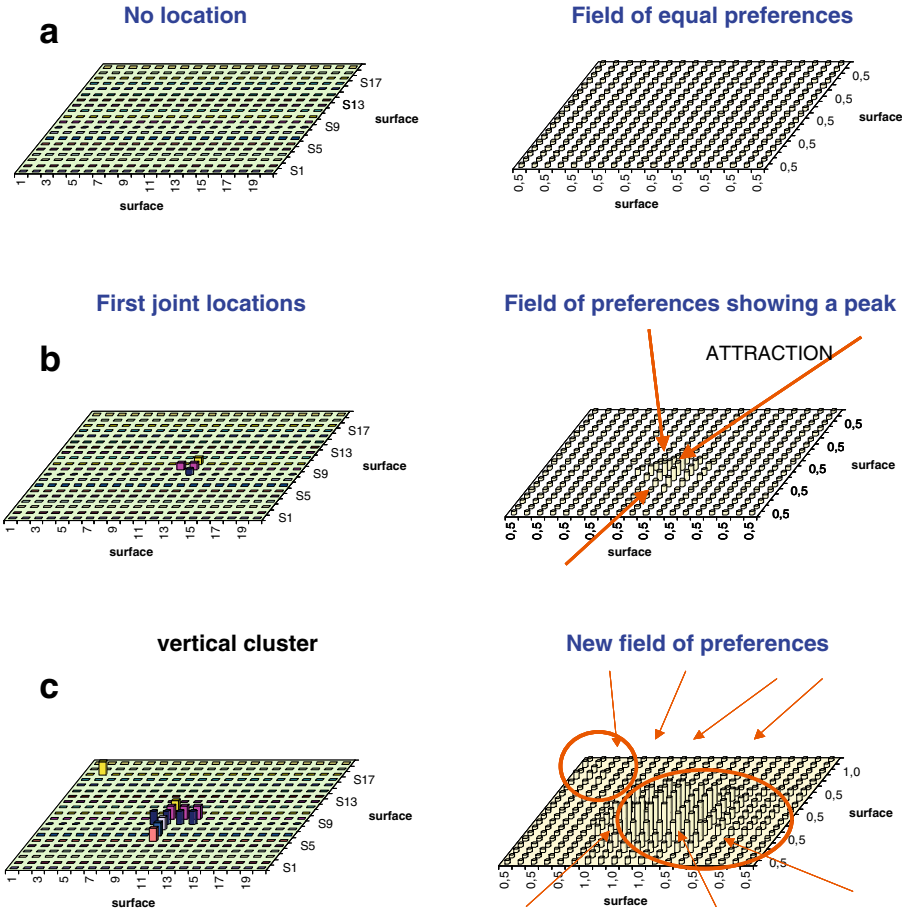

Fig. 5 Exogenous and endogenous clusters. (a) Empty space and flat attractiveness landscape. (b) First localisations and modified attractiveness landscape. (c) Further localisations and increased force of attraction

If the grid is sufficiently vast, we cannot exclude the possibility of other clusters forming that can coexist or join together (Fig. 5c).

If we introduce the assumption of *irreversibility*, then the clusters coexist, and they are enriched by new settlements, with the densest one increasing even more. If instead we introduce the assumption of *reversibility*—that is, of delocalisation—then the merger between clusters of differing densities is possible and the greater cluster absorbs the smaller one.

The same descriptive logic can also be used for the endogenous formation of clusters; we must assume that a cluster already exists and that it generates from within new agents that cause an increase in the preference for new location in the cluster.

The exogenous joint-location explained by accumulation systems

We have defined as *exogenous* the *cluster* deriving from the *joint-location* in a given area of productive units which were previously located elsewhere (Fig. 4, at left).

The procedural *explanation* of the phenomenon may be achieved by applying the logic of the *combinatory systems of accumulation*.

When a given area reveals advantages for the fitness of the firm, in that it can offer a *positive differential* in financial and economic *performance measures* (tax reduction, infrastructures, facilities, aid and subsidies, etc.) with respect to other areas (necessitating factor), then the *attractiveness landscape* presents a peak, so that the probability that a certain number of entrepreneurs will decide to locate (micro behaviour) their productive or commercial units (micro effect) in that area rapidly increases and the combinatory system can begin to produce the collective phenomenon of joint-location (macro behaviour), with the development of typical industrial and commercial clusters (macro effect).

If the joint location of the *initial nucleus* of enterprises (by chance or by external planning) produces, maintains, or increases intrinsic financial or economic advantages for the settlement (recombining factor), then the *attractiveness landscape* changes and the peak rises, so that the probability of new locations rises further, and this attracts new productive units (necessity), which produces strengthening actions in a typical *micro–macro feedback*.

The system accelerates if *strengthening* actions are carried out (for example, public aid, the building of infrastructures, etc.) and decelerates or ceases when *weakening* actions intervene (for example, urban constraints, taxes, etc.) that reduce the fitness for new potential entrants.

The functional explanation

In order to arrive at a *functional explanation* of the modus operandi of the system that produces a cluster by *exogenous joint-location*, we must specify the fundamental elements (Fig. 6).

Necessitating factors

The convenience of *exogenous* joint-location always resides in *economic advantages* which improve the performance measures of fitness with respect to the previous location, so that the new area is considered as more attractive.

Following Marshall's view on districts (Bellandi, 1996) and Williamson's transaction cost perspective (Dyer, 1997; Williamson, 1993), improvements in performance measures can derive from *lower costs* and/or *higher revenue* and/or *knowledge exploitation* and *preservation*.

Cost savings come from *advantages from specialized processes* offered by the site, and can be connected to the presence of better production and logistical conditions; for example:

- Presence of materials or the availability of work offers advantages in terms of quality/cost; the cluster is named as a resource area;
- Presence of favorable logistical conditions (lines of communication, parking areas, the nearness of suppliers);
- Extensive functional division of labor between small and specialized firms as a source of external economies of scale and scope (Bellandi, 1996);

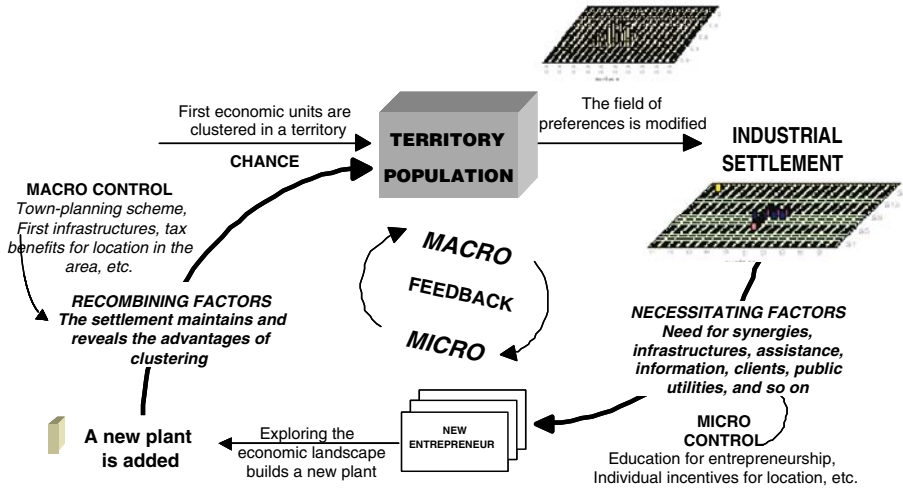

Fig. 6 Model of the system of accumulation for exogenous joint-location

- A local labour market (Scott, 1992);
- Ecological advantages (water, waste-disposal sites, etc.);
- Tax and financial advantages (reduced tax burden, incentives, aid and subsidies to businesses locating in a given area, etc.; Sthör & Taylor, 1988).

Revenue advantages are connected to market advantages, which are associated with the market "fertility" of the site; that is, the relative abundance of potential clients (especially for commercial areas). These advantages may also derive from prices, and they are connected to the quality of production or the efficiency of marketing processes (Chandler, 1990).

Knowledge and learning advantages are connected to greater possibilities for information search and share aimed at the behavioural control and coordination of activities and processes, and at performance evaluation (Maskell, 2001); other advantages also derive from learning the best practices and from the ease with which innovations spread (Asheim, 1996; Pilotti, 1998), in line with the cognitive approach, which considers knowledge as a codifiable resource that can be managed by the individual or the firm and transferred from one individual or firm to another. Industrial clusters and industrial districts, in particular, become geographical examples of a *learning economy*. Thus in districts, *knowledge is the most important resource and learning the most important process* (Lundvall & Johnson, 1994), and districts can be viewed as learning regions (Asheim, 1996).

Recombining factors

When a *critical activation mass* is reached, the endogenous joint-location system is set under way, but only under the condition that the system can recombine the micro behaviours, within an *innovative milieu* which conserves and accentuates the entrepreneurial mentality (Camagni, 1991; Maillat, 1998) and makes possible the selection of the best routines and procedures (Nelson & Winter, 1982; Nonaka, 1994) *"by imitating the observed behaviour of one or more "masters", in a community of practice"* (Nooteboom, 1999).

Due to the advantages from the physical proximity of the firms in the area (Brusco, 1999), which allow increasing returns in an economy of clusterized firms (Arthur, 1994), the cluster maintains the economic advantages and creates a critical mass of productive units that improves efficiency in productive, commercial and administrative practices and influences urban and territorial policies, with further improvements in economic differentials (Bellandi, 1996). As an "invisible factor", a network of information relationships and internal commercial transactions erects barriers to entry in order to maintain the economic advantages for a maximum number of firms in the cluster; the greater the advantages the site presents and maintains, the larger the number of firms that seek to locate at that site by overcoming the barriers. This reinforces the advantages, generating the typical micro–macro feedback that produces path dependence (Belussi, 1999).

When there are fewer recombining factors the necessitating factors are also less intense; when they are eliminated the macro behaviour ceases and the process of joint-location is interrupted; when they are negative the system shows signs of slackness (abandoning of productive units) or reversibility (processes of moving out and migration to other areas; Dunford et al., 1993).

Clusters are not necessarily closed to the external environment; they can represent a system area presenting various forms of connections with other areas.

Genesis

In general, exogenous joint-location arises as a spontaneous process, especially when the necessitating factors are in evidence; these are represented by revenue advantages (*rows of shops*, *shopping centers*), or by cost advantages (joint-location in areas with low-cost labor) or logistical ones (Schmitz, 1992).

Chance moves the initial firms to locate jointly at a favorable site; the intervention of necessitating factors then pushes the system to get under way as soon as the minimum activation density (critical mass) is reached, producing a typical path dependence (Antonelli, 1997).

Exogenous joint-location can nevertheless be favored by certain exogenous *strengthening* actions that create the conditions for producing the economic differences.

The possibility of the artificial activation of clusters and, in particular, of districts is controversial but in principle not impossible.

Particularly evident are *government policies* of incentives or constraints, as well as actions to create logistical infrastructures (highways, ports, equipped building lots, etc.) or research and educational centers (Nelson & Winter, 1982) and the specific recognition of cost advantages (lowering of labor costs, and tax and financial advantages).

Furthermore, policymakers might stimulate entrepreneurial activity in a local area by providing venture capital and preferential loan finance; by offering favorable tax incentives; by removing impediments to business start-up; and by providing management training and business advice. The policy of attracting *foreign direct investments* is another important economic development strategy of many city-regions (Gordon, 1999).

Porter (1990) nevertheless argues that government policy will be far more likely to succeed in reinforcing an existing or nascent industrial cluster rather than in trying to promote an entirely new one. Following Porter, the emergence of new clusters is produced by the systematic interrelationships between the following four factors: the nature of local demand conditions; the development and specialisation of factor conditions; the interactions with related and supporting industries; and the nature of cooperation and competition between firms within a cluster. Therefore, according to Porter the role of government is to reinforce these determinants rather than introduce them in a non-industrial area.

Endogenous joint-location explained by diffusion systems

The formation of industrial, commercial and professional areas can be the result of a process endogenous to the area itself: we must assume that a cluster already exists and that it generates from within new agents which find in the existing cluster the best environment for their *economic fitness* (Amin, 1993). The cluster thus increases in size by producing its own agents on the basis of a generative rate which depends on the dimension of the cluster.

According to the logic of *diffusion systems* (Fig. 7), when *by chance* successful firms locate in an area (original nucleus) and are able to internally develop their personnel (employees, managers, professionals), then *by chance* some of the personnel, after having acquired the necessary competencies and evaluated the fitness landscape of their potential firm, may decide to undertake an activity [micro behaviour] to take fitness advantage of their acquired capacities for personal profit. New enterprises are born [micro effect]. If they are successful in their new business activities the combinatory system can get under way, and more firms will locate in the area [macro effect] through endogenous growth. The process spreads [macro

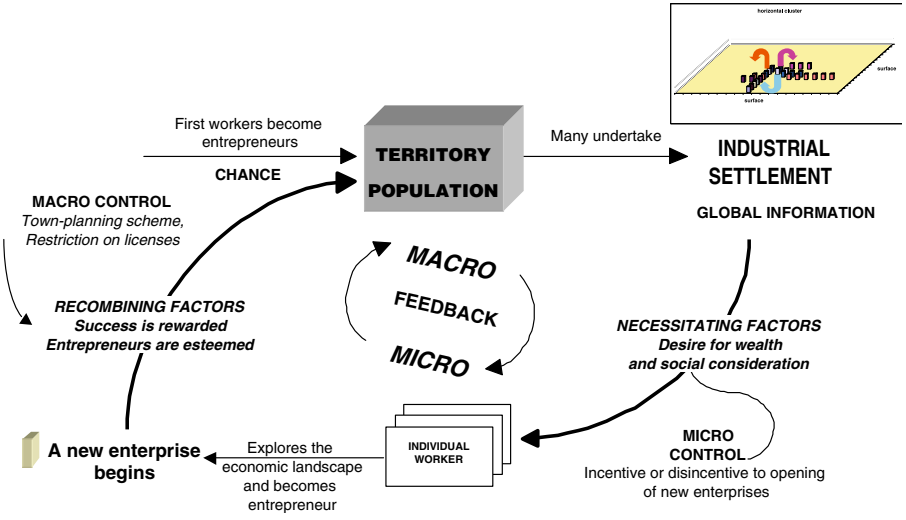

Fig. 7 Model of a system of diffusion for endogenous joint-location

behaviour] and the group of workers is gradually transformed into a collectivity of entrepreneurs (Antonelli, 1996).

The firms become increasingly more numerous (macro effect), and this raises the probability that individuals will start new enterprises (micro behaviour), in a typical *micro–macro feedback* typical of systems of diffusion. An area of workers gradually becomes an area of entrepreneurs that soon will have to import subordinate workers from other areas.

The functional explanation

While *exogenous* joint-location is based on differences in economic advantages that firms in the area can benefit from, *endogenous* location is based on the transmission of competencies, of faith, of rewards for risk.

In order to have a full understanding of the *functional explanation* we need to specify the fundamental elements.

Necessitating factors

An enterprise is born when someone, perceiving a peak in the fitness landscape of a potential firm, decides to risk his own capital and work at an independent activity. According to the institutionalist view (Camagni, 1991), the combinatory system for exogenous entrepreneurial development is set under way only if, within the collectivity living in a certain area, there is a spread of the entrepreneurial vision (mentality, logic, attitude, etc.): a sort of cultural isomorphism (Powell, 1990) which is the logic of investment, and thus of risking it alone. This mentality is based on three *necessitating factors*:

- The entrepreneurial activity offers a high probability of success, thus of *profit* and *personalprestige,* as a reward for the risk of the investment;
- The entrepreneurial activity is held to be *socially useful* and offers adequate forms of social recognition; this favours the formation of a *social identity*: the entrepreneurs feel part of a community, *defined as a state of mind, a place based on faith in certain assumptions and values* (Darrah, 1996);
- The entrepreneurial activity involves production for which it is easy to acquire the necessary skills, and there is the awareness of being able to put the acquired skills to good use.

There is no need for particular economic advantages in the area, which creates differences in economic possibilities; the economic advantages are considered the result of ability rather than the consequence of location advantages.

Recombining factors

When a *critical activation mass* is reached the endogenous joint-location system is set under way, but only under the condition that the system can recombine the micro behaviours, within an *innovative milieu* which conserves and accentuates the

entrepreneurial mentality (Camagni, 1991) and makes possible the selection of the best routines and procedures (Nonaka, 1994) *by imitating the observed behavior of one or more "masters", in a community of practice* (Nooteboom, 1999).

In other words, knowledge creation takes place in a social context of firms; the cluster environment is the place where entrepreneurs can create knowledge. *A consequence of the embodied nature of knowledge is a return to the social* (Dahl & Pedersen, 2004; Nightingale, 1998).

There are several fundamental recombining factors:

1) The system is composed of successful enterprises; the collective success spreads the *faith* in individual success and provides incentives for personal risk taking (Fukuyama, 1995); the cluster produces and reinforces networks of cooperation and trust and maintains a climate of social dialogue;
2) The entrepreneurial activity is able to transmit competencies (Florida, 2000) to all personnel (in production, finance, and marketing); the system must be composed of enterprises that use transmissible competencies (Lawson, 1999);
3) The enterprises in the system carry on business activities on a reduced scale or are divided up into discrete operations that can be carried out in productive units even of a modest size (Staber, 1998);
4) The system must be able to sustain the new activities with adequate equity and financial capital flows (Christensen, 1992);
5) The cluster generates some form of *governance* and a climate of social dialogue; internal and external stakeholders sustain the clustering processes and create and maintain an *industrial atmosphere*;
6) The cluster produces and reinforces a climate of social dialogue, with institutions which materialize those human meanings and intentions as well as reinforce them.

If the enterprises are successful and the return on equity is adequate, then the capital is available for new investments; the propensity to undertake entrepreneurial activities sustains the propensity to form companies for the raising and investment of equity.

When the recombining factors weaken, even the necessitating ones lose their intensity; when they are eliminated the macro behaviour ceases (the settlements that already exist remain, but the process leading to the genesis of new enterprises is interrupted); when they become negative the system begins to break down (closing of enterprises) or reverse itself (liquidation and transference of capital to enterprises in other areas).

Genesis

The genesis of the combinatory systems for the diffusion of entrepreneurial activity usually requires a *chance* event (Porter & Sölvell, 1998). As with any cultural change, the culture of the firm, of risk, of investment is difficult to create but, once created, difficult to eliminate.

When a class of entrepreneurs has been formed at a certain site, and the system of enterprises rewards the new business initiatives, the site is maintained and grows through endogenous genesis.

Chance can act in several ways to generate the systems of diffusion in the *entrepreneurial culture*:

- There can be an initial exogenous, chance location of firms that use local manpower, which they train by transmitting competencies;
- A firm that is already located in an area needs other forms of production to integrate its own processes both "up the line" as well as "down the line"; rather than import enterprises from outside the area, an initial spider-web of firms is endogenously formed; this sets off the system that widens the web;
- A fountain of fertility is discovered that is exploited either by firms exogenously located in the area or by those that have come about "by chance" from within; if the fertility guarantees a premium for risk, then the culture of the enterprise spreads and, when the critical mass is reached, the system is set under way.

The combinatory system of endogenous joint-location can be favored by particular *strengthening* measures, among which (Breschi & Lissoni, 2001):

- The activation of professional schools that guarantee an initial employment in a certain career;
- The availability of risk and loan capital;
- The incentive to form new enterprises through facilitating measures (e.g., young entrepreneurs);
- The creation of forms of protection against unsuccessful activity;
- The incentive for the exogenous joint-location of small enterprises;
- The creation of places for exchanging knowledge; the idea is to look at the cluster as a "ba", "as a shared place for emerging relationships" (Nonaka & Konno, 1998). In this sense the success of the cluster form could be found in the fact that it could represent a natural form of "ba".

The exogenous creation (or that by public authorities) of enterprises with the appropriate features (small-scale businesses, the need for small-scale collateral production, professional training) can artificially set off the system, on the condition that the *critical mass* of new enterprises arising *in loco* is reached, so that the necessitating and recombining factors emerge which can assure the occurrence of the micro–macro feedback.

Business dynamics: Brief conclusions

Although many authors have doubts about the possibility of clusters and districts to revitalize stagnant economies (Amin, 1993), the process of joint-location is important for local employment and welfare.

The joint-location of enterprises in a circumscribed area can be explained, when it is not completely a casual development, as the macro effect of a combinatory system.

We can arrive at some immediate conclusions regarding *exogenous* joint-location:

- Exogenous joint-location is thus based mainly on the perception by entrepreneurs, who are already located elsewhere, of possible economic differences in a given area (Busch & Reinhardt, 1998);

- Entrepreneurs who have made a careful economic calculation and whose production is not exclusively local initiate migratory processes toward areas that offer better economic conditions (especially concerning the cost of labor and capital, and the existence of logistical infrastructures and economic incentives);
- When the economic differences no longer exist we have the reverse process of moving away; to avoid this the economic advantages must be maintained within the area.

We can come to the following conclusions regarding *endogenous* joint-location:

- Endogenous joint-location arises in an area when it is possible to train people in the necessary skills and there is a climate that rewards the successful entrepreneur;
- It is equally necessary to have a *climate* of faith in the possibilities of investment and in the realization of the economic results that this entails (business atmosphere);
- In order to begin the endogenous joint-location process the presence of productive units managed with public capital could be useful, but on the condition that these units are involved in activities which are split up into discrete processes, and thus can be managed by new enterprises; or that require the integration of processes "up the line" and "down the line" which can be managed by new enterprises and, above all, can generate the necessary know-how.

A final observation: the two forms for the development of enterprises in a given area are not mutually exclusive; in fact, they are usually complementary: on the one hand, an initial exogenous settlement can start up the system of diffusion that leads to endogenous joint-location; on the other hand, the endogenous formation of entrepreneurs, which occurs by chance, not only is able to set under way the process of endogenous joint-location but, if the local public authorities provide the appropriate incentives, can also set under way the system of accumulation of enterprises, which leads to the migration in loco of other productive units.

Challenges and future research

To understand the phenomena attributable to the action of combinatory systems the combinatory system theory tries to uncover and make clear the *necessitating factors* (that cause the micro behaviour of each agent in the system) and the *recombining factors* (that produce and maintain the unit's macro behaviour). The theory then concludes that, in the presence of suitable necessitating and recombining factors, "chance" will trigger the dynamic process of the system that "by necessity" is then maintained and influences the individual behaviours;

There are many challenges regarding CST:

(i) To undertake concrete studies (questionnaires, interviews) within clusters to identify the factors of attractiveness and the performance indicators used to establish the attractiveness landscape;
(ii) To try to understand from the factors of attractiveness what are the necessitating and recombining factors that have set off the system we have observed;

(iii) To develop general and sophisticated combinatory automata that, by introducing estimates for the values of the necessitating and recombining factors, can simulate the development of systems of accumulation and of diffusion;
(iv) Apply the theory to understand the co-localisation process for systems operating in different cultural areas (the United States, Japan, India, China, Europe, etc.);
(v) To analyze how the dynamics of co-localisation can also depend on an appropriate neighborhood as well as, naturally, on the macro behaviour;
(vi) To study the process by which combinatory systems, even though they are unorganized systems (a group of houses on a hill), can organize themselves into specialized subsystems (districts, municipalities, public services) and expand their effects on elements belonging to a vaster environment

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