Rivals' identification and inter-organizational learning processes: What are the horizontal benefits of clustering?

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"Clusters, network organisation & the informal economy"

Introduction

Since knowledge has become a crucial asset in modern production systems, its creation has become a key process in order to sustain or increase competitiveness. This shift toward a knowledge-based economy has amplified the interest on geographical clustering as a key factor on inter-organizational learning.

Unfortunately, while this interest has produced a number of investigations on the structure, types and strength of collaborations within clusters, little has been said regarding rivalry both within and across clusters. However, this orientation is at odds with standard theoretical assumptions regarding the influence of localisation on both cooperation and rivalry. Moreover, it is inconsistent with several long-term observations highlighting that industrial clusters exhibit more rivalry than diffused industries.

The ensuing lack of theoretical speculation and empirical research on rivalry impairs our ability to answer important questions, such as those regarding the advantages of geographical proximity. In particular, studies of inter-organisational learning would greatly benefit from appreciating the impact of competitive relationships on the access of firms to information and their judgement of its relevance.

The approach proposed in this paper is based on simulating the spatial dynamics of inter-organizational learning between rivals by means of an agent-based model (ABM). In our implementation, the ABM is used in order to derive structures of interactions from behavioural rules of single firms. In particular, the mechanisms regulating the behaviour of firms have been deduced partly from empirical studies, partly from widely accepted theoretical speculations.

The process of the identification of rivals is crucial for the dynamics of the model. In a previous empirical study of the Italian packaging cluster we have come to the conclusion that, for each firm, rivalry regards a small number of competitors. This finding is of great importance for our model, since the number of rivals adds to geographical proximity to determine a learning framework that drives decisions to strategically persist and reorient.

In our model, firms make decisions concerning both existing and novel combinations of products and markets. In order to update beliefs over novel possibilities, Shafer's evidence theory has been employed. In particular, novel combinations of markets and products have been handled as unexpected testimonies that change current beliefs. On the other hand, beliefs over the opportunities provided by current combinations decay if they are not reinforced by additional information.

The choice between exploiting available knowledge or exploring the possibility of creating a new one is assumed to depend on local complementarities between known pieces of knowledge. On the contrary, market evaluation is supposed to depend on global complementarities. This strain introduces the possibility of interesting dynamics of the creation and diffusion of knowledge.

THEORETICAL BACKGROUND

Rivalry and the competitive advantage of firms inside geographical clusters

According to Baum and Sorenson (2003) the last few years have witnessed a rapid rise in interest about the topics of place and space in the social sciences. Economy, sociology and strategy scholars have become particularly interested in studying the implications that spatial distribution of firms has on economic growth, on network development and its consequences on knowledge diffusion, and on firms performance.

The general assumption on the concept of geographical cluster, as a spatially concentrated group of firms that compete in the same or related industries and are connected through a set of vertical and horizontal relationships (Porter, 1990; 1998a), is that localization fosters both cooperation and competition among firms, thereby supporting the competitive advantage of the cluster and of the individual firm.

Although this general assumption addresses both cooperation and competition, researchers commonly focus their attention mainly on how the localization of firms in geographical clusters enables cooperation among the firms concerned, enabling them to create and sustain competitive advantage (Lazerson & Lorenzoni, 1999a; Lipparini & Lomi, 1999; Lipparini & Sobrero, 1997; Lorenzoni & Lipparini, 1999; Saxenian, 1994, Lorenzen, 1998).

Far less attention has been paid to the impact of industrial clustering on competition, even though it is recognized as an important factor supporting the competitive advantage of geographical clusters and of the individual firms inside them. Long-term observers of industrial clusters have noted that these show more cooperation as well as more competition, compared with non-co-localized industries (Beccattini, 1990; Dei Ottati, 1994; Enright, 1991). Local competition enables both the transfer and the adoption of "best practice" within clusters, and fosters innovation. In view of this, competition should be encouraged or at least allowed within industrial agglomerations of firms (Piore & Sabel, 1984). Porter considers localization as a "booster" to domestic rivalry, which he regards as the most important determinant of the competitive advantage of a nation (Porter, 1990; Porter, Sakakibara & Takeuchi., 2000). Localization increases rivalry and the "more intense (the rivalry), the better" (Porter, 1998a: 181).

According to the industrial organization theory, rivalry involves a large number of local firms and is defined as an "all against all" fight (Piore & Sabel, 1984). Researchers of the resource-based view see an extreme division of labor within the cluster and a forced specialization. These indicators support the idea that rivalry is limited to a few competitors (Lazerson & Lorenzoni, 1999a). Both the two interpretations have been neglected by the empirical investigations.

Rivalry as cognitive and social dimension of competition

A possible explanation of the scarce relevance given to the theme of rivalry inside geographical clusters, is linked to the fact that researchers on geographical clusters have taken rivalry and competition as synonyms. In fact since the early days of economic thinking, competition and rivalry have assumed two different meanings (Scherer & Ross, 1990). On the one hand, the term competition has been used to identify firms that depend on the same resources, while rivalry has been interpreted as the individual firm's behaviour towards other firms operating in its own market. Rivalry is the conscious struggle on the part of each individual firm to establish its own supremacy in a specific market, and it is not always coincident with competition. While it is generally recognized that space represents a fundamental force affecting all social relationships, for a long time its role in understanding competition has been neglected because of its representation as an "under-socialized" phenomenon occurring among competitors largely anonymous to each other (Lomi & Larsen, 1996: 1293). In economic theory, competition has been treated as a property of market structure whose form is determined by market forces not subject to the conscious control of individual firms (Baum & Korn, 1996: 225). In organizational ecology competition occurs as largely anonymous organizations vie for a limited common pool of resources (Baum & Korn, 1996: 225). This aggregate approach to competition failed to recognize the concept of rivalry that, as the interactive market behaviour between dyads of firms (Chen & McMillan, 1992; Chen, 1996: 100), has relational nature (Baum & Korn, 1999; Korn & Baum, 1999) and depends on firm-specific competitive conditions (Baum & Korn, 1996).

Rivalry' s studies have developed following two separate approaches: a rational-economic model and a cognitive managerial model (Baldwin & Bengtsson, 2004; Chen, 1996; Farjoun & Lai, 1997). In the rational-economic model the inputs to construct similarity concepts reflect material and "objective" constructs, in the second one the inputs are cognitive concepts reflecting managers' perceptions. The cognitive approach to rivalry's study explored the role of geographical space both as explicit and implicit criterion to "market construction".

According to the cognitive approach "rivalry occurs when one firm orients toward another and considers the actions and characteristics of the other in business decisions, with the goal of achieving a commercial advantage over the other" (Porac et al., 1995:), consequently it implies mutual recognition and occurs between paired organizations each identifiable by the other (Lomi & Larsen, 1996: 1293). In this interpretation, the relevance of the cognitive aspects is evident because of the necessity for the firms involved to be aware of - and to make comparisons with – other firms. Awareness automatically introduces subjectivity, as it evokes the attentional cognitive process (Chen, 1996; Miller & Chen,

1996). "Defining rivals is not so much a matter of overt behaviour as it is one of managerial attention and discrimination" (Porac & Rosa,1996: 372).
The cognitive approach to rivalry has highlighted some important aspects aimed at improving our understanding of the process of identifying and classifying rivals.

- Rivalry has been described as a "small number" phenomenon, because of the limited number of rivals that any individual firm is usually able to recognize (Boari, Odorici & Zamarian, 2004; Clark & Montgomery, 1999; Gripsrud & Gronhaug, 1985; Lant & Baum, 1995; McNamara, Luce & Tompson, 2002; Odorici & Lomi, 2001; Porac, Thomas & Baden-Fuller, 1989; Porac, Thomas, Wilson, Paton & Kanfer, 1995; Porac & Thomas, 1994; Walker, Kapelianis & Hutt, 2005). Although firms are able to recognize and report many competitors the attention they pay to the actions of their few rivals is limited. Most studies show firms perceive on average a number of rivals ranging from 3 to 5. The perceived rivals do not exceed the number of 8 rivals. Cognitive studies ascribe this phenomenon to the cognitive limitations of the human being (Porac & Thomas, 1990, 1994; Reger & Huff, 1993; Walton, 1986), such as their limited capacity for processing information in the environment, the necessity to simplify ambiguous and excessive data (Daft & Weick, 1984), and the human need to categorize events and objects in the environment (Dutton & Jackson, 1987; Porac & Thomas, 1990; Porac & Rosa, 1996; Reger & Huff, 1993; Walton, 1986).

- Rivalry has been described as a localized phenomenon because of the geographical space's influence on the process of rivals' identification. According to several authors (Baum & Haveman, 1997; Baum & Mezias, 1992; Gripsrud & Gronhaug, 1985; Lant & Baum, 1995; Porac et al., 1995) entrepreneurs are more likely to identify nearby competitors as rivals. Two explanations in particular seem to support the notion of rivalry as a localized phenomenon. The first concerns the influence of geographical distance on observability (Cyert & March, 1963). It seems that the closest firms are more likely to be noticed and observed, largely for reasons connected with the abundance of information. Proximity increases the availability of information and the incentive to attend to it (Porac at al., 1995). This evidence suggests that the nearest competitors are more likely to become rivals. They are more noticeable given the limited attentional resources of the firm. The second reason for seeing rivalry as a localized phenomenon concerns the relationship between localization and the choice of market domain and it derives from studies in the domain of service firms or manufacturing firms with local markets (Gripsrud & Gronhaug, 1985; Lant & Baum, 1995; Porac et al., 1989; Porac & Thomas, 1994; Reger & Huff, 1993). In these selected samples the choice of location largely overlaps with the choice of market's domain, thus limiting the possibility of applying this line of reasoning to other industries.

In a study of rivalry inside the Italian geographical cluster of packaging machines Boari et al. (2004) tried to overcome this limitation i.e. the overlap between the choice of localization and the choice of market domain in service industries selecting firms belonging to manufacturing cluster exporting over 85% of their sales. Boari et al. (2004) found evidences about rivalry as small number phenomenon but not as localized phenomenon. The authors showed that, when localization and market domain do not coincide, rivals are not identified among competitors within the geographical cluster (i.e. "close competitors"). On the contrary, a majority of rivals were identified among firms located outside the cluster. Their research advanced some doubts regarding the "obvervability" explanation: it is not necessarily true that rivals are chosen among co-localized firms. Even if firms within the cluster share space with many competitors, they do not choose, on average, rivals only among them. Boari et al. (2004) suggested a more complex relationship between rivalry and geographical space investigating not only the process of rivals' identification but the process of rivals' interaction.

A complex intertwine between space and rivalry

Boari et al. (2004) advanced the idea that sharing the geographical space with competitors can help to extend managerial representations, that is to increase the amount of rivals a firm can see and to enrich it, that is to improve the quality of the ways the firm compares itself with rivals (Boari et al., 2004). So it could be that is not necessarily and exclusively to nearby competitors that firms focus their attention transforming them in rivals but that those nearby competitors that become rivals change greatly the amount and the quality of the comparison. Proximity with competitors, space *per se* such as the geographical cluster, could not limit the borders of a firm's constructed competitive environment but it could influence how many rivals a firm can see and how deep the comparison can be (Boari, Odorici & Zamarian, 2004; Boari, Espa, Odorici & Zamarian, 2004).

According to the evidences of the exploratory study of the packaging-machinery geographical cluster in Northern Italy Boari, Odorici & Zamarian (2004) advanced among the others the two following propositions:

1. Firms inside geographical cluster with local rivals identify a number of rivals larger then the one indicated by cluster firms without local rivals. Firms which identify rivals among local competitors, can observe them easier and this frees monitoring attention that can be spread over a larger number of rival firms, regardless of their location.

2. Comparison with local rivals is deeper then with rivals outside the cluster. Geographical space enlarges the number of strategic aspects firms take into consideration (Bogner & Thomas, 1993). Geographical proximity affects the complexity of entrepreneusrs' cognitive representations about rivals.

These propositions support the idea that the competitive advantage of clusters and individual firms inside clusters could be ascribed more to a different way of competing than to a more intensive competition. In particular these propositions describe the possibility of co-localization with rivals to extend and enrich managerial vision. Both these two dimensions describe a situation where geographical space could increase the variety firms perceive in the environment, improving the principal condition for the inter-organizational learning process (Nooteboom, 2004). The understanding of the relationship between geographical space and rivalry it is a necessary condition "to establish a specific theory of the cluster where learning occupies centre stage" as recommended by Malmberg and Maskell (2002: 429).

The understanding of the intertwine between geographical space and rivalry should occupy a central role in the explanations of the industry agglomeration advantage, as most geographical clusters are based on firms that are competitors and rivals one of each other. Malmberg and Maskell (2002) believe in the need of explanations about the horizontal benefits of clustering, that is about the advantage for competitors and rivals to be in the same geographical place. Because geographical distance is just one of the many possible metrics to measure proximity (Lomi, Larsen & Ackere, 2003: 242), the geographical cluster, as spatially concentrated group of competitors is becoming too much of an aggregate concept (Lomi et al., 2003). For example many authors (Boari et al., 2004; Breschi and Lissoni, 2005; Greeve, 2005) suggest that there could be many mediators between co-localization and the observability, such as inter-firm relationships. However, "whereas suppliers and customers in a vertically organized production chain need to interact with each other in order to do business, competitors do not" (Malmberg & Maskell, 2002: 439), consequently localization economies should be independent by the degree of internal interaction, at least in principle.

Consequently many scholars from different perspective are suggesting investigations where relational , strategic and geographical proximity will be treated as different context for learning (Amin and Cohendet, 2004; Giuliani and Bell, 2005; Greeve, 2005).

Learning from rivals

Among the many sources of organizational learning considered in the literature the experiences of others are important. Inter-organizational learning occurs when one organization causes a change in the capacity of another, either through experience sharing or by somewhat stimulating innovation (Ingram, 2002). Even if learning from the experience of others is considered to produce less unique outcomes compared to learning from own experience, it received great attention by researchers. Innovations occur as a result of interactions between various actors, rather than resulting from the creative act of the solitary genius (Malmberg and Power, 2005: 410).

Usually the abstract inter-organizational learning process is broken down to identify key components (Ingram, 2002: 643). Inter-organizational learning requires that a "sender" or "source" organization does something that stimulates learning in a "receiver" or "destination" organization. This learning process is influenced by the characteristics of sender and receiver organization that set respectively the frameworks of learning opportunities and the possibility of exploitation of these opportunities. Moreover learning process is influenced by the relationships between the two organizations. Usually learning from other depends on mechanisms that give access to, or generate exposure to experiences of others (Schulz, 2002). These different mechanisms have to facilitate information transmission among organizations. Greve (2005) uses the term social proximity to define all the social structures affecting learning outcomes from others.

The mechanisms that give access to, or generate exposure to experiences of others are often reduced to the presence of some kind of inter-organizational relationships, both formal and informal (Schulz, 2002). The relationships going on between sender and receiver organization allow easy information transmission. However the relationships contributing to social proximity are not only inter-organizational interactions but abstract ties that organizations themselves and/or third actors establish with a process of comparison aimed to establish the degree of similarity (Greve, 2005).

Similarity has been considered an important organizing principle by which individuals classify objects, form concepts and make generalizations (Farjoun and Lai, 1997). Similarity drives individual learning processes and consequently has been included in theories of knowledge and behaviors. At the business level too, strategic similarity has received attention as firm attempt to overcome information uncertainty. Businesses need to be able to share knowledge with each other and learn from the experiences of others in order to keep up with the changes that happen in every industry (Darr and Kurtzberg, 2000). Essential to the inter-organizational learning process is the context of understanding that can be created trough similarities. The more that one business has in common with another, particularly with respect to the problems that they face and the decisions that they make, the more likely it is that the lessons and examples of one will be of use to the other. Similarity provides a heuristic for managers to choose both when to contribute knowledge and from whom to adopt knowledge (Darr and Kurtzberg, 2000). Darr and Kurtzburg (2000) found four explanation why similarity in strategy should have more impact in knowledge transfer (similarity-attraction theory, better alignement, common problem, easly assimilation and implementation). Strategic and organizational similarities define the comparable organizations which suggest the opportunities to follow (White, 1981; White and Eccles, 1987). The observation of others' behaviors and results has not the aim to define the alternatives but to define the group of firms that, for their strategic similarities, can offer experiences useful to define their own behaviors and their own role compared to them. According to White (1981) work on the social nature of market, similarities represent a condition to market existence and working.

According to Greve (2005) strategic similarities between "receiver" and "sender" contributes to increase the relevance of the information on the "sender" organization as well as the absorptive capacity of the "receiver" organization.

Despite the relevance of similarity to the inter-organizational learning processes, learning from rivals, that is learning from firms that share organizational and strategic similarity, has been documented in few investigations (Ingram, 2002). However, most of them have considered the influence of rivals on the learning process looking for the effect of the rivals aggregation (Ingram and Baum, 1997; Aharonson, Baum and Feldman, 2004) rather then for the effect of the single dyadic relationship (Darr and Kurzburg, 2000; Henderson and Cockburn, 1996) .

MODEL DESCRIPTION

The model describes the development and exchange of knowledge between geographically clustered rivals. Its aim is to study the interplay between geographical dispersion, variety of knowledge and behavior of firms. We describe first its elements; subsequently, the processes that they enable.

Elements of the model

The model is a virtual environment populated by:

1. Actors (also called "agents, or "firms") characterized by identity, position, a knowledge base, an algorithm to identify other actors as "rivals" and a set of computational tools to handle knowledge;
2. A common knowledge, accessible to all actors.

Knowledge is assumed to be specific to particular knowledge fields. In general, actors may extend their knowledge over several fields.

Each field may span several domains, e.g.. markets, products, technologies, organizations, cultures etc. Thus, knowledge fields may be similar to one another on the domains they eventually share.

Knowledge is assumed to be context- and time-specific, to deteriorate over time and to be subject to a ceiling due to human bounded rationality. These assumptions are intentionally at odds with the concept of human capital.

The model assumes that the actors are able to develop a knowledge mass that is less or equal to a constant, conventionally set to one. Knowledge is developed in specific fields. Thus, the i-th actor has N_i knowledge fields denoted by an index $n_i = 1, 2, \ldots N_i$, each characterized by a *depth* d_n^i such that:

$$\sum_n d_n^i \leq 1 \tag{1}$$

$$\sum_i \sum_n d_n^i \leq I \tag{2}$$

where I is the number of actors.

No operations are necessarily carried out on the set of knowledge fields, denoted by Θ. Knowledge fields can only be created or destroyed upon purposeful deliberation by the actors.

The depth assigned to Θ is residual to the depths assigned to the knowledge fields and has the meaning of "anything that might happen, that the actor is currently unable to imagine" (Shafer 1976). By denoting with d_Θ^i the depth of Θ for the i-th actor, eqs. (1) and (2) become:

$$\sum_n d_n^i + d_\Theta^i = 1 \tag{3}$$

$$\sum_i \left(\sum_n d_n^i + d_\Theta^i \right) = I \tag{4}$$

The existence of knowledge fields, their intersections and inclusions is assumed to be common knowledge. Furthermore, this knowledge is not affected by physical distance.
On the contrary, the depth of particular knowledge fields is private knowledge of the actors. As an exemplification, one may speculate that all firms know that packaging machines exist and that their production is related to that of robots, but only some firms are able to produce packaging machines.

Actors may communicate this knowledge, but if they do so, depth is taxed by physical distance. On the contrary, information concerning intersection and inclusions of knowledge fields is not affected by physical distance. For instance, knowledge that the production of packaging machines is related to the production of robots is not affected by physical distance; on the contrary, the knowledge concerning how to produce packaging machines can be more easily acquired by spatially proximate competitors.

In our paper decisions about the opportunities to make some kind of change and consequently the decision to be involved in some kind of learning process depend on two elements: past performances and cognitive distance from rivals. Performance and cognitive distance determine the motivation and the capability to act, respectively.

Past performances

Past performances are considered a major explanatory variable in organizational learning theory (Cyert & March, 1963; Lenvinthal & March, 1981). However, measuring performances of changing knowledge is not a trivial task. In fact, since the outcomes of innovative activities cannot be foreseen, *ex-ante* evaluation by means of utility functions makes little sense.

An alternative route is to conceive the usefulness of a piece of knowledge as deriving from its connections with other pieces of knowledge. For instance, a possible explanation of the success of innovations is their ability to connect with other products creating new markets (Polanyi 19??). Following this interpretation, let us ascribe the performance of knowledge to its ability to bridge structural holes (Burt 19??).

Let us interpret common knowledge as a directed weighted graph, where nodes are knowledge fields, edges are intersections and their weights are values associated to these intersections. Let us stipulate that the intersection of field A with field B is characterized by two numerical values in $[0, 1]$. The first one is the ratio of the area of $A \cap B$ to the area of A. The second one is the ratio of the area of $A \cap B$ to the area of B. These values are the weights of the edges of the graph.

Given this graph, performance is measured by betweeness centrality (Barthélemy 1998):

$$g_i = \frac{1}{(n-1)(n-2)} \sum_{s \neq i \neq t} \frac{\sigma_{sit}}{\sigma_{st}} \tag{5}$$

where σ_{st} is the number of minimum paths between node *s* and node *t*, σ_{sit} is the number of minimum paths between node *s* and node *t* passing through node *i* and *n* is the number of nodes. Our model computes betweeness centrality by means of the Brandes algorithm (Brandes 2001).

According to Lenvinthal and March (1981) firms compare their performances with the average performance of their industry. For the moment, in our model performance is simply weighted over the actions undertaken in a simulation tick and compared with an exogenous standard of performance. If performance is zero because no action was undertaken during a tick, the performance value of the previous tick is maintained.

Cognitive distance and multi-market contacts

Cognitive distance between the agent and its rival measures the different way of perceive, interpret and evaluate the word due to their different paths and conditions of development (Nooteboom, 2004). This cognitive distance can be the result of the comparison of the knowledge fields of the agent against the knowledge fields of the rivals considering both knowledge content and depth. Depending on the situation the distance can be the result of the comparison of the agent with the whole set of its rivals as well as with each single rival identified. In the first case cognitive distance is the result of the comparison with the combined knowledge of the set of the identified rivals on content, correlation and depth. Cognitive distance measures two dimensions of diversity: the one associated with the number of the rivals identified and the one associated with the differences in knowledge (Nooteboom, 2004).

According to Nooteboom (2004: 4) this cognitive proximity contributes to facilitate as well as to restrict inter-organizational learning. Cognitive proximity makes inter-organizational learning easier because increases firms mutual understanding. At the same time this proximity reduces what one actor can learn of really new from the others, consequently it reduces the interest in inter-organizational learning.

Cognitive proximity is a way to measure competitive pressure because it is a measure of the market domain overlap. Consequently when cognitive proximity with their own rivals is high agent changes its domain entering in a new market.

Cognitive proximity is influenced by the geographical proximity of the agent with its rivals. Geographical distance can modify the possibility to observe the knowledge of the rivals. Looking at the business knowledge, firms can always understand what are the business knowledge fields, that is what they do, of very far rivals but they have difficulties to understand knowledge deepness, that is how they do it what they do. Firms with nearby rivals can conduct a much fine-grained comparison then with distant rivals, "just as people in a residential area simply cannot help noticing what their next-door neighbours do" (Malmberg and Maskell, 2002: 439).

To understand how firms decide to enter in a new business we consider literature on multi-market contacts. Two firms have multi-market contacts when they are engaged simultaneously in more than one distinct product and/or geographic market (Baum and Korn, 1996; Baum and Korn, 1999; Haveman and Nonemaker, 2000; Gimeno and Woo, 1999). Multi-market contacts have been studied as forbearance forces, able to reduce the reciprocal aggressiveness among rivals. In particular multi-market contacts studies established:

1) an inverted U-shaped relationship between firm's rate of entry and exit into a competitor's market and the level of multi-market contact in the competitor dyad. Rivals entry escalates until the level of multi-market contacts between firms lead them to a mutual recognition (Baum and Korn, 1999).
2) rivals that meet each other in multiple markets refrain from competitive interaction with one another and, instead, engage in intense rivalry toward other rivals with whom they have little or no multi-market contacts because they do not register such a competitor either as capable of retaliation or as a possible partner with which it can reach a forbearance agreement (Baum and Korn, 1999)

We suppose that actors average the knowledge of their competitors so as to stress coherent elements and distress the uncoherent ones. We use the Dempster-Shafer rule (Shafer 1976) to reproduce the combination of rivals' knowledge into a coherent compound knowledge.

Given two bodies of knowledge $A = \{d_A^1, d_A^2, \dots d_A^\Theta\}$ and $B = \{d_B^1, d_B^2, \dots d_B^\Theta\}$, consisting of series of depths on knowledge fields, the combined knowledge $C = \{d_C^1, d_C^2, \dots d_C^\Theta\}$ is such that, $\forall k$:

$$d_C^k = \frac{\sum_{A_i \cap B_j = C_k} d_A^i \, d_B^j}{1 - \sum_{A_i \cap B_j = \varnothing} d_A^i \, d_B^j} \qquad (6)$$

On each single knowledge field, an actor compares the depth of the combined knowledge with the depth of its own knowledge. This amounts to measure, on each field, to what extent one is following the stream or rather tracing an original course. Note that, by using (6), cognitive distance is influenced both by the overlap of knowledge fields and by their depths.

In this version of the model, financial consideration do not enter to constrain choices by selecting particular knowledge fields. In each field, decision is made without considerations deriving from costs and limited budgets.

The actions undertaken by the actors

The actors undertake two kinds of action. The first one is the search and identification of rivals. The second one is learning and developing knowledge under the influence of rivals' knowledge.

<u>Rivals identification</u>

The first process in which agents are involved is environmental scanning for rivals' identification. According to Boari et al. (2004) firms use geographical space as a cognitive tool in scanning the competitive environment for rivals. Entrepreneurs use location as a way to retrieve information about their rivals. They tend to mention local rivals first and distant rivals later, using geographical distance as a criterion.

Actors are placed in a toroidal space. On this space, they diffuse an *appeal* which is proportional to their performance.

At each simulation step, they pick a position at a distance specified by a decreasing exponential distribution. Thus, contacting new rivals that are geographically close is much more likely than contacting new rivals that are geographically far.

The position is tried until there is either an actor that is not already entailed in the list of rivals, or until a position is found where a positive appeal emanating from some neighboring agent is recognized. In this last case, the space is explored around squares of increasing size until one or more actors are found, that are not already in the list of rivals.

In order to be regarded as a rival, an actor must have a knowledge base that, according to an aggregate index, is sufficiently similar to the knowledge base of the exploring actor. Since the knowledge of rivals might have changed due to rivals' decisions, this check is made on the list of accepted rivals as well. If an actor that was previously considered a rival changed its knowledge to an extent such that it is no longer similar to the actor, it is expunged from the list of rivals.

Both empirical observations and theoretical considerations have suggested that the number of rivals is never more than 10, and often less than five. Thus, parameters must be chosen such that the number of rivals is compatible with the empirically observed numbers.

If the number of rivals exceeds an exogenous threshold, the rivals whose knowledge base is most similar to the actor's are expunged from the list. In a future implementation, the size of rivals should also be considered.

Inter-organizational learning

Actors scan their *M* knowledge fields and the *N* knowledge fields of the compound knowledge of their rivals. For each pair (kf_m, kf_n), with $m = 1, 2, \dots M$ and $n = 1, 2, \dots N$, actors choose among a set of actions centred around the distinction between exploration and exploitation.

In general terms, exploration is the pursuit of knowledge and things that might to be know (Levinthal and March, 1993) and it requires important investments on resources difficult to reverse. According to Swaminathan and Delacroix (1991) exploration is firm answer to rivals' pressures by searching for alternative ways to sustain themselves. On the contrary, exploitation consists in the use and the development of what is already known (Levinthal and March, 1993). Exploitation is the marginal refinement in the consolidated knowledge fields.

Though the distinction between exploration and exploitation is well established in the literature, we found that a further refinement was in order. Both exploitation and exploration can be the result of original as well as imitative effort. Furthermore, actors have the possibility of exiting a particular field as well as of doing nothing.

On the whole, actors one among the following actions: original exploration, imitative exploration, original exploitation, imitative exploitation, exit and inaction:

1) *Original exploration* takes place when an actor creates an entirely novel knowledge field. In general, innovations are made by extending previous knowledge into a different domain (Nooteboom, 20??). Thus, novel fields generally have some intersections with an actor's previous fields.
2) *Imitative exploration* takes place when an actor creates a knowledge field that is novel for him, but out of imitation of a field where some of his rivals operate. If several rivals have the field to be imitated, the actor selects the rival whose knowledge on that field has the highest depth. Upon transferring, depth is taxed depending on the similarity of an actor's previous knowledge to the knowledge to be imitated.
3) *Original exploitation* takes place when an actor improves the depth of his knowledge in a particular field independently of any transfer of knowledge from rivals. No new field is created.
4) *Imitative exploitation* takes place when an actor improves his knowledge in a particular field by absorbing some knowledge from his rivals. Also in this case the actor selects the rival whose knowledge on that field has the highest depth. Upon transferring, depth is taxed depending on the similarity of an actor's previous knowledge to the knowledge to be imitated. No new field is created.
5) *Exit* occurs when an actor abandons a field. Note that this decision is defined on an actor's *M* fields whereas all previous actions were defined on $M \times N$.

6) *Inaction* is when none of the previous actions takes place. Inaction does affect knowledge in the sense that unused knowledge is forgotten. Thus, on fields where inaction is chosen, depth decreases at a specified rate. Inaction, as well as exit, is defined on an actor's *M* knowledge fields.

The above actions are selected depending on past performances and cognitive distance from rivals. Parameters must be such that inaction and exploitation are more frequent than exploration, as established by research studies on organizational and strategic change (Lant, Milliken and Batra, 1992).

Poor past performances give firms the impetus to reorient strategic actions rather then to persist on the same strategic actions (Tushman and Romanelli, 1985). Good past performances produce more inertial behaviours then poor past performances because they induce: 1) managers to believe they have gotten it right, 2) managers to interpret them as a sign that less vigilance ad less environmental scanning or search are required, 3) they assure leaders status and resources to perpetuate their power, 4) managers to attribute success to their own actions, according to attribution theory (Miller and Chen, 1994; Lant, Milliken & Batra, 1992).

Cognitive distance favours transfers of knowledge when it takes intermediate levels (Nooteboom 19??). In fact, knowledge at a too low cognitive distance might be too similar to be interesting, whereas knowledge at a too high cognitive distance is likely not to be understood. Thus, two thresholds for cognitive distance are given as exogenous parameters and for each knowledge field the actor is able to establish whether the cognitive distance with its rivals is low, intermediate, or high.

Behaviour is partly determined by attitudes that (at the time scale considered by this model) are independent of environmental influences. In particular, entrepreneurial attitudes may be unevenly distributed across actors.

In order to account for the diversity of attitudes we consider two types of actors. The first one is made of actors who only make a change by imitating rivals. These will be called *Walrasian* actors. The second one is made of actors who are able to produce original business knowledge. These will be called *Schumpeterian* actors.

Walrasian and Schumpeterian actors may exhibit different behaviour when facing the same combination of past performance and cognitive distance from rivals' knowledge. In particular, the following behavioural rules have been envisaged:

WALRASIAN ACTORS:

- **If** past performances are **poor** and **if** the cognitive distance from rivals' compound knowledge is **intermediate** → IMITATIVE EXPLORATION: the actor will try to add a new market domain, it maintains the old one because of the moderate cognitive distance that denotes a low competitive pressure. In choosing in which business to enter it will consider the rival who, in that particular field, has the highest depth.
- **If** past performances are **good** and **if** the cognitive distance from rivals' compound knowledge is **intermediate** → IMITATIVE EXPLOITATION: the actor will exploit its knowledge field trying to make improvements. These improvements derive from imitation of the rivals. Knowledge is absorbed from the rival who, in that particular field, has the highest depth.
- **If** past performances are **poor** and **if** cognitive distance from rivals' compound knowledge is **low** → EXIT: the actor will try to exit from the field because of the low cognitive distance that shows a strong competitive pressure. At the same time it is difficult to identify a new market domain where to enter.
- **If** the cognitive distance from rivals' compound knowledge is **low** the competitive pressure is high even if the actor obtained **good** performances in the past; thus, its level of attention is high. **If** the cognitive distance from rivals' compound knowledge is **high** the rivals are too different to learn

from them, so the competitive pressure is very low. **If** past performances are **good** the actors tend to relax. **If** past performances are **poor** do not have any clue of what strategy they might undertake. Thus, in all cases except the ones above → INACTION.

SCHUMPETERIAN ACTORS:

- **If** past performances are **poor** and **if** cognitive distance with rivals is **low** → EXIT and ORIGINAL EXPLORATION: the actor will try to exit from the field because of the low cognitive distance that shows a strong competitive pressure. At the same time it will try to create a new market domain. The really new business can be the result of the combination of one or more dimensions of my business with new ones or completely innovative business.
- **If** past performances are **poor** and **if** cognitive distance with rivals is **intermediate** → IMITATIVE EXPLORATION: the actor will try to add a new market domain, it maintains the old one because of the moderate cognitive distance that shows a low competitive pressure. It will enter in the market domain of the rival with which it has less in common.
- **If** past performances are **good** and **if** cognitive distance with rivals is **low** → ORIGINAL EXPLOITATION: the actor will exploit its knowledge field trying to make improvements. The low cognitive distance with rivals shows a strong competitive pressure which could affect performances in the market and at the same time reduces the possibility to learn from rivals. This kind of actor decides to make original improvements to its business knowledge.
- **If** past performances are **good** and **if** cognitive distance with rivals is **intermediate** → IMITATIVE EXPLOITATION: the actor will exploit its knowledge field trying to make improvements. These improvements derive by the imitation of the rivals. To choose the rival to copy from they will look for rivals with the same knowledge field but higher depth.
- Independently of past performances, **if** cognitive distance with rivals is **high** → INACTION: the actor does not do anything because the rivals are too distant to learn from them, because they are so distant the competitive pressure is very low.

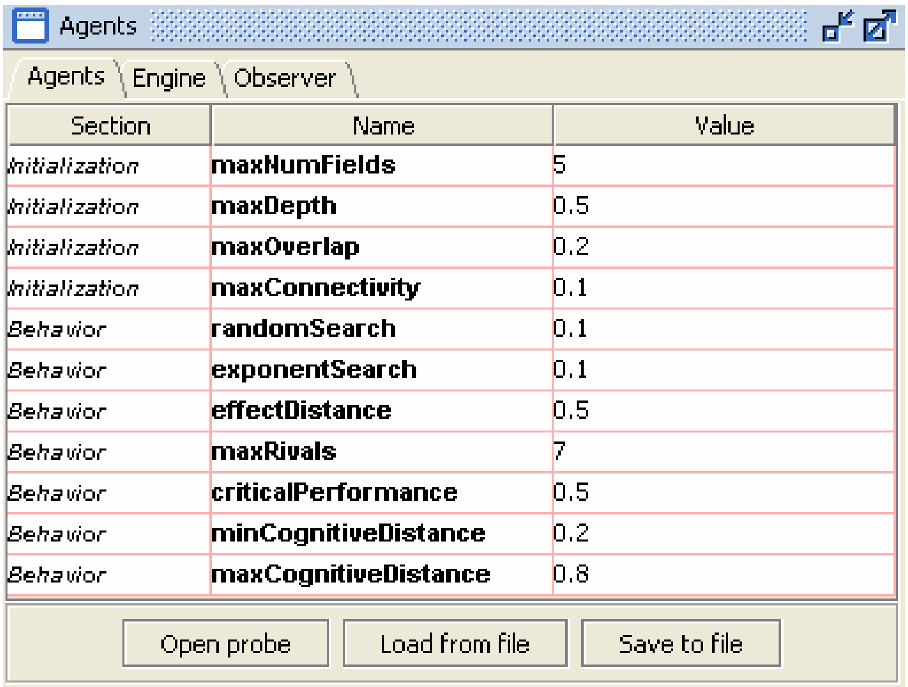
PARAMETERS AND INDICATORS

We may distinguish parameters regarding (1) the agents, (2) the engine of the simulation, and (3) the observer of the model. Figures (1), (2) and (3) illustrate the popouts for these three groups of parameters.

In their turn, the parameters that regard the agents may either concern their initialization, or their behaviour during the normal operation of the model. The entries in figure (1) are:

- (initialization) *maxNumFields*: Agents are initialised with a random number of knowledge fields drawn from a uniform distribution that extends over the interval [1, *maxNumFields*]. By definition, $maxNumFields > 0$. This parameter is also used when original exploration is made.
- (initialization) *maxDepth*: The depth of the knowledge fields with which the agents are initialised is drawn from a uniform distribution that extends over the interval (0, *maxDepth*]. By definition, $maxDepth \in [0, 1]$. This parameter is also used when original exploration is made.
- (initialization) *maxOverlap*: The extent of the overlap of novel knowledge fields with existing fields is drawn from a uniform distribution that extends over [0, *maxOverlap*]. By definition, $maxOverlap \in [0, 1]$. This parameter is also used when original exploration is made.
- (initialization) *maxConnectivity*: The fraction of existing knowledge fields that a novel field intersects is drawn from a uniform distribution that extends in the [0, *maxConnectivity*] interval. By definition, $maxConnectivity \in [0, 1]$. This parameter is also used when original exploration is made.

- (behaviour) *randomSearch*: The probability with which a search for a new rival is undertaken, independently of the number of rivals that are being considered. By definition, $randomSearch \in [0,1]$.
- (behaviour) *exponentSearch*: Rivals are searched by drawing random positions from a negative exponential distribution decreasing with distance. This parameter is the exponent of this distribution. By definition, $exponentSearch > 0$.
- (behaviour) *effectDistance*: Information concerning the depths of knowledge decreases with physical distance with a coefficient $effectDistance \in [0,1]$. When this parameter is equal to zero, physical distance has no effect. When this parameter is equal to one, depth decreases with physical distance until reaching zero when distance is equal to the diagonal of the square out of which the torus is made, where the agents are.
- (behaviour) *maxRivals*: The maximum number of rivals that can be considered by each agent. By definition, $maxRivals > 0$.
- (behaviour) *criticalPerformance*: Performance is considered to be "good" or "poor" if it is greater or equal, or less than, *criticalPerformance*. Since performance is normalized to the $[0,1]$ interval, it must be $criticalPerformance \in [0,1]$.
- (behaviour) *minCognitiveDistance*: Cognitive distance is considered "low" if it is less than *minCognitiveDistance*. If it is greater or equal than *minCognitiveDistance*, it may either be "intermediate" or "high". Since cognitive distance is measured by a depth difference weighted by an intersection value, and since both magnitudes take values in the $[0,1]$ interval, also $minCognitiveDistance \in [0,1]$.
- (behaviour) *maxCognitiveDistance*: Cognitive distance is considered "high" if it is greater than *maxCognitiveDistance*. If it is less or equal than *maxCognitiveDistance*, it may either be "intermediate" or "low". Since cognitive distance is measured by a depth difference weighted by an intersection value, and since both magnitudes take values in the $[0,1]$ interval, also $maxCognitiveDistance \in [0,1]$.



Section	Name	Value
Initialization	maxNumFields	5
Initialization	maxDepth	0.5
Initialization	maxOverlap	0.2
Initialization	maxConnectivity	0.1
Behavior	randomSearch	0.1
Behavior	exponentSearch	0.1
Behavior	effectDistance	0.5
Behavior	maxRivals	7
Behavior	criticalPerformance	0.5
Behavior	minCognitiveDistance	0.2
Behavior	maxCognitiveDistance	0.8

Figure 1

The parameters that regard the “engine” of the model concern the environment where the agents are, as well as the organisation of their interactions. As illustrated in figure (2), these parameters are grouped into those that regard the context where agents are and those that regard their location in physical space:

- (context) *diffusion*: A constant specifying the rate of diffusion of appeal in the space surrounding an agent. By definition, $diffusion > 0$.
- (context) *decay*: The rate of decay of appeal, as well as the rate of decay of depths when “inaction” is chosen and also the rate of growth of depths when “original exploitation” is carried out. By definition, $decay \in [0,1]$.
- (location) *worldXSize*: The length of the square from which the torus is fold, where the agents are. By definition, $worldXSize > 0$.
- (location) *worldYSize*: The height of the square from which the torus is fold, where the agents are. By definition, $worldYSize > 0$.
- (location) *numClusters*: The number of clusters of agents that are generated. By definition, $numClusters > 0$.
- (location) *varLocation*: The variance of the normal distribution, by which the centres of clusters are placed. By definition, $varLocation > 0$.
- (location) *spread*: The variance of the normal distribution, by which the agents are placed within each cluster. By definition, $spread > 0$.
- (location) *exponentClusterSize*: The size of clusters is regulated by a power law, specified by an exponent and a threshold. By definition, $exponentClusterSize > 0$.
- (location) *maxClusterSize*: The size of clusters is regulated by a power law, specified by an exponent and a threshold. By definition, $maxClusterSize > 0$.
- (location) *proportion*: The proportion of Schumpeters to total agents. By definition, $proportion \in [0,1]$. When *proportion* is equal to zero, all agents are Walras. When *proportion* is equal to one, all agents are Schumpeters.

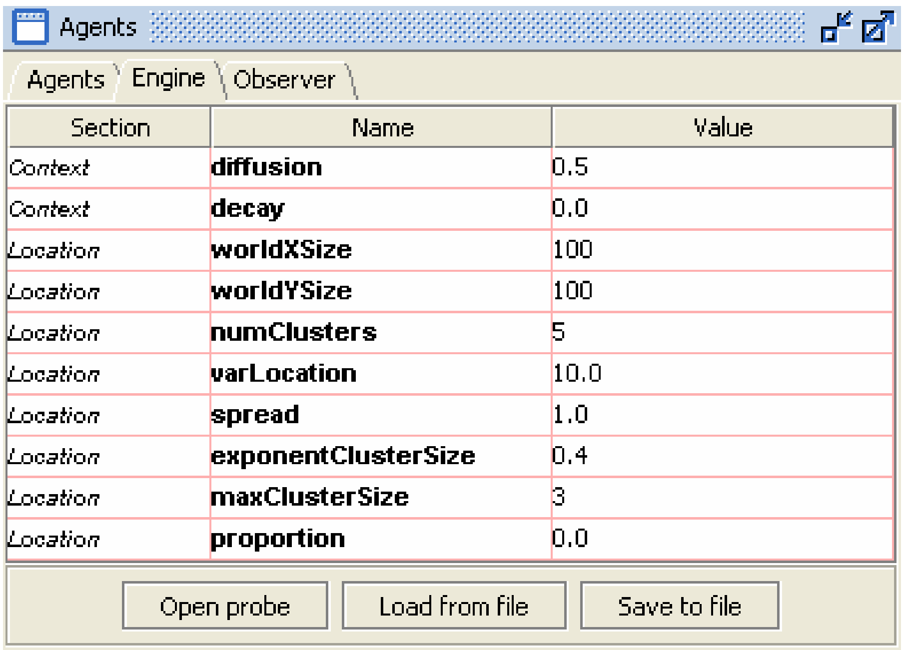


Figure 2

Finally, the parameters under the label "observer" regard the graphics by which we observe the model. They may either regard the display on which the agents are shown, or all graphical objects:

- (display) *zoom*: A zoom factor to enlarge the image where the agents are shown. By definition, $zoom \in N$.
- (all objects) *displayFrequency*: The frequency by which all graphical objects are updated. The higher this value, the faster the simulation but the less precise the graphs. By definition, $displayFrequency \in N$.

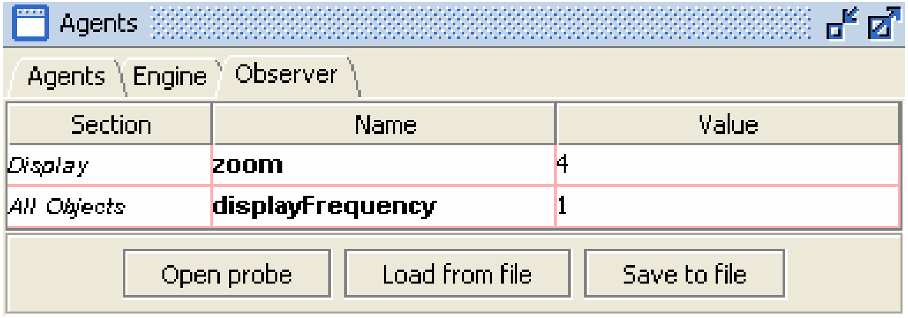


Figure 3

The graphs illustrate a certain number of indicators of the state of a simulation. Indicators can be thought of belonging to three groups of two graphs each:

1. At each simulation step, the agents carry out (1) a search for new rivals, and (2) inter-organizational learning. The first action is reported by the number of rivals and the number of new rivals at each simulation step. The second action is described by the proportions of original exploration, imitative exploration, original exploitation, imitative exploitation, exit and inaction.
2. The absorptive capacity describes the ability of a firm to recognize the value of new, external information, assimilate it, and leverage it to its economic advantage (Cohen and Levinthal, 1990). The underlying premise of absorptive capacity is that the ability of firms to recognize valuable information and make use of it largely depends on the level of prior related knowledge. We measure the absorptive capacity of the actors by means of (1) the number of their knowledge fields, and (2) the sum of the depths of their fields other than Θ. Both indicators are illustrated separately for Walrasian and Schumpeterian agents.
3. The two financial indicators of our model are (1) the performances of the agents and (2) their size, which is the integral of performance over time. Both indicators are illustrated separately for Walrasian and Schumpeterian agents.

All of the above indicators are shown as averages of the values attained by each single agent. For many of them, the minimum and maximum values attained at each simulation step are shown as well. In general, minimum and maximum values refer to different agents at each step.

INITIALISATION

The model needs to be initialised with respect to (a) the position of agents in physical space, and (b) their knowledge when the simulation is started. In this version of the model the agents do not move in physical space.

The distribution of agents on physical space attempts to reproduce some features of the growth and space distribution of firms and industries. The algorithm proceeds through the following steps:

1. A position is identified by means of a uniform probability distribution on physical space. This is the centre of the first cluster.
2. A normal distribution is created, centred on the position found at step (1), whose variance is provided by the parameter *varLocation*. The coordinates drawn from this distribution identify the centre of the second cluster.
3. The smallest and largest coordinates among the centres found so far delimitate a square. In this square, a position is drawn at random by means of a uniform probability distribution.
4. A normal distribution is created, centred on the position found at step (3), whose variance is provided by the parameter *varLocation*. The coordinates drawn from this distribution identify the centre of the next cluster.
5. Steps (3) and (4) are repeated until the coordinates of the centres of all clusters are found.
6. The number of Walras and Schumpeters in a cluster are drawn from a power law with parameters *exponentClusterSize* and *maxClusterSize*.
7. The positions of the agents in a cluster are drawn from a normal distribution with mean at the centre of the cluster and variance provided by the parameter *spread*.
8. Walras and Schumpeters are placed one at a turn, in order to avoid clusters of a homogeneous type within a cluster. The proportion of Schumpeters to Walras is set by the parameter *proportion*.
9. Steps (6), (7) and (8) are repeated for all centres identified at the end of step (5).

This algorithm has the inconvenience that the number of Walras and Schumpeters cannot be specified in advance. However, it has two important advantages:

- The placement of clusters follows a plausible mechanism for diffusion processes whereas the size of clusters depends on empirically validated distributional forms;
- It allows a wide choice of space distributions of firms and clusters with only five parameters.

Figure (4) illustrates a possible outcome of this algorithm (Walras are yellow, Schumpeters are green).

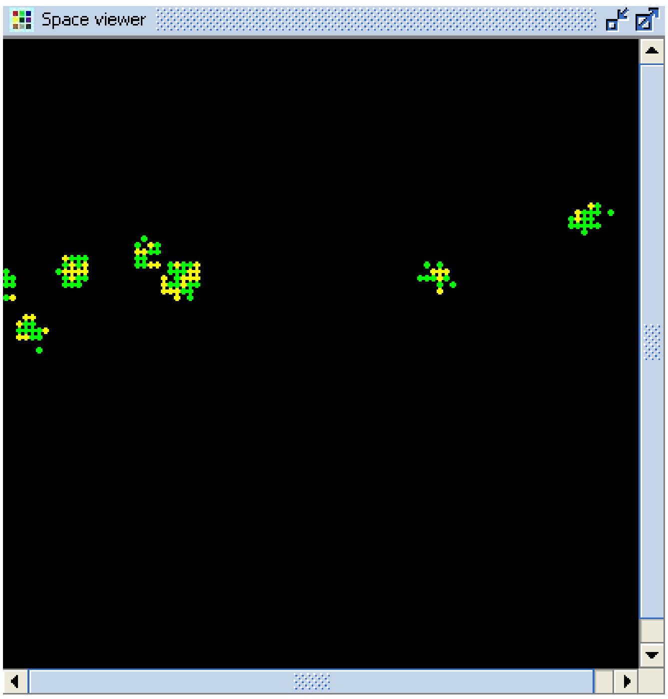


Figure 4

The initialisation of knowledge fields cannot make use of plausible assumptions regarding the structure of knowledge. In order to limit the number parameters a rather rough initialization procedure has been devised, based on uniform probability distributions.

Knowledge is initialised by means of:

- A uniform probability distribution in the interval [1, *maxNumFields*], from which the number of knowledge fields is drawn for each agent;
- A uniform probability distribution in the interval (0, *maxDepth*], from which the depth of these fields is drawn;
- A uniform probability distribution in the interval [0, *maxConnectivity*], from which the fraction of fields is drawn, that a novel field intersects.
- A uniform probability distribution in the interval [0, *maxOverlap*], from which the extent of these intersections is drawn.

RESULTS

Conclusions

This model may be extended in order to include:

- Dynamics of birth and death of firms;
- Dynamics of movements of firms and clusters in physical space.

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