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# Modeling strategic interactions between firms and local authorities The case of a biotechnology cluster

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Keywords: cluster, network, biotechnology, strategic bargainings, complex adaptative system, artificial life, firms, local authorities.

**Résumé** : L'objet de cette contribution est de mobiliser le champ de la vie artificielle pour étudier les relations stratégiques entre les firmes et les collectivités territoriales au sein d'un cluster biotechnologies. Elle montre que les techniques de vie artificielle permettent d'améliorer la compréhension des stratégies adaptatives et d'identifier des sources éventuelles de vulnérabilité des clusters. Le modèle de simulation implique des firmes et des collectivités territoriales qui négocient pour le partage d'une quasi-rente et qui développent au fil du temps des stratégies plus ou moins sophistiquées et opportunistes. Les résultats des simulations mettent en évidence que les firmes adaptent leurs stratégies de négociation en fonction de l'évaluation des gains collectifs espérés. Le modèle montre également que les collectivités territoriales interviennent dans la régulation des comportements opportunistes. De nouvelles pistes de recherche théoriques et empiriques sont développées à partir de cette métaphore d'un cluster.

**Abstract**: This paper presents artificial life as a new way of exploring strategic relations dynamics between firms and local authorities within a biotechnology cluster. It shows that artificial life offers a significant approach to understanding adaptative strategies and the potential vulnerability of clusters. The simulation model involves firms and local government administrations which negotiate to share a quasi-rent, and which develop strategies which are to a greater or lesser extent sophisticated and opportunistic. The results bring to lights that the firms adapt their bargaining strategies according to their assessment of collective gains. The model also shows that the public actors play a regulatory role against opportunism. New avenues of theoretical and empirical research are developed starting from this cluster metaphor.

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# MODELLING STRATEGIC INTERACTIONS BETWEEN FIRMS AND LOCAL AUTHORITIES

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# THE CASE OF A BIOTECHNOLOGY CLUSTER

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**Key-words** : cluster, biotechnology, strategic bargainings, complex adaptative system, artificial life, firms, local authorities.

**Abstract** : This chapter introduces artificial life as a means of exploring strategic relations dynamics between firms and local authorities within a local biotechnology cluster. It argues that artificial life, combined with a conception of bioclusters as complex adaptative systems, offers a significant approach to understanding the co-evolution of strategies and the potential vulnerability of such systems. The simulation model involves firms and local government administrations which negotiate to share a quasi-rent, and which, to this end, use strategies which are to a greater or lesser extent sophisticated or opportunistic. The results show that the firms adjust their bargaining strategies according to their assessment of gains which might be collectively generated. The results also bring to light that the local authorities play a regulatory role against opportunism and that they are the key players in local coordination. Stemming from these simulations, the authors develop promising new avenues of theoretical and empirical research.

## I. INTRODUCTION

Confronted with their tardiness, compared to the United States, the countries of Europe have put in place voluntary biotechnology development policies over the last ten years. In consequence, geographic clusters linked to healthcare activities, the environment and seed production have appeared or increased in Europe; for example the Medicon Valley on the border of Denmark and Sweden, and the Evry Génopole in France. The cluster concept is defined by Porter (1998) as a group of geographically close companies and institutions whose activites are complementary and characterised by a high degree of specialisation and technology transfer. The cluster is based on dense networks of inter-firm relations, characterised by cooperative and competitive links. This strong bond produces collective benefits, such as “quasi-rents”, owing to the operation of licences or the effects of the agglomeration (Zucker and Darby, 1997; Dyer and Singh, 1998).

While the literature on biotech clusters is centred particularly on the strong competitiveness of such innovative systems, certain studies relativise these successes by underlining coordination difficulties linked to conflicts about the sharing and redistribution of the collective benefits (Owen-Smith and Powell, 2003). These coordination flaws are linked structurally to features of biotech clusters. They present as opportunistic behaviours favoured by cross-sector cooperation-competition or by a dual-market structure (Roijakkers et al, 2005). Equally, these coordination difficulties arise from differences of interests which divide public and private players.

However, although there are many studies of the links between firms and public laboratories (Audretsch and Stephan, 1996; MacMillan et al, 2000), there are few which raise the issue of coordination difficulties involving firms and local government administrations (Chataway et al, 2004; Leroux, 2004; Rausser et al, 2000). These links are fundamental, however, given the controlled and much-debated nature of activities connected with biotechnologies. Indeed, local government authorities play an important role in local industrial policy, because they have to guarantee the ethical nature of the research undertaken. This results in highly complex negotiation strategies, as firms seek to appropriate the collective benefits by putting pressure on local authorities, while at the same time currying favour with them. Concentrating on this angle, the present chapter will focus on an analysis of negotiation strategies linking companies and local public authorities. Which negotiation strategies occur most frequently? How do these strategies develop together over time? Do they contribute to strengthening or altering the cluster’s performance? By addressing these questions, this chapter aims to offer a dynamic quantitative analysis, based on an artificial life simulation, and enabling a first evaluation of the occurrence of particular coordination mechanisms within biotech clusters.

The theoretic positioning used here is the evolutionary perspective, which is based on the analysis of complex evolving systems. This permits an understanding of the emergence of the combined properties of a system of agents from the interaction of its constituent elements (Arthur et al, 1997). The system is characterised by a great number of interconnected heterogeneous agents who choose their action according to the choices of the other participants, such that a variety of complex dynamics can be observed. The system's dynamic is sensitive to environmental disturbance. Thus it is possible to analyse its instabilities and potential vulnerability.

With this in mind, we decided on an exploratory simulation model, with a heuristic aim. The model involves firms and local government administrations which negotiate to share a quasi-rent, and which, to this end, use strategies which are to a greater or lesser extent sophisticated or opportunistic. The simulation results confirm that the negotiation strategies adopted by the players have an impact on cluster performance. The firms adjust their bargaining strategies according to their assessment of gains which might be collectively generated. The results also show that the local authorities play a regulatory role and that they are the key players in local coordination, even if the situation does not necessarily favour them at the outset.

The second part of the chapter is devoted to a review of the literature and to the propositions that underpin the model. Part III shows the model in action aiming to test these propositions. Part IV presents the results of the simulations and Part V consists of a discussion of the results and of lines of future research.

## II. TOWARDS AN EVOLUTIONARY APPROACH TO STRATEGIC BARGAININGS WITHIN BIOTECH CLUSTERS

The coordination difficulties which might call into question cluster performance are linked to conflicts about the appropriation of resources and collective rents. In this regard, an initial area examined by researchers relates to the negative impacts of the cooperation-competition duality within biotech clusters. While this duality may be a source of competitive spirit (Jorde and Teece, 1989; Gulati et al, 2000), it can, on the other hand, lead to opportunistic free-riding behaviours, which translate into unequal gaining of resources or of collective rents (Nooteboom, 1999; Stuart and Sorensen, 2003). This phenomenon occurs particularly frequently in biotech clusters because of the cross-sector (health, environment, foodprocessing) and fragmented nature of their activities, as Argyres and Liebeskind (2002) demonstrate.

A second issue raised by studies is that of coordination difficulties linked to the heterogeneity of the firms involved (Powell et al, 2005; Saviotti, 1998; Roijakkers et al, 2005). Biotech clusters are organised as a “dual market”, based on partnerships between big, international firms and small and medium enterprises (SME). Nevertheless, these partnerships, based on survival strategies, and strategies to achieve both pecuniary and information rents, lead to imbalances of power and to opportunistic behaviours. This results in instability which is sometimes “chronic” in the links between small and large firms, which can cast doubt over the performance of biotech clusters.

A third subject raised and demonstrated by research works is that of coordination flaws linked to the highly-regulated and controversial nature of innovative biotechnology activities, both public and private. First of all, a number of studies, such as those by Lawson (2004) or Sherry and Teece (2004), emphasise the issue of conflicts about property rights in relation to resources and incomes. Other studies, focused on network dynamics, discuss the notion of “partial embeddedness” between the public and private spheres. Owen-Smith and Powell (2003) show that research laboratories need to establish a strategic balance between academic and industrial priorities in order to avoid “the danger of capture by industrial interests” (p1695). Finally, some works concentrate on the role of national and local institutions (Dasgupta and David, 1994; Teece, 1996; Etzkowitz and Leydesdorff, 2000; Lehrer and Asakawa, 2004). Some of these authors are particularly interested in the controversial nature of the biotechnologies (the fight against genetically modified organisms (GMOs)…) and in public and private management problems from the viewpoint of the ethical and regulatory concerns (Chataway et al, 2004). While the role of public players in systemic risk reduction is mentioned (Dohse, 1999; Peters and Hood, 2000), it nevertheless forms the basis of no research programme.

This literature review shows that few works are devoted to the essential links between companies and local public authorities. As Chataway et al (2004) and Rausser et al (2000) say, strategic relations between firms and the public administrative bodies are crucial. Leroux (2004) shows that firms develop bargaining strategies with the aim of capturing quasi-rents and influencing the decisions of the local public authorities, who are guarantors of the general, public interest. The evolution trajectories of the clusters depend on this, in a technological and partnership context which is constantly changing. In this study, we develop the first exploratory research to clarify these strategic links, with the objective of better understanding their nature, and of measuring their impact on the performance of the cluster. We will consider more precisely the bargaining strategies aimed at gaining the collective benefits. What kind of bargaining strategies do the firms and the local authorities take part in? How do the players adapt their strategies according to environmental change? Do these bargaining strategies play a part in the medium and long-term performance of the cluster?

The theoretic position chosen in order to answer these questions is evolutionary theory, based on the complex adaptive systems paradigm (Arthur et al, 1997; Kirman, 1997). Evolutionary theory, linked to cognitive economics (Simon, 1955; Walliser, 2000), is based on the following principles that challenge the fiction of the representative agent and limited rationality: 1) *heterogeneity* of agents; 2) *variability* that corresponds to the endogenous capacity of the system to produce new directions depending on behavioural mutations of the agents involved; 3) *path dependency* that results from learning effects and auto-reinforcement mechanisms leading to the irreversibility of the cluster's evolutionary dynamics; 4) *inductive learning*, according to which agents are individually involved in a cognitive process of problem-solving. They learn and adapt themselves with experience in a complex evolving system; 5) *situated rationality* inspired by Simon's (1955) work and taken up by Walliser (2000), concerning a rationality that is constructed through interaction and that involves rationally adaptive agents.

From this evolutionary perspective, the biotech cluster can be understood as a complex evolving system (Janszen and Degenaars, 1998). The significance of this approach is that it takes into account internal mechanisms of decision-making and adaptation, both in their development and in their reversal. This is important because, built on a wide variety of partnerships and strategies linking private and public players, the cluster's evolution trajectory can prove to be unstable, and even chaotic in certain cases (Luukkonen, 2005; Mangematin et al, 2003; Stuart and Sorensen, 2003..). Now, following a series of research questions about evolution trajectories (Mangematin et al, 2003) and the strategic importance of coordination (Chataway et al, 2004; Rausser et al, 2000; Etzkowitz and Leydersdorff, 2000..), this approach allows a dynamic analysis of the different bargaining strategies used depending on environmental uncertainty. As stylised facts show (Leroux, 2004), local authorities tend to make concessions when faced with relocation or closure threats, by opportunistic firms which are trying to appropriate the quasi-rents generated by the cluster. The question, then, is whether the firms' strategies depend on the certain or uncertain nature of the future collective rent. Three propositions can be put forward in order to look for answers to this question. The first seeks to test agents' behaviour when the quasi-rents are known. If we distinguish firms' motivations, which satisfy their private interests, and the local authorities' motivations, which satisfy the general interest, then the aim is to grasp the nature of the evolution of the sharing mechanisms when there is no uncertainty about gains.

<u>Proposition 1</u> *: when the quasi-rents are known and stable over time, firms tend to develop opportunistic negotiation strategies in order to appropriate them. Firms benefit from concessions granted by local authorities in response to the firms' threats of possible disengagement.*

The second proposition aims to test the development of agents' sharing strategies when there is an uncertainty on the amount of the quasi-rents, and they have to estimate it. While stylised facts show bargaining strategies to be prudently less opportunistic in an uncertain situation (Leroux, 2004), it is necessary to find the determining factors in agents' sensitivity to environmental disturbance.

<u>Proposition 2</u> *: when there is uncertainty over the value of quasi-rents, firms develop less opportunistic behaviours, while still benefitting from the concessions made by the local authorities.*

The aim of the third proposition is to test the behaviour of the local authorities when the amount of the quasi-rents is uncertain and firms' opportunism can call the performance of the cluster into question. A further aspect is to discover if authorities have the capacity to reduce systemic risk.

<u>Proposition 3</u> *: when the value of the quasi-rents is uncertain and opportunistic behaviour could contribute to a reduction in cluster performance, the local authorities overcome the harmful effects of the firms' strategies.*

In order to test these three propositions, we develop an artificial life simulation based on a genetic algorithm involving mutation and crossover operators (Holland, 1975; Goldberg, 1989). The significance of a simulation lies in the endogeneous capacity of agents involved to search systematically for new behavioural rules and to include them within their own "world model" according to an adaptative process (Marney and Tarber, 2000; Vriend, 2000). The research methodology associated with this tool is a “theoretic exploratory” approach (Snow and Thomas, 1994). The objective is to explore and develop theoretic teachings by testing research propositions, in order to open the way to new research questions. The simulation consists, then, in exploring a metaphoric world which generates artefacts for analysis in a heuristic perspective.

# III. THE MODEL

## A. INTERACTION WITHIN BIOTECH CLUSTERS AND THE “STATE OF THE WORLD”

In accordance with the three given propositions, the model consists of three simulations of processes of bargaining involving firms and local government administrations. They bargain to share a collective benefit, affiliated to a quasi-rent, represented in the model by a pie. This is a strategic game under ultimatum (Ellingsen, 1997). When the two transactors involved both want to appropriate an over-large part of the pie, using opportunistic means, the negotiation fails. So two kinds of transactors take part in the model, as a “state of the world”.

Firms are modelled as “obstinate agents” (Obs) whose demands are independent of those of the adversaries. As they participate in the cluster’s performance they want to appropriate the part of the pie that they fixed themselves depending on their profitability objectives. Some of them expect a large part (more than 50 %) whereas others expect a less significant part (less than 50 %). The part expected also depends on the more or less powerful and opportunistic behaviors adopted by these firms.

Local authorities are modelled as “sophisticated agents” (Soph) which adapt their demand to that hoped for by their adversaries rather than gain nothing. As they answer for the “general interest”, they adapt themselves to the firms’ expectations. The stake here is to fix firms within the cluster, to avoid relocations, to stimulate research-innovation links and territorial performance. So they are under firms’ ultimatum because the latter sometimes make relocation or employment threats to gain advantages. However, when two local authorities bargain together, they share the pie in a 50/50 proportion with respect to the “general interest” and to their common stake - local development and performance.

## B. DEMAND DETERMINATION

### 1. Firms' demands

The obstinate firm's demand $d_i$ is broken down into two components, the size of the pie expected and the portion demanded. Thus :

$$d_i = \text{expected size of the pie (teg)} * \text{demanded portion (i)}$$

with

T : the real size of the pie

$teg \in [0,TG]$, minimum value and maximum value of teg

$i \in I \subset [0,1]$, I set of portions demanded

of which

$d_i \in D \subset [0,TG]$, D finite set of possible demands.

The strategy $d_i$ with $i = 0.5$ is called a "fair strategy". Any strategy for which $i > 0.5$ is called a "greedy strategy". And the other strategies for which $i < 0.5$ are called modest strategies.

### 2. Local government demands

Local authorities, whose strategies we called r, are supposed to identify the adversary's strategy and adapt their demand to that expected by the adversary. Consequently, when an authority bargains with a firm whose demand is $d_i$, it demands :

$$r = teg_r - d_i$$

Nevertheless, local authorities can also risk a failure situation if they overestimate the size of the pie. So the set of possible strategies is $S = D \cup \{r\}$, with $d_i$ the obstinate demand and r the sophisticated demand.

## C. PAY-OFF FUNCTION

If firm i asks for $d_i$ and firm j asks for $d_j$, then firm i receives the following pay-off :

$$\Pi_{ij} = \begin{cases} d_i \text{ if } d_i + d_j \leq T \\ 0 \text{ if not} \end{cases}$$

If the total of $d_i$ and $d_j$ is greater than the real size of the pie T, then the bargaining has failed and neither firm obtains any gain. The surpluses are not redistributed and are considered as lost.

A local authority that negotiates with a firm thus obtains :

$$\Pi_{ri} = teg_r - d_i \text{ if } teg_r \leq T \text{ et } d_i \leq T$$

And when two authorities meet, they obtain :

$$\Pi_{r1r2} = \frac{teg_{r1}}{2} \text{ if } \frac{teg_{r1} + teg_{r2}}{2} \leq T$$

So the following pay-off matrix is obtained:

| | Obstinate $d_i$ | Sophisticated r1 |
|---|---|---|
| Obstinate $d_j$ | $d_i$<br>$d_j$ | $teg_{r1} - d_j$<br>$d_j$ |
| Sophisticated r2 | $d_i$<br>$teg_{r2} - d_i$ | $teg_{r1} / 2$<br>$teg_{r2} / 2$ |

Table 1. The pay-off matrix

## D. SIMULATIONS

### 1. Implementation of the genetic algorithm

Each agent is determined by its "genotype", broken down into two components: its strategy and the expected size of the pie. The obstinate population (firms) is divided into seven profiles which correspond to seven discrete intervals between 0 and 100[1]. Each profile has been arbitrarily fixed and corresponds to the portion demanded[2].

[1] The discrete intervals allow precise statistical evaluation of the results.
[2] The choice of 7 profiles is sufficiently high to be representative of the principal large categories of possible demands, while guaranteeing legible results on a histogram.

| | | |
|---|---|---|
| Obs 7 | Firms whose demand is 7 % | Modest |
| Obs 21 | Firms whose demand is 21 % | |
| Obs 35 | Firms whose demand is 35 % | |
| Obs 50 | Firms whose demand is 50 % | Fair |
| Obs 64 | Firms whose demand is 64 % | Greedy |
| Obs 78 | Firms whose demand is 78 % | |
| Obs 92 | Firms whose demand is 92 % | |

Table 2. The seven obstinate profiles

The simulations[3] are based on the following parameters : the initial size of the pie is 1; the pie can vary according to the interval [0.1 : 2.0]; the number of agents within the population is 1000; the mutation rate is 10 %; the crossover rate is 50 %; the initial distribution of the different populations involved at the start of the game is 12.5 %. The choice of these parameters is the result of a compromise between keeping a selective pressure on the population in order to ensure algorithm convergence, and maintaining genetic diversity in the population to avoid a too rapid convergence (Bäck,1994 ; Schoenauer and Sebag, 1996)[4]. In a cluster, agents do not systematically bargain with the whole population, but only with some agents when necessary. Consequently, this constraint has been introduced into the model. At each bargaining an agent bargains with a representative sample of 10 % of the whole population. Each agent is next assessed according to the gains he can generate. Each simulation was carried out 1000 times.

## 2. Relationship proximity

The model introduces a "relationship proximity" linking some agents within this artificial world. Although firms and local authorities can bargain with every agent within the cluster (*notation step*), they exchange information on the pie size only with partners that they have noticed adopting the same strategy as them during the bargaining phase (*crossover step*). Consequently, if certain agents are not able to recognize at the outset the strategy of their

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[3] Each simulation is performed according to the following steps : 1) *Initialisation* : random or deliberate choice of strategies; 2) *Notation* : bargaining process and notation, ie assessment of each agent according to the gains he can generate; 3) *Selection* : process through which agents are chosen to be replicated, the most favored being those with the highest level of notation; 4) *Crossover* : crossover and reproduction of the most successful agents; 5) *Mutation* : random deterioration of one or several genetic characters of an agent; 6) Return to 1.

[4] Simulations have been tested with mutation rates varying from 0 % to 15 %. When the mutation rate is less than 5 % the percentage of algorithm errors is more than 10 % and distorts the analysis of the results. At 15 %, the mutation rate becomes destructive and does not match the propositions' realism, favouring the greediest profiles.

adversary, they are nevertheless in a position to know it at the end of the bargaining process. So an internally-generated, close relationship occurs which links agents in a common, mutual, self-protection strategy. This strategy enables the selective exchange of information on the pie size between agents that have the same strategic approach.

## 3. Simulation S1 : the size of the pie is known and does not change

In this first simulation, we test proposition 1. The size of the pie is T = 1 and does not change during the bargaining. Using a simulation enables step by step observation of the strategies adopted by the agents involved, and of the changes of direction possible over 500 periods.

## 4. Simulation S2 : the size of the pie is unknown

In this second simulation, we test proposition 2. Uncertainty is introduced into the bargaining game. The pie size is not known and the agents have to try to estimate it. The size of the pie is fixed at T = 1. Here, firms and local authorities are endowed with an endogeneous capacity to modify their respective demands d. More precisely, a learning process in respect of teg, based on the use of evolutionary operators such as crossover and mutation, enables them to estimate the size of the pie. Each agent has the capacity to assess the expected size of the pie (teg), and each new assessment leads to a changed demand d. The possibility of failure is higher because agents can tend to overestimate or underestimate the size of the pie during the evaluation process.

## 5. Simulation S3 : the size of the pie varies depending on the behaviours of the agents involved

In this third simulation, we test proposition 3. The pie size becomes variable and represents the performance of the cluster. The more firms and local authorities choose opportunistic strategies leading to the failure of negotiations, the greater the negative impact on the global performance of the cluster and thus on its viability over time (the size of the pie decreases). On the other hand, the more the agents choose strategies supporting the success of negotiations (as concessions, or fair vs modest strategies), the more positive the impact on the global performance of the cluster (the size of the pie increases). So we need to observe how the different strategies develop under these conditions and to see whether the local public authorities manage to get around the firms’ opportunism.

Technically, a parameter of influence k, here affects the real size T of the pie. If at the preceding step (n-1) the number of successful bargainings is higher than the number of failures, then the size of the pie increases by 0.01. In the opposite case, it decreases by 0.01. The choice of this parameter k = 0.01 is arbitrary and fixed at a low level. Its purpose is to illustrate that bargaining failure influences the cluster performance but in a non-radical way; it will not induce a major economic crisis or bring about the closure of a company which is a major source of orders. In these last two cases, the performance of the cluster can be radically disrupted, which is not our case here.

# IV. RESULTS

## A. SIMULATION S1

The simulations show that bargaining behaviours evolve in two distinct phases. First, local authorities making concessions are more important than the other transactors during the first twenty generations. During these periods, bargaining leads mainly to an equal share of the pie (50/50). Second, this superior tier of local authorities which make concessions then contributes to the emergence of the greediest firms, which demand 92 % of the pie, and a smaller proportion of firms which demand 78 % of the pie.

So it is important to note that in the medium and long terms bargaining is stabilized around a majority of greedy firms whose existence is maintained by the presence of local authorities making concessions. Without uncertainty on the pie size, the greediest firms take advantage of the situation. We can further assert that the local authorities play a distributive role, albeit neither directly nor deliberately, since by making concessions they contribute to enabling the greediest firms to gain quasi-rents to the detriment of the modest and fair firms. Without local authorities making concessions, then, the greediest firms could not take advantage of the situation.

This simulation validates proposition 1. When quasi-rents are known and stable over time, firms' behaviour is very opportunistic, and they make use of concession-giving local authorities.

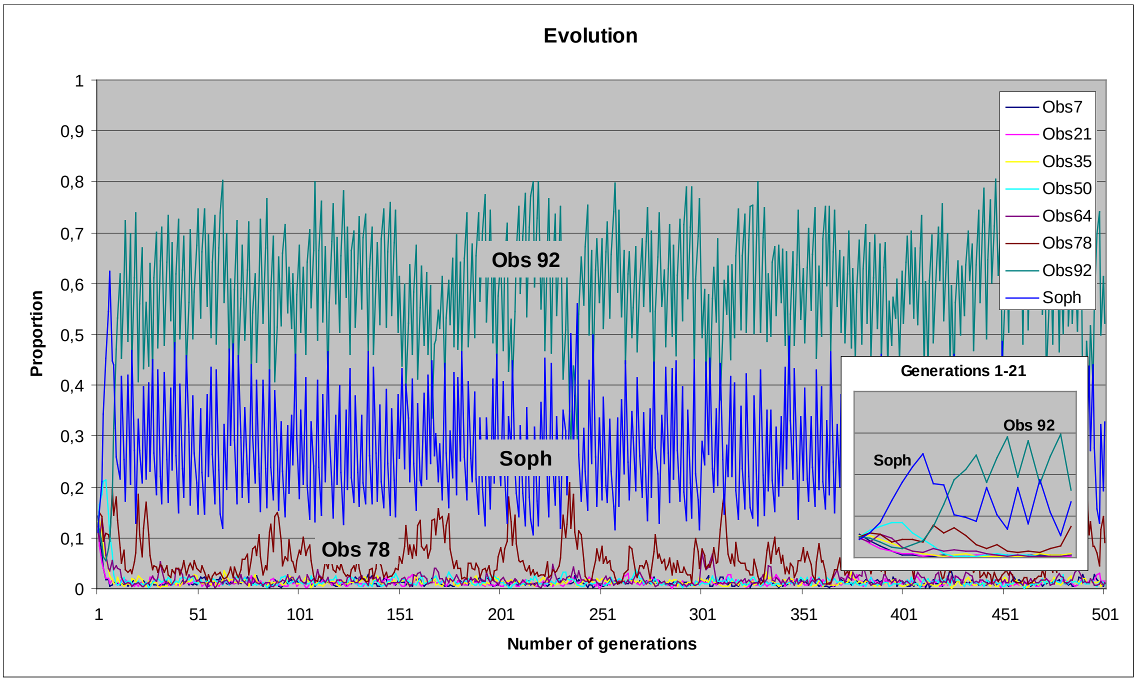



Figure 1. Simulation S1[5]

## B. SIMULATION S2

After a thousand tests, the results show a variety of possible outcomes :

- In 46.20 % of cases, the bargaining is stabilized around the greediest firms, whose demand is for 92 %, and the local authorities. The existence of these firms in the game is maintained by the presence of these public authorities, as in simulation S1.
- In 29.6 % of cases, the bargaining is stabilized around firms demanding either 78 % or 64 %, and the local institutions.
- In 22.4 % of cases, the bargaining is stabilized around the fair firms, whose demand is 50 % of the pie, and the local institutions.
- In 1 % of cases, the bargaining is stabilized around the modest firms which demand less than 35 % of the pie, and the fair firms. In these very rare cases, local public authorities are missing.
- The last 0.8 % consists of errors or accidents in the evolutionary process which sometimes occur.

[5] The abscissa represents the successive generations or periods of bargaining. The Y-axis represents the proportion of each population within the total population.

So when the pie size is unknown, results can be very different and depend on the capacity of the agents involved to find and appropriate the right size of pie quickly. The “winners” are those who succeed in correctly estimating the size of the pie as soon as possible, and who exchange information with the most successful agents. In 46.20 % of cases, the greediest firms rapidly benefit from the very large presence of local authorities during the first forty generations. The authorities have such a significant presence because of the pie size researching process. Concessions facilitate correct evaluations; the low demands of modest and fair firms contribute as well to this, and help to avoid failure. In other cases prudent and fair strategies are prioritized, such as the downward revision of demands. Concessions are plentiful at the start of the period and then give way to more prudent, obstinate strategies once the size of the pie is approximately estimated. So when the pie size is unknown, the distributive role of local authorities is very high. In only 1 % of cases can modest firms survive without the local public administrations because they themselves play a distributive part. This simulation validates proposition 2. Firms develop generally less opportunistic strategies, but continue to draw benefit from concession-giving local authorities.

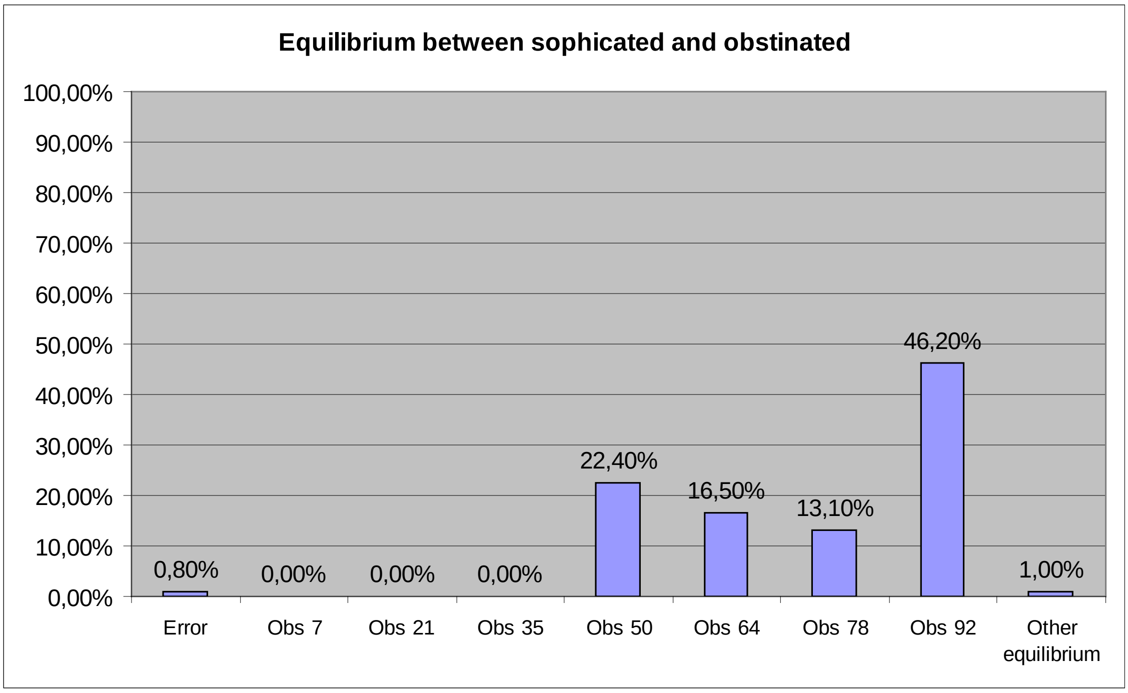



Figure 2. Average results on 1000 generations

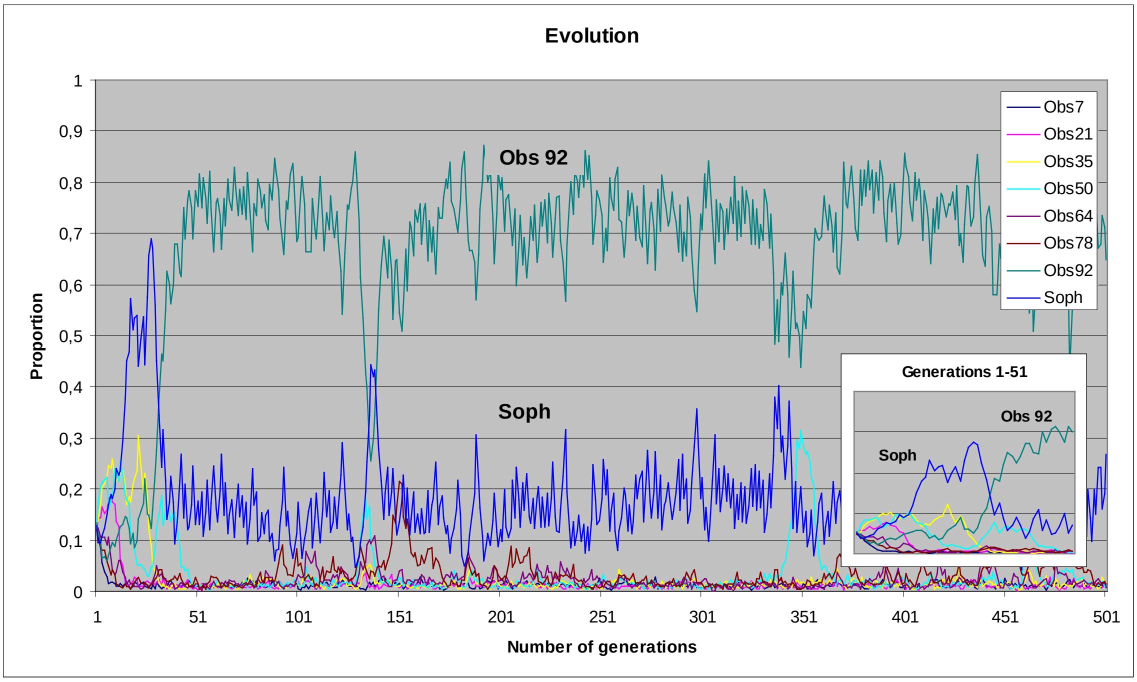
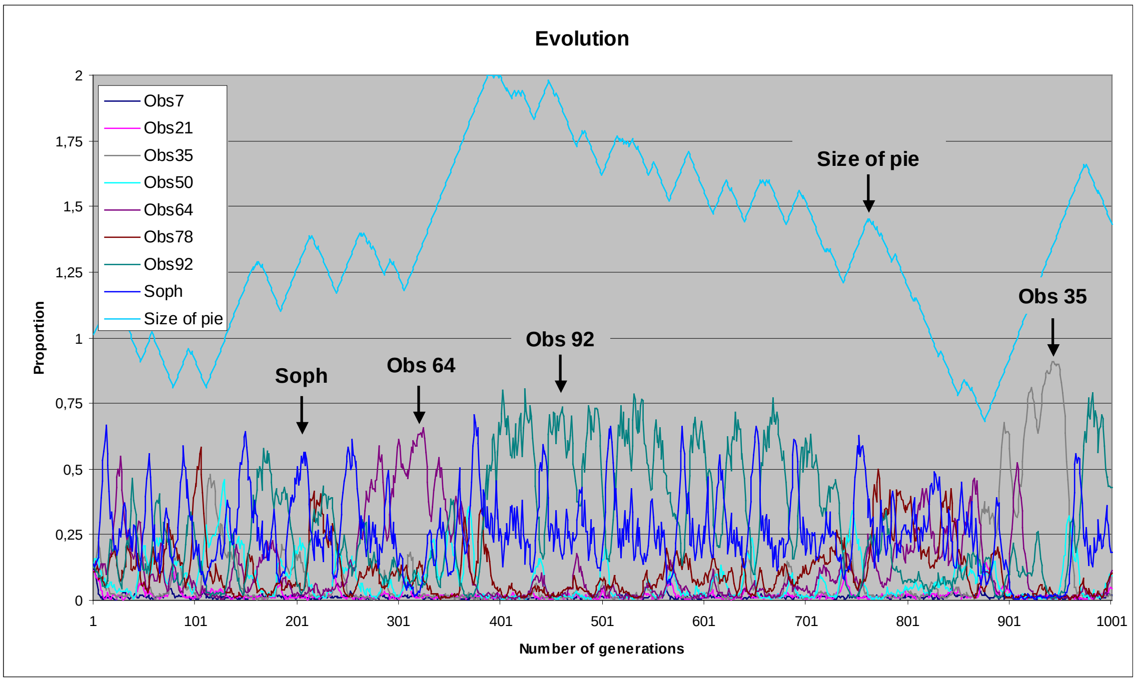



Figure 3. Simulation S2 with Obs 92

## C. SIMULATION S3

The results show that agents adapt their behaviour in order to preserve the pie size. As the bargaining game has no stability, one thousand periods are represented here. They show primarily that firms tend to exploit the bargaining process according to their evaluation of the pie size, its evolution, and the more or less significant presence of local public administrations and modest/fair firms. Thus, once the pie has reached a size near the maximum expected threshold, the move from prudent/fair/modest strategy to the greediest strategy can be observed. As an example, the periods [275 : 375] are characterized by a strong presence of the prudent firms whose demand is 64 %. During this period, prudent behaviours contribute significantly to making the pie grow towards the maximum threshold. Once the pie has reached this size, we can observe the move from the prudent 64 % strategy to the greediest 92 % strategy. This is possible because of the presence of the local authorities, which reduces conflict between the greediest agents and thus averts any radical reduction of the collective performance. So when the cluster is threatened by too much greedy behaviour, which can considerably alter its global performance, local authorities appear and play a regulatory role, allowing the pie to grow. In this way, cluster performance is maintained principally because of the role of local authorities. This simulation, then, validates proposition 3. When there is uncertainty about the quasi-rents and opportunism threatens cluster performance, the local authorities overcome the harmful effects of opportunistic behaviours.



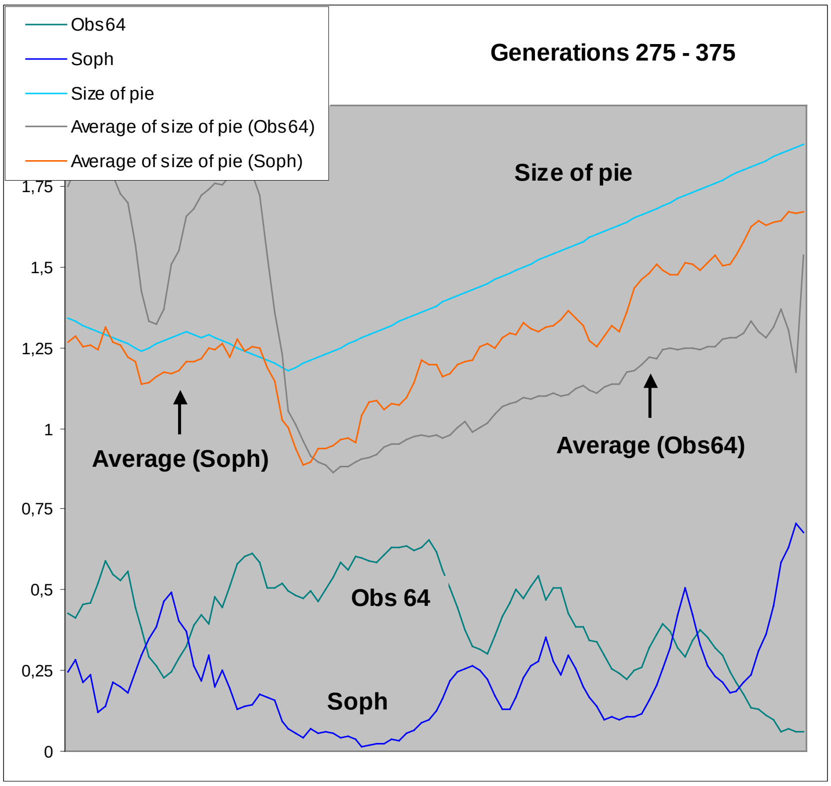




Figure 4. Simulation S3 and zoom

# V. DISCUSSION AND CONCLUSION

The results of these simulations validate our propositions and open the way to new research questions. The evolutionary approach allows a first reflexion on dynamics and phases of strategic behaviours within a biotech cluster. The simulations show that agents modulate their behaviour through time according to various parameters: the profits withdrawn during bargaining; the effects of their own behaviour on the global performance of the cluster; the uncertainty and their capacity to observe their partners' strategies and to make concessions. Supported by the assumption of " situated rationality ", the cluster can be viewed as an "emergent processual regularity" that is highly individual and differentiated owing to the different combinations of strategies. This model can then contribute to a deeper analysis focused on clusters' intrinsic characteristics (Waluszewski, 2004; Carbonara, 2004; Peters and Hood, 2000).

These simulations also call into question the assumption that "rivalry-cooperation" systematically produces emulation, and raise questions about the vulnerability of such local systems. As the idea of cluster vulnerability through collusion and lock-in effects is developed in the literature (Floysand and Jakobsen, 2002; Peters and Hood, 2000), so this chapter offers an analysis centred on strategic opportunistic behaviours. Artificial life simulations enable us to observe step by step how the agents "instrumentalise" their relationships and modify their strategies in a complex environment so as to appropriate benefits or to preserve collective performance. At any moment, an "accident" of system evolution, viewed as an artefact, can considerably affect the composition of the cluster. This suggests that further analysis of clusters' survival and perenniality through the strategic approach is a promising avenue for future research.

As we have argued, only a few studies develop the part played by local government in biotech clusters (Dohse, 1999). The evolutionary perspective can contribute to correcting these inconsistences and show the importance of the regulating role of local administrations, which have a power that can be said to be the "power of the weak" as developed by Schelling (1960). Without these local authorities, the cluster's performance could not be maintained. The "power of the weak" follows from the fact that they are the key players in the groupings, even if the situation (disengagement threats and concessions) is not favourable to them at the beginning. Further, this model raises one of the main ambiguities of public-private coordinations that can occur within biotech clusters (Leroux, 2004). On the one hand, they are supported by local government because of the uncertainty which can be caused by firms' behaviours (relocation and closure threats…) and by environmental evolution. On the other hand, supporting firms can in some cases contribute to the emergence of the greediest strategies and to the ousting of the less opportunist firms. A fruitful direction for further empirical analysis may be a deeper probing of the question of clusters' strategic local governance in relation to the networks strategic analysis (Powell and al., 2003; Gulati and al., 2000).

From an exploratory point of view, such a model with a heuristic aim opens new avenues of theoretic and empirical research. From a theoretical point of view, it can lead to a reflexion focused on conflict and power analysis within clusters, according to an evolutionary approach centered on the analysis of emerging rules. As part of the research carried out in the institutionalist framework (Hodgson, 1998), the analysis of micro-regularities emerging from interaction certainly brings to light the arbitral dimension of bargaining rules. They are both a constraint for collective action and the outcome of this collective action. Thus the theoretic question is about the emergence and the evolution of these rules under uncertainty, and about the links that can be established with the cluster's performance and survival. From an empirical point of view, an interesting avenue to develop would be an analysis focused on conflicts within biotech clusters, such as the nature of conflict, the different resolution processes adopted by the local actors involved and dependent on environmental constraints (market, legal regulation…), and finally their impact on the evolution system.

However, while these heuristic simulations lead towards new areas of research, their limitations, too, point to other directions for future research. The first limitation of the model is that it proposes and develops only two kinds of agents, firms on one hand and local government authorities on the other hand. So the scope needs to be enlarged, taking into account a greater diversity of agents (research laboratories, development agencies,…) and a greater diversity of exchanges (sellers-suppliers,…). Second, this model is limited to relationships developed within the cluster, so it is important to take into account a more complex environment including the embeddedness of the actors involved in complex social relations outside the cluster (relations with client companies, relations with shareholders, and European policies…) such as is developed within some earlier empirical studies (Peters and Hood, 2000; Floysand and Jakobsen, 2002). The questioning here is focused on the various levels of decision and their impact on the cluster performance and survival. The third limitation of the model is that it introduces proximity as a relational and communicative distance, but not as a geographic one. With this in mind, we now intend to introduce geographical distance such as in the studies of Brenner (2001) and Zimmermann (2002). Computing tools such as MAS (MultiAgents Systems) can also contribute to the reinforcement of the mechanisms of inductive reasoning, while introducing geographic proximity parameters. Future research may examine lock-in effects and the intrinsic vulnerability of biotech clusters by reducing these constraints.

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