We present a linear agent based model on brand competition. Each agent belongs to one of the two brands and interacts with its nearest neighbors. In the process the agent can decide to change to the other brand if the move is beneficial. The numerical simulations show that the systems always condenses into a single state when all agents belong to a single brand. We study the condensation times for different parameters of the model and the influence of different mechanisms to avoid condensation, like anti monopoly rules and brand fidelity.

Keywords: Econophysics, competition, condensation, complex systems.

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1. Introduction

During the last few years a great amount of work from the physics community has been devoted to the application of methods from statistical physics to the study of economic problems, or econophysics. A wide range of problems have been studied, for example, the shape of the distribution of price changes, theoretical models of financial markets, portfolio selection and optimization, and wealth distribution, to name just a few.

Here, our interest is the study, via Monte Carlo simulations on an agent based model, of brand competition in a bipartite market. We present a very simple “toy” model describing a situation where companies can choose one of two available brands of a certain product or service. The decision of which of the two available options will be selected by the company is based on a cost and payoff mechanism. It is assumed that the product or service has a certain cost, and the company will obtain a benefit or payoff from its use. The products are subject to technological innovation, and
this innovation can persuade a company to switch to the competing brand. We also explore the effect of anti monopolistic policies and brand fidelity.

2. The model

Consider a population of \(N\) agents that lie in a one-dimensional chain with periodic boundary conditions. Only nearest-neighbor interactions are allowed to keep the model as simple as possible. Each agent represents a company that uses some kind of tool or service of a certain brand (i.e. Apple or PC computers, Citibank or Lloyd’s financial services, etc.). It can be assumed that an agent will not switch to another brand unless something is gained with the change, for example, a company may be happy using Apple computers but, if a big improvement or technological advance in PCs enters the market, then it may have a reason to switch computer brands.

In our model, we consider that only two different brands for a product or service exist, say A and B. Agents are given initially one or the other brand at random. Now suppose that a technological advance appears in one of the two brands, for example in A. One of the agents using brand A will now have a better product, and the neighbors of this agent may also want to switch to the new improved A brand, however, this change will have an associated cost. This cost will depend on whether the neighbor is also using brand A or is using the other brand. Typically the cost of upgrading the same brand is less than the cost of changing to a different brand. It may be the case that the neighbor does not want to change because the technological improvement is too small to compensate for the cost of upgrading or changing, and it may decide to wait for another version of the product to make the change. If the neighbor decides to upgrade or change, then its own neighbor may also want to do the same, and so on, until all agents change/upgrade or one decides not to do so and the process stops. At this point a new improvement in one of the brands enters the market and the process is repeated. The simulation therefore proceeds as follows:

A set of \(N\) agents is created. Each agent is assigned at random a number that identifies the brand that is using (0 or 1). The agent has also a real number \(T\) assigned that is a measure of how new its product is. For example an agent with a Pentium 4 computer will have a higher value of \(T\) than an agent with a Pentium 2. A cost \(C\) of upgrading is defined, this cost applies when an agent wants to upgrade to a new version of the same brand. Another cost \(S\) is defined that applies when an agent wants to switch brands. Then:

1. Randomly pick one of the agents, say agent \(i\), and increase its technological level \(T\) by a random amount \(\delta\) between 0 and 1.
2. For the neighbor \(i + 1\) calculate the quantity \(z = T_i - T_{i+1} - \text{cost}\), where cost is \(C\) if agents \(i\) and \(i + 1\) use the same brand, and \(S\) if they use different brands.
3. If \(z > 0\) then the gain in technological level is greater than the cost and the agent \(i\) upgrades or changes. If \(z \leq 0\) then agent \(i\) stays with its brand and does not upgrade nor change.
(4) Repeat steps (2) and (3) for $i + 2, i + 3, \ldots$ until one of the agents has $z < 0$ in which case the avalanche of upgrading/changing stops.

(5) Repeat steps (2) to (4) for neighbor $i - 1$.

(6) One time step has finished. Return to step (1).

The repetition of the above process $N$ times constitutes one Monte Carlo simulation (MCS), and its the unit of time. Note that an agent that upgrades or switches will earn the quantity $T_i - T_{i+1}$ but it has to pay a cost $C$ or $S$. Only when this quantity is greater than the cost will the agent upgrade or switch. Therefore several time steps may be necessary until the sufficient quantity accumulates to offset the cost.

The simulation stops when all agents have the same brand. This phenomenon of condensation is observed to happen for any set of model parameters. The condensation time may be small or large, depending on those parameters, but the end result is always a single brand system. The brand that wins in the end is basically the one that, by chance, starts growing earlier, initiating a positive-feedback effect. The initial growth is generally triggered by a high technological innovation. This condensation on one of two initially equivalent brands has also been observed in previous works in economics, Ising models, and opinion dynamics.

3. Results

Condensation times depend on both the cost of upgrading $C$ and the cost of switching $S$. In Fig. 1 we show the results for condensation time as function of the switching cost. Each curve is for a different value of upgrading cost. As it can be seen, times increase for higher values of the switching cost $S$. This is expected since more time steps need to pass until the earnings are high enough to offset a high cost $S$. If we increase the upgrading cost $C$, a similar curve is obtained, only with higher times.

The upgrading cost, unlike the switching cost, has a saturation value. That is, if we increase $C$ while keeping $S$ fixed, the condensation time will stop increasing at some point. This is due to the fact that if the upgrading cost is too high compared to the switching cost, agents will prefer to switch their brand as soon as they can (when one of its neighbors begins using a different brand). This is illustrated in Fig. 2.

Since there is no preference for any of the brands, either one can dominate the market with equal probability. As we said before, the process by which one of them grows and eventually condenses is started by the formation of a cluster and the eventual growth and coagulation with other same-brand clusters.

3.1. Anti monopolistic policies

Companies can grow too big if they are left free to develop in an unregulated market. In order to prevent the formation of monopolies, several types of antitrust laws are used. In our model, we introduce a simple antitrust rule: at each Monte Carlo step, companies are counted and the upgrading cost of the larger company is increased in
proportion to its size. For example, if the number of companies using product A is larger than the number of those using B, then the upgrading cost $C$ for companies using product A is increased by a factor

$$f = 1 + k \left( \frac{N_A}{N_B} - 1 \right),$$

(1)

where $N_i$ is the number of companies using product $i$ and $k$ is a parameter that controls the intensity of the antitrust mechanism. In the above formula, $f = 1$ when $N_A = N_B$, and increases linearly as $N_A/N_B$ grows.

As it can be seen from the curves in Fig. 3, a higher value of the antitrust parameter $k$ extends the condensation time, however, it saturates at some value of $k$, as shown in the inset. When $k > 0$, agents are penalized for upgrading their brand, it becomes cheaper to switch, and this retards the condensation of the system. However, there is a point when $k$ is so high, that agents do not upgrade, they simply stay with their old technology for very long time. At this point the value of $k$ no longer affects the dynamics, and we see the saturation shown in the inset. From a practical point of view, this implies that an antitrust mechanism can be good at preventing a monopoly but, if it gets too high, it will only retard the technological innovations.

### 3.2. Brand fidelity

Another mechanism that can slow the condensation process is brand fidelity. A company that is used to a certain product will be reluctant to change for several reasons, for example, it will have to train the employees in the use of the new product or service. There may be also concerns about the quality of customer service of the new product, personal reasons, etc. All this ends up in that the company may have a certain degree of fidelity for a particular product or service. This mechanism is modeled introducing a modified switching cost:

$$S(y) = S + \frac{y}{1 + \exp(-t/10)} - \frac{y}{2},$$

(2)

where $t$ is the number of time steps that a company has been using a particular brand, and $y$ is a parameter that controls the degree of fidelity. In this way, the cost of switching brands increases with time, up to an asymptotic value $y/2$. Since as time passes it becomes increasingly costly for a company to change its brand, this mechanism implies a higher degree of fidelity for companies that have more time using a brand. Note that when $t = 0$, Eq. (2) reduces to $S(y) = S$.

Figure 4 shows the results of this mechanism. Again we see that condensation time increases with the fidelity parameter, in almost a linear fashion. The inset of the figure shows that, unlike the antitrust parameter of the previous section, the fidelity parameter can be augmented without saturation in the condensation time. Of course, the extreme case when a company is completely faithful to a brand will make the condensation time to diverge, therefore no saturation is expected in this parameter.
4. Conclusions

We have studied a model of brand competition in the simplest case of two brands and nearest-neighbor one-dimensional dynamics. It is found that the system always reaches a condensed state where a single brand dominates the market. This state is reached despite the introduction of mechanisms to avoid it, like anti-monopoly rules and fidelity to the brand behavior. These mechanisms succeed in delaying the condensation but do not prevent it. The final single-brand state cannot be avoided and the system is doomed to become a monopoly. We have cited results from other authors that show a similar behavior, even in more than one dimension. In the Sznajd model of opinion dynamics for example, condensation appears in all dimensions. Our future work will therefore extend the present model to include multi-brand and two-dimensional situations.

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Fig. 1. Condensation time is plotted against the switching cost $S$. Each curve is for a different upgrading cost $C$ which, from bottom to top are $C = 1, 2, 3, 4, 5$. Each point in the curves is averaged over at least 2500 independent realizations.

Fig. 2. Condensation time is plotted against the upgrading cost $C$. Each curve is for a different switching cost $S$ which, from bottom to top are $S = 0.0, 0.4, 0.8, 1.2, 1.4$. Each point in the curves is averaged over at least 2500 independent realizations.
Fig. 3. Condensation time against the switching cost $S$ for a fixed value of upgrading cost $C = 1$. Each curve is for a different value of the parameter $k$ which, from bottom to top are $k = 0, 0.1, 0.2, 1, 10$. The inset shows the condensation time as function of $k$ for a fixed value of $S = 6$, with the lower curve corresponds to a value of $C = 1$ and the upper curve is for $C = 2$. Each point is averaged over at least 2500 independent realizations.

Fig. 4. Condensation time against the switching cost $S$ for a fixed value of upgrading cost $C = 1$. Each curve is for a different value of the parameter $y$ which, from bottom to top are $y = 2, 5, 10, 15, 20$. The inset shows the condensation time as function of $y$ for a fixed value of $S = 6$, with the lower curve corresponds to a value of $C = 1$ and the upper curve is for $C = 2$. Each point is averaged over at least 2500 independent realizations.