SOFT COMPUTING TECHNIQUES TO MODEL THE ECONOMICS OF INCENTIVES

Marina Resta,
D.I.E.M. sez. Matematica Finanziaria, via Vivaldi 2,
16126, University of Genova, Italy
resta@economia.unige.it

Abstract.

In this paper Soft Computing Techniques (SCT) are applied in economic dynamics modeling. In particular, the topic of the economic of incentives is therein addressed, focusing on the potential of new paradigms, such as cybershares, as well as on the way SCT may be of help to properly insert them into an economic model. To this aim, a simulation where control parameters are driven by Topology Representing Networks is here presented and discussed, and some preliminary conclusions are drawn.

Keywords: Soft Computing, Topology Representing Networks, Cybershares.

I. Introduction.

Over the past decades the role of interaction arose as a fundamental issue in the simulation of social environments (in the wider sense of such expression). Such assumption suits particularly well to various fields of economic theory, such as endogenous growth theory, or any general social-economic situation, where it is necessary to deal with a number of agents with some independent decision power.

The key idea is to view at economic systems as a collection of identities, each of them evolving through learning of the value of their activities, as well as the value of partnerships. In this context, modeling dynamical aspects of collective behaviour, generated by local interactions, has gained more and more attention.

Traditionally, the solution to this problem passes through considering a set of simultaneous changes, which evolve with the whole population, so that an exhaustive dynamical description would require the assumption of a system of Partial Differential Equations (PDEs), as wide as the number N of individuals in the model. This makes, obviously, the problem intractable for larger values of N.

However, since computers have become widely available, heavy computational methods, mutated both from statistical mechanics and artificial life, have been introduced to model phase transition in economic systems.

Shell models, coupled map lattices and cellular automata (CA from now on), have appeared as suitable methods to understand basic mechanisms of phenomena under examination, building a bridge between traditional descriptions in statistic terms, and dynamical behaviour in phase space. Such methods have made possible to reproduce economic dynamics by means of some kind of discretization, where the PDEs governing the process are transformed into a set of ordinary differential equations (ODEs).

This hold particularly true for CA, which discretise both space, time, and the variables themselves, and, additionally, support the following features:

- Cells change their state according local rules;
- The same transition rules apply to all cells;
- In each period cells are updated.

CA have been extensively employed in economic modeling (see for example Sakoda Checkerboard Model [8] or, more recently, Gaylord and D’Andra [1], Hegselman [3], and many others).

Against this formalism, on the other side, there has been pointed out two basic stylised facts (see Hors and Lordon [4]). First, the excess of schematism of a situation wherein agents are faced with a binary choice has been underlined. Secondly, it has been argued that since the comprehension of CA still remains generally poor (see for recent advance Wuensche [9]), it is not possible to claim as made by several authors the capability of these models as a cornerstone, since the danger to confuse spontaneous switches, inherited in the algorithm, with endogenous ones.

On the other side, the extensive use of Artificial Intelligence paradigms such as Genetic Algorithms (GA) or their ibridisations find a criticism in the recent work of Geisendorf [2], who proved that certain results obtained in Resource Economic problems were due mostly to randomisation insight of the GA model rather than mating or crossover.

Hence, starting from this point, this paper analyses a different approach to economic systems modeling. To this aim, an economic system is monitored both in absence of trade, and at the presence of cybershares (recently introduced by Longley [6]) as incentives. The idea is (i) to exploit capabilities of Soft Computing Techniques (SCT), and Topology Representing Networks [5], [7] in particular, when they are used to drive control parameters (namely propensity to study and to work) of an economic system; (ii) to verify the impact of (flexible) neighbourhood structures in the economic modeling (iii) to suggest an earlier formalization of cybershares, which may be applied to general economic systems where internet services are not available.

The structure of this paper is as follows: section II introduces main features of the (toy) economic model therein observed, under the assumption of absence of trade. Additionally, a snapshot over simulation results is presented. Section III, starting from previous section results, introduces a possible formalisation for cybershares, and discusses implications that come. Section IV provides some conclusive remarks.
II. Toy Model Discussion.

Topology Representing Networks (TRNs) [5], [7], has been employed to drive control parameters in an economic system, whose features are briefly recalled.

According to TRN formalism, each agent of the system is embodied by a neuron, that is a cell over a two-dimensional grid.

An overlapping generation model is taken into account: the same cell is occupied by one member of each generation: the younger studies for a part of the period, and works for the remaining part. Its savings are retained and consumed by the older member in the following step.

Each neuron is represented by a varying along time 6th-uple:

\[ x = \{ v, z, q, h^*, h, u \} \]

where \( v \) and \( z \) are, respectively, the propensity to study and to invest in physical capital; \( q \) is the production output, depending on human (\( h \)) and physical capital employed, as well as by labor input. Those latter, in turn, are linear functions of \( v, z \), or both. Finally, \( h \) is human capital, \( h^* \) the average human capital in neighbouring cells (i.e. conditioning to human working level which comes from neighbour agents), and \( u \) the utility.

At each step, every individual checks his own utility against that of the best performing agent in the grid, hence modifying values of \( v, z \), (and, therefore, \( h \), and \( q \)) to make \( u \) more and more similar to that latter.

The concept of neighbourhood, crucial for the success of this task, is interpreted (thanks to features of TRNs) into two different ways:

- in spatial terms over the grid, i.e. the set of neurons surrounding the given cell, according to one of the typical features (von Neumann, Moore). Additionally the edges of the grid have been pasted together so that a flat surface is available for experimentation (see figure 1 for details).
- in spatial terms over the space of couples \( \{v,z\} \), i.e. by considering the centroids of the resulting adiacents Voronoi polygons.

\[
\begin{array}{cccccc}
1 & 2 & 3 & 4 & 5 \\
6 & 7 & 8 & 9 & 10 \\
11 & 12 & 13 & 14 & 15 \\
16 & 17 & 18 & 19 & 20 \\
21 & 22 & 23 & 24 & 25 \\
\end{array}
\]

Figure 2. Differences between Voronoi (b) and classical concept of neighbourhood (a). According to the latter, neighbourhood of cell 3 is made by 3 itself, 2,4,8, and 23. Proximity in the sense of Voronoi excludes cell 4 but adds to the remaining ones also cells 5 and 7.

This solution tempers major criticism to spatial grid approaches (see again Hors and Lordon), because proximity, in this way, may involve also cells which are not near (in the strictly sense) to the one under examination. In a certain measure, it is possible to think that latter neighbourhood solution, takes into account a “psychological” rather then geographical affinity among cells.

From this starting point, the evolution of the system (400 agents arranged into a 20x20 grid) has been monitored in terms of individuals (economic) wealth over a temporal frame of 1000 steps.

Final situation is represented in figures 3-4.
III. Modeling cybershares.

Cybershares have been recently introduced by Longley [6] in the following terms: “A cybershare is a share of stock, or a fraction of a share, sold to the public in conjunction with merchandise or services sales, or sold upon signing a contract to purchase goods or services in the future. … With this technique, the natural tendency of the rich to get richer is preserved, as the rich have more money to spend and would therefore buy more shares in conjunction with merchandise. … Yet at the same time, equity would be distributed to wider circles, because more people at or above the subsistence level would absorb shares. Therefore, the underprivileged would gain economic resources they would not otherwise have had. All parties benefit.

Longley continues: “…the current algorithm for distributing equity in group productivity is to save cash for years, until there is enough to buy shares in the group effort. Many never save enough cash and merely subsist, devoting only desultory effort to work. This structure not only makes life difficult for the poor, it perhaps stunts the growth of the stock market. If those living at a subsistence level are able to absorb some of the supply of equity, the reduction in supply might raise the value of shares that trade”.

How it is possible to render such concepts into a suitable form for simulation?

What is coming on, is an earlier proposal of solution.

The idea is quite simple. The population can be divided according to (i) its propensity to work (PW) respect on neighbours, and to (ii) its level of welfare (LW).

Since in this way people will show low or high level of both PW and LW, the following additional rule has been implemented into section II model:

“Agents with Highest Values of both PW and LW share a quote λ of their excess of LW with their poorer neighbours, beneath condition that those latter modify their propensity to work”.

The modified model has been hence monitored, using different neighbourhood shapes and amplitudes, (see Table 1 for more details) starting from the same initial conditions previously considered.

<table>
<thead>
<tr>
<th>Amplitude</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Von Neumann (cross shaped)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moore</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Neighbourhood shapes.

For sake of brevity, only results for cross-shaped neighbourhood with radius three are reported.

The results seem to confirm that the introduction of cybershares might effectively bring the system to a redistribution of equity.
Note that situation in figure 5 sensitively differs from the one in figure 4, although no other elements but the presence of cybershares have been introduced.

Also notable is the observation that although a number of people at level of subsistence remains, this percentage is reduced from the 40% in the first model to about 18% of the whole population.

IV. Conclusions.

In this paper the potential of Soft Computing Techniques, and particularly, Topology Representing Networks, has been exploited in economic dynamics modeling.

Topology Representing Networks have appeared to be a quite promising tool for the task under examination, thanks to their capabilities to reproduce neighbouring relationships.

To this purpose, a number of considerations may be drawn down.

First of all neighbourhood is a key factor for the emergence of growth and development: strongly localised conditions suffer for isolation, whilst wider proximities benefit of the effect of endogenous spanning politics.

However, the wealth (equity) of a system may be driven to assume a different distribution, by introducing proper incentives.

In this work a particular form of incentive, named cybershares has been considered, and an implementation via soft computing techniques has been suggested. Although there is need for more refining, the principle seems to run proficiently, evidencing the importance of connections among agents in the system.

References.


[2.] S. GEISENDORF, Genetic algorithms in resource economics models, a way to model rationality in resource exploitation?, draft paper.


