Competition and Cooperation in Development Regions

New England Complex Systems Institute
One-Week Intensive Course: Complex Physical, Biological and Social Systems
MIT, January 6-10, 2003
Supervisor: Prof. Yaneer Bar-Yam

Submitted by:
Andac Arikan
Hans-Peter Brunner
Jeroen Struben

NECSI One Week Intensive Course
January 6-10, 2003
Supervisor: Prof. Yaneer Bar-Yam

Competition and Cooperation in Development Regions

Andac Arikan
Hans-Peter Brunner
Jeroen Struben

I. Introduction

The companies in a region are linked to other local and non-local companies. They exchange information, goods and are financially interrelated. For example Gilbert et al. (2001) simulated interactions between large and small biotechnology firms that are competing in the open market. In their simulation, companies can form partnerships or exist in information networks. The firms must research, promote endogenous innovations, and cope with exogenous innovations. They conclude that smaller firms cannot survive without rewards from innovations but do not have the capital to market them, so the larger firms tend to survive in the long run. The smaller firms that succeed make partnerships or exist within information networks with larger firms.

Our study aims to examine the effects of interdependencies between companies on their spatial distribution. We developed and simulated a cellular automaton model that focuses on the nature of interdependencies (competitive, cooperative) and the characteristics of the environment.

II. The Model

In the model, two types of companies exist. For the sake of illustration, let us describe A companies as international firms, who seek local suppliers for their relatively high-tech, international standard production. Local firms of type B are eager to supply the A firms with labor-intensive component supplies. A firms thus attract B firms. A firms also tend to favor other non-competing A firms in their environment (a realistic assumption). B firms are in competition

The idea is to work out dynamic A and B firm interactions in two-dimensional space. For demonstrational and visual purposes we work in a 20 by 20 cell grid. The cells can assume three states: They can occupied by a firm of type A (red), type B (green), or they can be empty (state X). Firms persist and thrive in a conducive environment, they die out in an adverse environment. The attractiveness of the environment for a particular cell is primarily determined by the types of firms occupying the cells surrounding the focal cell. This relationship is determined by four “J” parameters: JAA and JAB specify how A interacts with A and with B respectively. Similarly JBA and JBB shows interactions for type B firms. The interaction range “r_g”, is defined as the 8 cells surrounding the focal cell. The model also includes four “H” parameters that assign different attractiveness values to the four quadrants of the grid. The parameter represents attractiveness of the environment due to factors independent of the interdependencies amongst firms (e.g. better geography, communication structure, living conditions, etc.). The parameter introduces a bias for particular locations..

The status of a cell at time t is determined according to the following logic:

If cell is occupied by an A type firm at time (t-1):
A stays if (# of A’s in the range r>=JAA) and (# of B’s in range r>=JAB) otherwise it vacates the cell.
If cell is occupied by a B type firm at time (t-1):
B stays if (# of A’s in the range r>=JBA) and (# of B’s in range r>=JBB) otherwise it vacates the cell.
If cell is empty at time (t-1):
It stays empty if **<**(# of A’s in the range r<JAA) or (# of B’s in range r<JAB)**>** and
<(# of A’s in the range r<JBA) and (# of B’s in range r<JBB)**>**
It is occupied by A or B based on excess over (JAA and JAB) or (JBA and JBB):

$$S_{Ai}(t) = sign[H + J_{AA} \sum_{r_{ij} < R_{AA}} S_{Aj}(t-1) + J_{AB} \sum_{r_{ij} < R_{AB}} S_{Bj}(t-1)];$$

$$S_{Bi}(t) = sign[H + J_{BB} \sum_{r_{ij} < R_{BB}} S_{Bj}(t-1) + J_{BA} \sum_{r_{ij} < R_{BA}} S_{Aj}(t-1)];$$

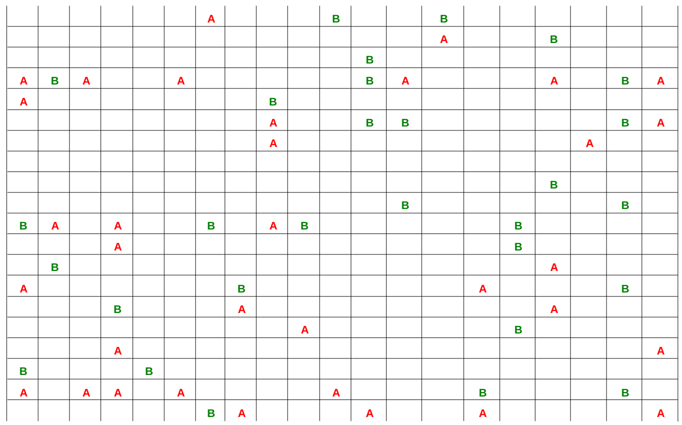
We ran the simulation with different interaction strengths (i.e. J Values). A negative “J” value represents a competitive relationship whereas a positive value represents the minimum number of firms of a particular type the focal firm needs to survive. Firms that do not have the right environment, that is the right number of neighboring cells filled by either A or B, vacate the cell. An empty cell can remain empty, or be occupied by a type A or type B firm in the next period. If interdependence conditions are satisfied for both type A and type B firms, the model makes the assignment based on the attractiveness of the environment for particular firm types as defined by the excess number of firms over the number required by the firm to survive.

III. Analysis

This sections reports examples of behavior patterns that our model generated. The following paragraphs describe the set of parameters for each experimental set and the resulting final spatial distribution after 250 iterations. Each experiment starts with a random distribution of As, Bs and empty cells across the grid.

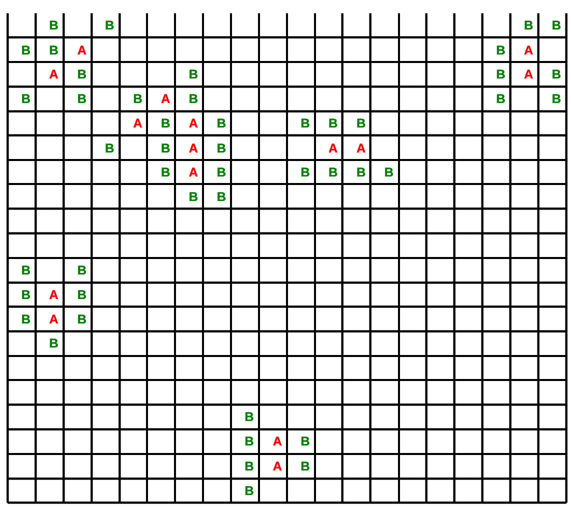
1) Intra-type competition, no cooperation: JAA=JBB=-1 JAB=JBA=0

This is our base run case. Firms can only tolerate 1 firm of their own kind around them and do not need the other type to survive. The final equilibrium is a scattered, non-orderly pattern.



2) A's depend largely on B's (JAB=4) and B's can tolerate at most 2 B 's around them (JBB=-3). (JAA=1, JBA=1)

This parameter set results in orderly patches across the grid. Initially A's start dying because of lack of B's around them. Then the B's die due to lack of A's or presence of too many B's. The following figure shows the final equilibrium state.



3) Regional bias. In this run, the upper left quadrant is specified as a more attractive area than the rest of the grid (H=1). Also firms need to be around their own kind but can tolerate only one of the opposite type (JAA=JBB=2, JAB=JBA=-1)

The following figure shows the final equilibrium state. Most firms end up at the attractive location, there is a small patch at the lower left quadrant. The distribution in the upper left quadrant is somehow orderly.

		B	B	A	B		B	A	A										
		B	A	A	B		B	A	B										
B	B	B	A	A	B		B	A	B	B									
B	A	A	A	A	B	A	B	A	A										
B	A	A	B	B	B	A	A	A	B	B									
B	A	B	A			B	B	B	A										
B	B	A	B	B	B	B	A	A	B										
	B		B			A	A	B	B										
	B				B	B	A	A	A										
						B	B	A	B										
									B										
			B		B														
		B	A	A	B														
			A	A	B														
		B	B	B															

4) Each type of firm needs its own kind to survive (JAA=JBB=2) but can only tolerate one of the opposite type (JAB=JBA=-1).

The final equilibrium state shown below is interesting because this particular set of parameters describe two types of firms that need to be around their own kind but can not tolerate the other type, so they aggregate together and create a band of empty cells at the boundary (separated “islands”).

B	B	B		A	A	A	A	A	A	A	A	A	A	A	A	A			
B	B	B		A	A	A	A	A	A	A	A	A	A	A	A	A		B	B
B	B	B					A	A	A	A	A	A	A	A	A	A		B	B
B	B	B	B	B	B			A	A	A	A	A	A	A	A	A			
B	B	B	B	B	B	B			A	A	A	A	A	A	A	A			
B	B	B	B	B	B	B	B			A	A	A	A	A	A	A		B	B
B	B	B	B	B	B	B	B	B		A	A	A	A	A	A	A		B	B
B	B	B	B	B	B	B	B	B						A	A	A			
B	B	B	B	B	B	B	B				B	B		A	A	A	A	A	A
B	B							A	A		B	B		A	A	A	A	A	A
		A	A	A	A	A	A	A	A				A	A	A	A	A	A	A
	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
B	B			A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
B	B	B	B			A	A	A	A	A	A								
B	B	B	B	B			A	A	A	A		B	B	B	B	B	B	B	B
B	B	B	B	B	B		A	A	A			B	B	B	B	B	B	B	B
B	B	B	B	B	B	B		A	A		B	B	B	B	B	B	B	B	B
B	B	B	B	B	B	B					B	B	B	B	B	B	B	B	B

IV. Conclusion

Our simulations demonstrate the effects of interdependence between firms on their spatial distribution. The model is very simple in the way it characterized interdependence (i.e. competition and cooperation) yet we were able to show emergence of orderly states from random initial distributions. Attractive development regions exogenously influence firm location. Acknowledging all the simplifications and shortcomings, the model does point towards potential for cellular automata simulations in studying dynamics in geographical distribution of economic activity.

References

Gilbert, Nigel and Andreas Pyka, Petra Ahrweiler. (2001) "Innovation Networks – A Simulation Approach." Journal of Artificial Societies and Social Simulation, vol. 4, no. 3, <http://www.soc.surrey.ac.uk/JASSS/4/3/8.html>