LSE Complexity Seminar

Complex Systems:
from concepts to business applications,
especially markets

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What can we learn from the Complex systems approach to improve our understanding of markets, firms, institutions?

Gérard Weisbuch

Laboratoire de Physique Statistique
de l'Ecole Normale Supérieure

Tél : 44 32 34 75 - Fax : 44 32 34 33 - email : weisbuch@physique.ens.fr

0.1 Emergence of Institutions

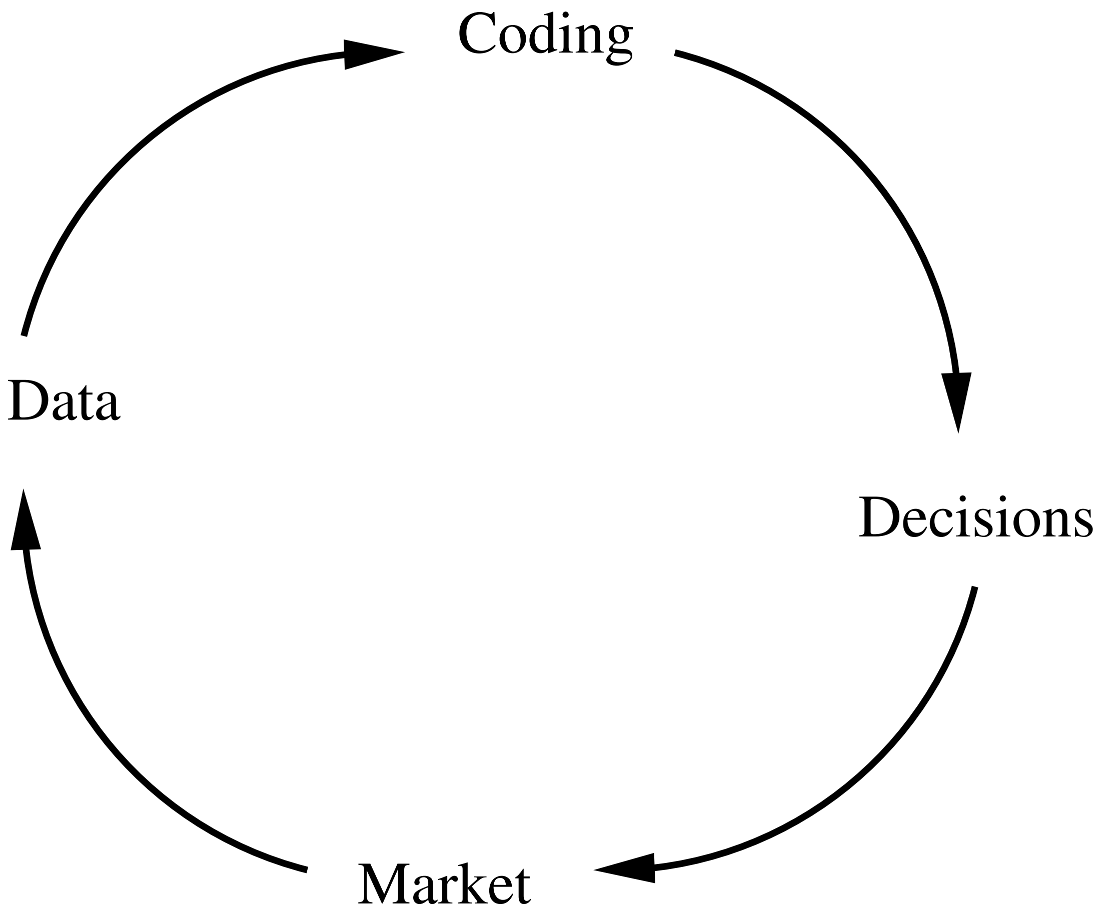
The Institutions which structure markets relate to bounded rationality

Agents only access incomplete information:

- How they search, access, code and use it in the decision process;
- How the combination of individual actions results in global changes in the market

shape the market and the related institutions.

- beliefs,
- routines,
- preferential choices,
- patterns of exchange
- ....



Entangled non-linear decision loops result in a complex dynamical system which organises in attractors i.e. for us in institutions.

Methods

Formal algebraic for the simplest versions of the model.

Multi-agent simulations.

Comparison with empirical datas.

0.2 Some issues arising on a market and examples of institutions “solving” these problemes

Issues concerning producers:

- What should I produce, in which quantity?
- Supply curve?

Issues concerning buyers

- Which brand and which producers satisfy my needs?
- Demand curve ?

Emergence of institutions “solving” these problemes:

- Brokers, wholesale, banks, unions ..
- Beliefs, conventions, rules of behaviour;
- Transaction networks;

in relation to available information, their cost, risk aversion of economic agents.

0.3 Buyers and brand choice

Two extreme possibilities

- Public information, but agents have short term memory. Choices are made by imitation of other agents choices.
- Private information , and agents with long term memory choose according to the history of their previous transactions.

In the case of public information, preferences are based on imitation:

$$U_l = u_{l0} + Jn_l, \tag{1}$$

n_l is market share of brand l.

In the case of private information, preferences are based on personnal experience of previous transaction. Coding implies learning by taking a moving average of the “utilities” of previous choices:

$$U_l(t) = (1-\gamma) \cdot U_l(t-1) + \ u_l(t), \tag{2}$$

γ is an updating coefficient which decreases older memories.

In both cases choose brand l according to preference U_l according to a probability distribution:

$$P_l = \frac{\exp(\beta U_l)}{\sum_l \exp(\beta U_l)}, \tag{3}$$

where β is the agent discrimination coefficient.

The above rule is an Exploration/Exploitation compromise.

0.4 The Mean Field Solution

Replace n_l et $u_l(t)$ in previous equations by their averages computed from the exponential probabilities

For public information:

$$n_1 - n_2 \;=\; Th[\beta \, \frac{u_{01} - u_{02} + J(n_1 - n_2)}{2}], \tag{4}$$

For private information:

$$\gamma(U_1 - U_2) - \frac{u_{01} - u_{02}}{2} = \frac{u_{01} + u_{02}}{2} \; Th[\frac{\beta(U_1 - U_2)}{2}] \tag{5}$$

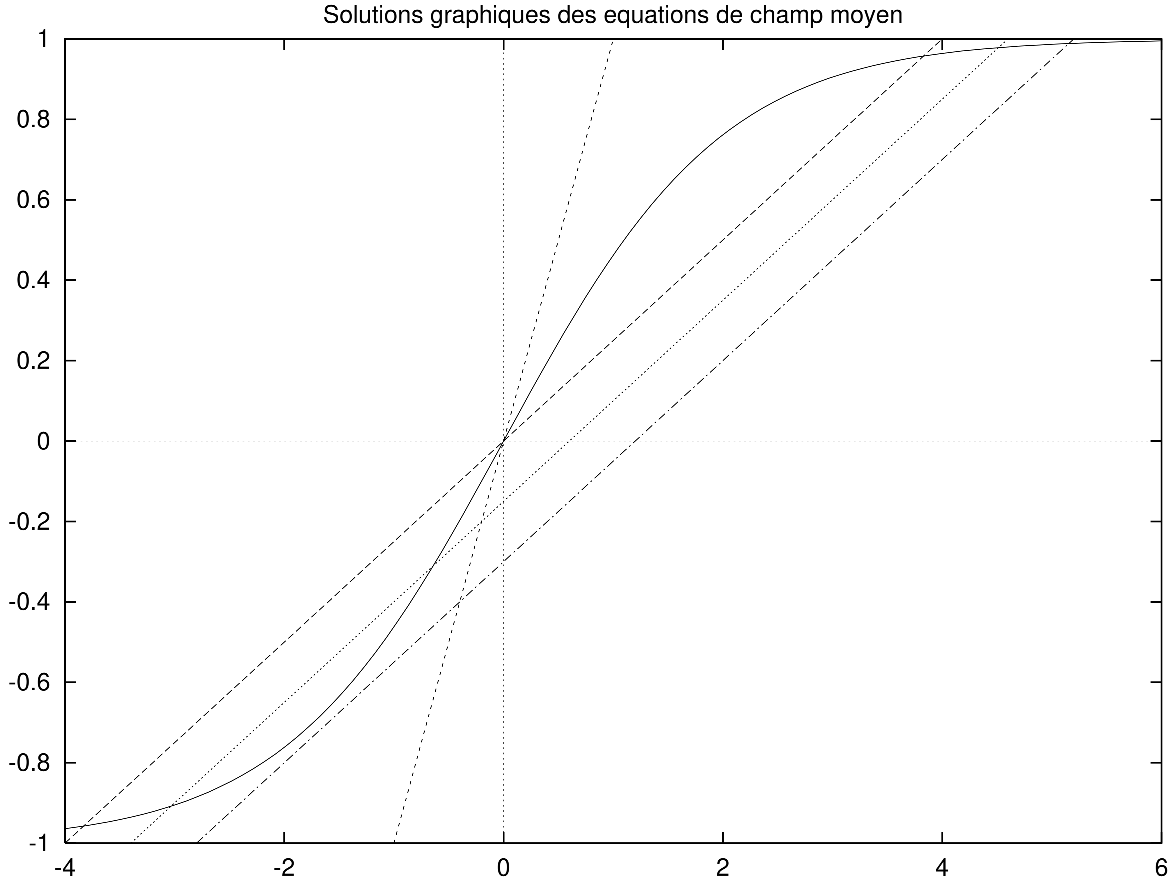
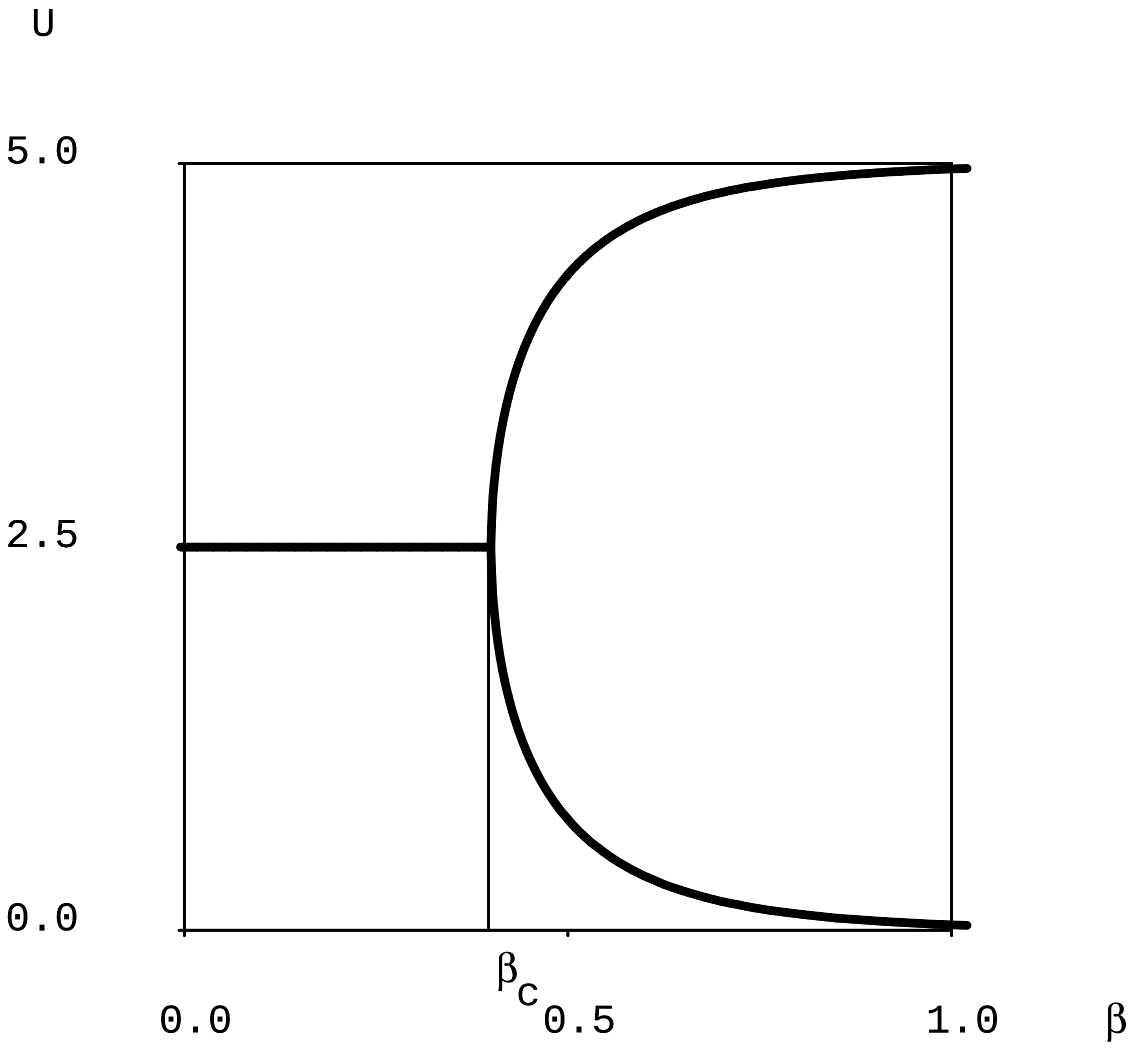


Figure 1: Graphical solution: One or three intersections are observed depending on the relative slopes and positions.

0.4.1 The Phase transition

Two disctinct dynamical regimes are observed according to β, the discrimination rate. the transition is abrupt.

- When β is small, preferences are equal or only slightly different when $u_{01} \neq u_{02}$.
- When β is large, so are the differences in preferences. One brand dominates the market, even when $u_{01} = u_{02}$). This is the organised regime. Which brand dominates depends more on history rather that intrisic brand quality.



The abrupt transition between the two regimes occurs when $\beta = \beta_c$, when both slopes are equal:

$$\beta_c = \frac{2}{J} \; resp. \; \frac{2\gamma}{u_0} \tag{6}$$

for public and private information.

Uniformity et diversity

in the organised regime

- Public information: one brand dominates, the imitation process results in uniformity of choices.

- Private information: buyers behave independantly, the memory process applies individually to each of them and no brand dominates; still each buyer is faithfull to one brand.

Role of heterogeneity in buyers characteristics

On real markets, buyers have different characteristics.

- In the case of imitation, the dynamical regime, and hence the whole market, is either disordered or fully ordered.

- By contrast, in the case of memorisation, some buyers are faithfull, while others randomly buy either brand. Order and disorder coexist, but the distribution of behaviours is bi-modal.

Conclusions

- Structures for exchange depend upon information available to economic agents
- Existence of well characterised behaviours separated by phase transitions
- From ”model” situations to more complex cases