Computers, Evolution and Roman Economy

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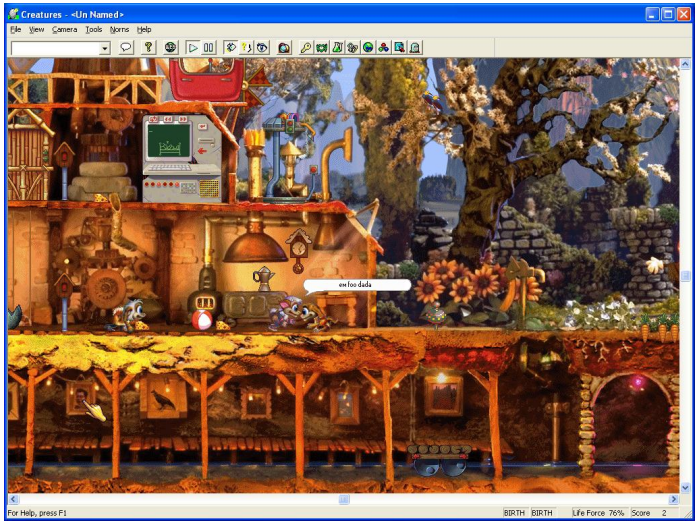
Barcelona, November 26th, 2015

Introduction

1. What brings me here
   (Background and Motiviations).

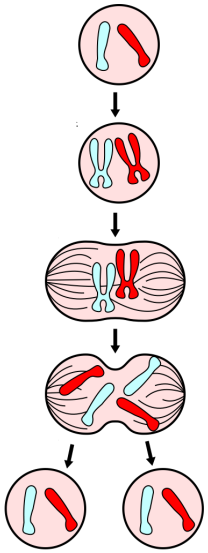
2. What I am doing and will do here
   (Current work and PhD goals)

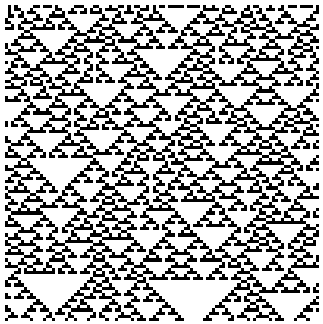
Computer and Living Systems



Find the good "rules" and "something unexpected" will happen.

Biology and computers





Why sometime, Computer and Living 'stuff' show similar properties?

Biology and computer

Simple rules, simple modifications, complex mechanism

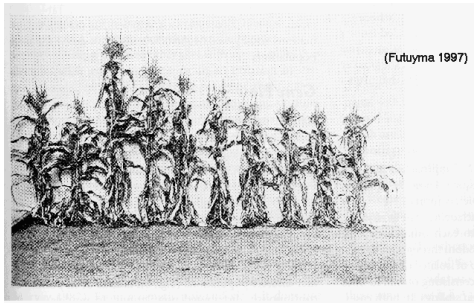
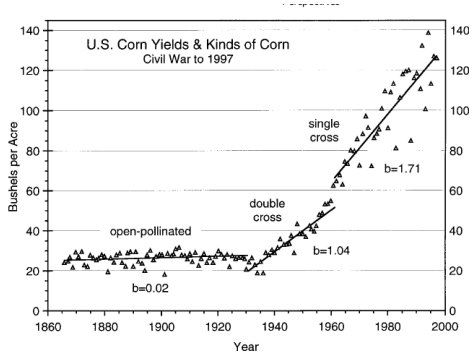
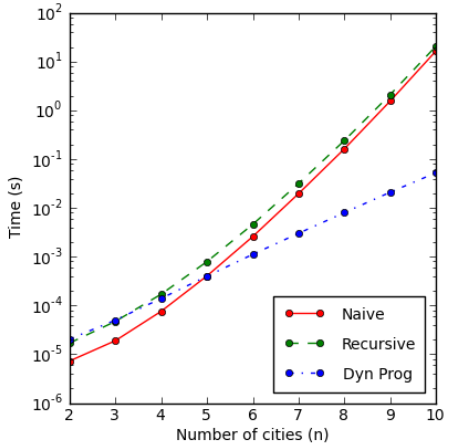


FIGURE 11.14 Effects of outcrossing and inbreeding on stature in corn. The two plants at the left are both inbred, homozygous strains. The third plant from the left is the F_1 offspring of these two strains, which displays heterosis ("hybrid vigor"). Successive self-fertilized generations from the F_1 are shown to the right. They display inbreeding depression in their stature, as well as in fitness components such as seed production. (From Jones 1924.)





Biology and computer

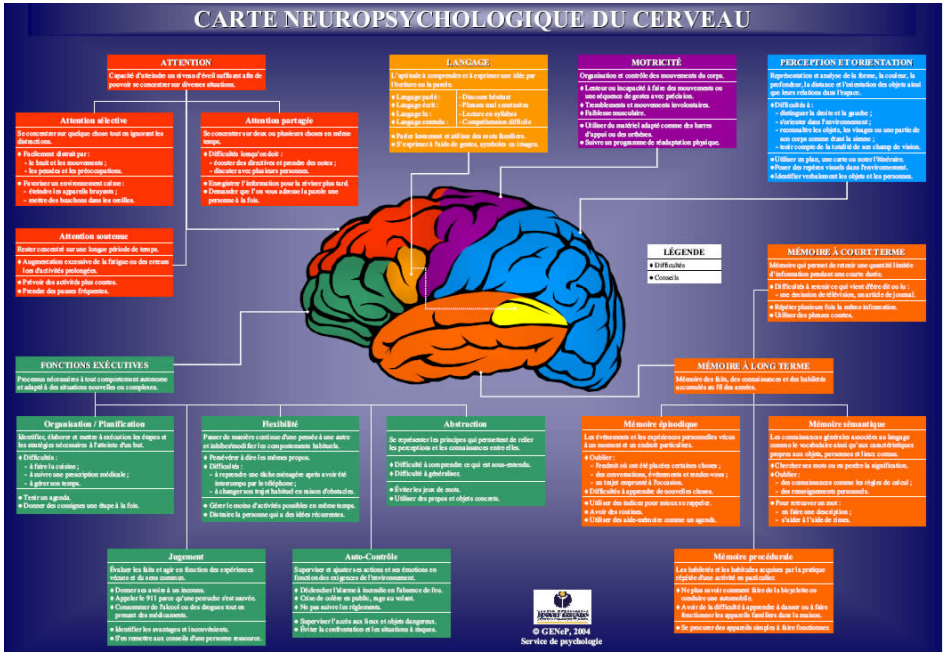
A remaining frustration...

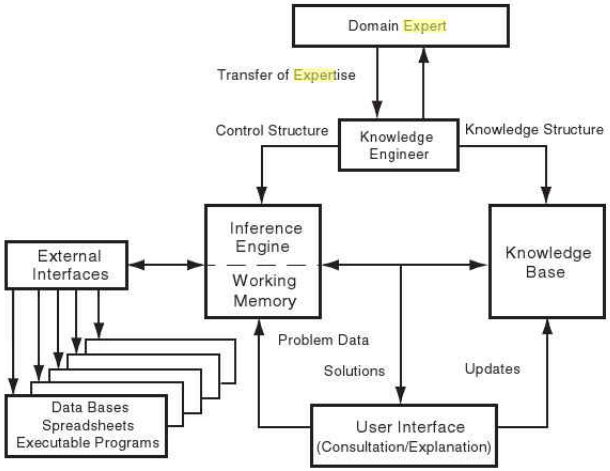
Feeling like :

Tool	**Interest**	
Informatic	Biology	$\rightarrow$ Biologist using Informatics
Biology	Informatic	$\rightarrow$ Computer Scientist using Biology

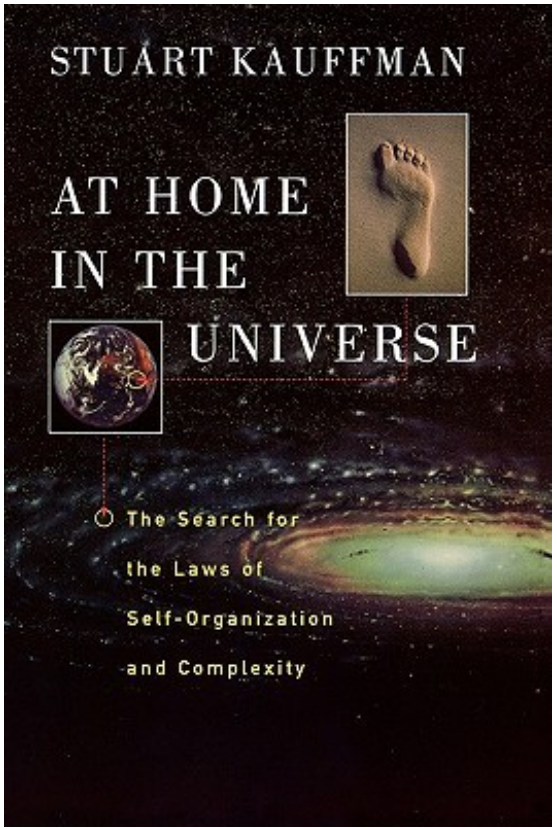
Neurosciences & Artificial Intelligence

"Simple" rules, "simple" modifications, more "complex" mechanism:





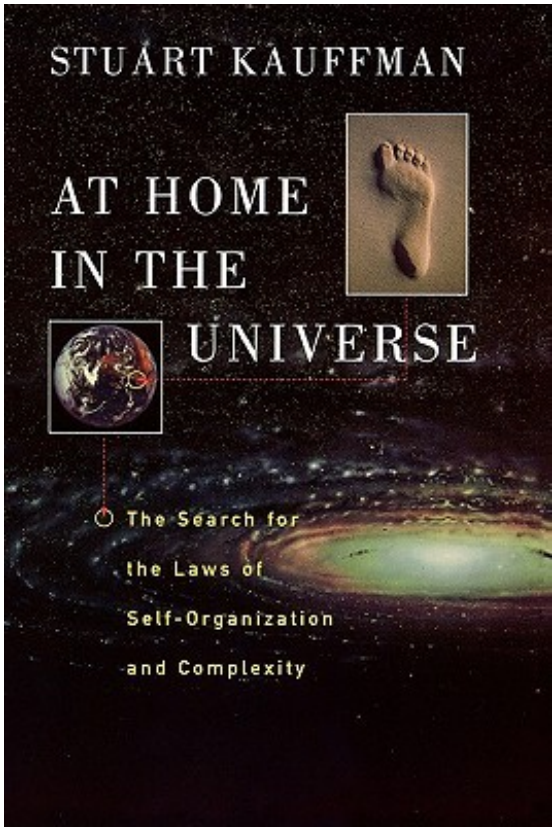
Cognitive Sciences & Complex Systems



'Unification'

Tool	Interest	
Informatic	Biology	→ Biologist using Informatics
Biology	Informatic	→ Computer Scientist using Biology

Cognitive Sciences & Complex Systems

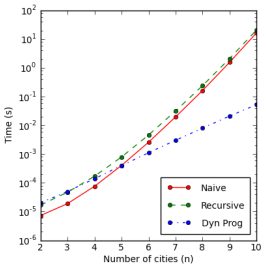


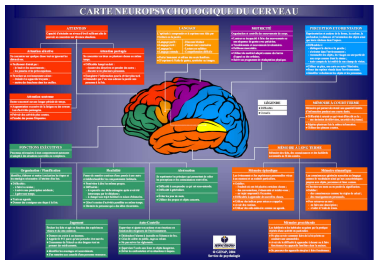
'Unification'

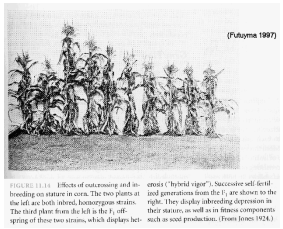
Tool	**Interest**
Informatic	Biology
Biology	Informatic

$\}$ $\rightarrow$ Complex Systems Scientist

Evolutionary studies



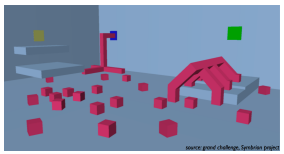


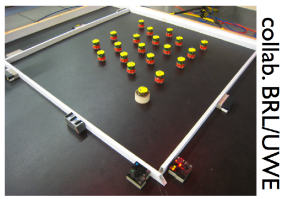


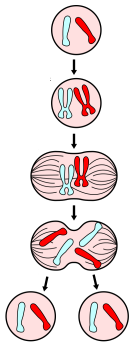
A common way to approach all that?

Simple rule, simple mechanism, complex dynamics...

- The Theory of Evolution?







Evolutionary Robotics

Study of speciation & specialisation by artificially evolve swarm of robots.

...

Philosophy of Biology

What am I *really* learning with that? Who will I convince?

- What is the Evolutionary Theory?
- How can I study it?
- What are the tools I used and how/why they can help me?

How to use artificial model to study Evolutionary Biology

What is a model? What is a theory? an explanation ? What is the Theory of Evolution? Lamarck? Darwin? Spencer? The Biometricians? Mendelism? The Modern Synthesis? Dawkin? Gould? ...

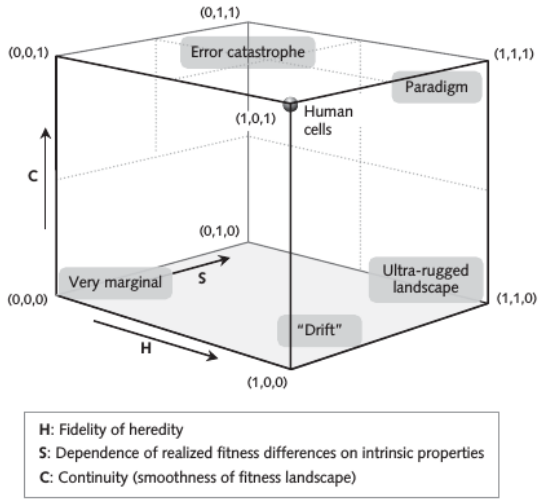


Figure: From Godfrey-Smith 2009

And with all that?

A huge mess, a lot of knowledge, but...

no MBA!

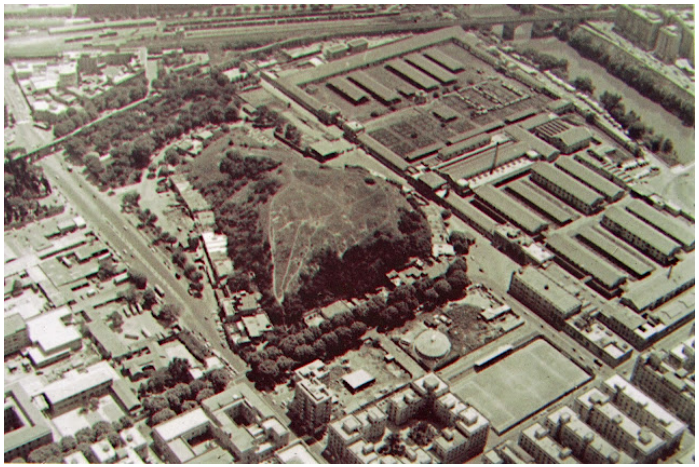
An ERC grant, 2 dynamics research center, 4 years of PhD, an amazing case study :

The evolution of Economy and Culture in the Roman Empire.

(ERC advanced grant : Production and Distribution of Food during the Roman Empire: Economic and Political Dynamics EPNET)

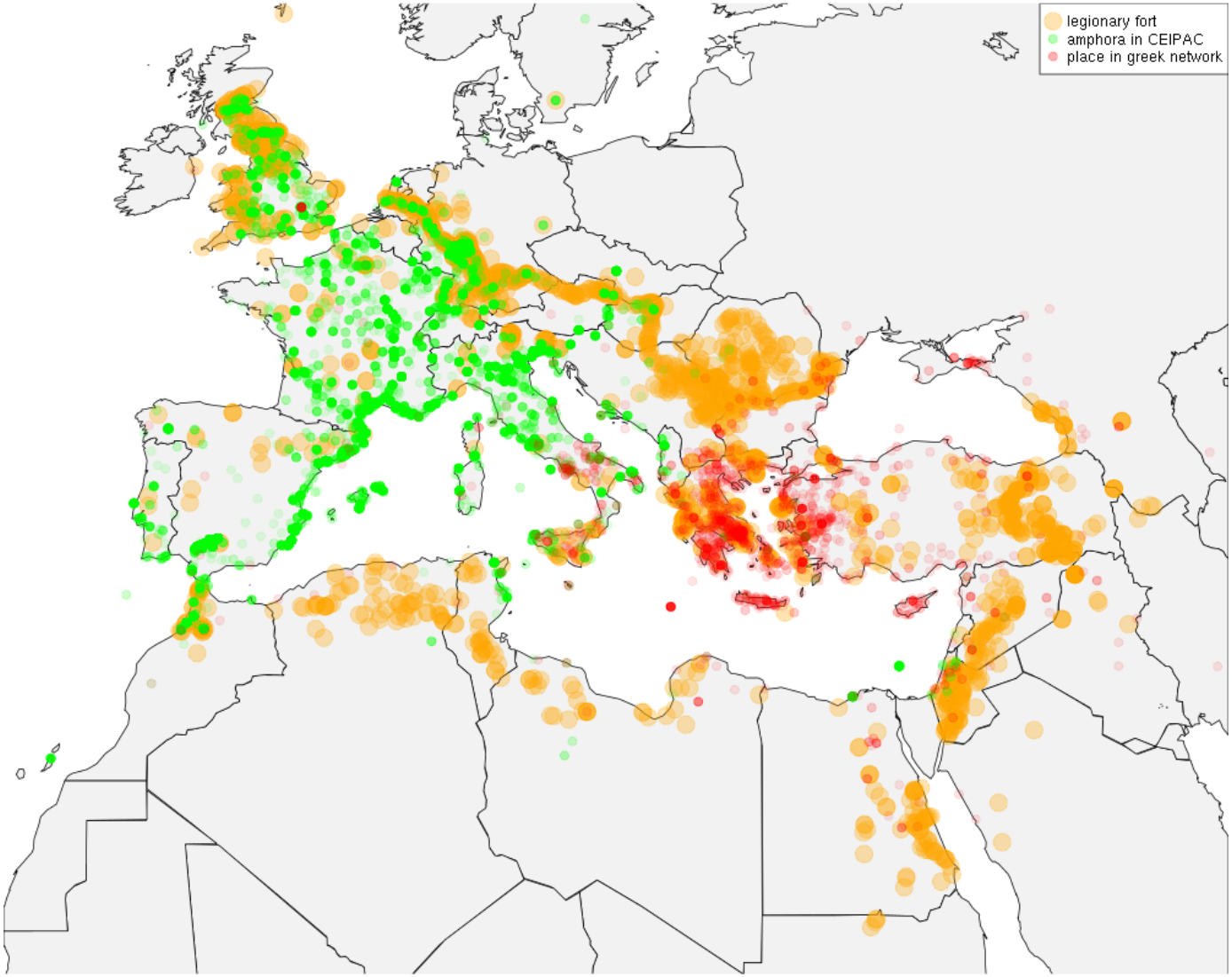
The Monte Testaccio

An amphora garbage in Roma.



Data

About 47000 amphora from CEIPAC database and other data in other databases (places in Pleiade, Greek names in Oxford...)



What was the nature of the Roman Economy?

The primitivism/modern debate

"The Roman Economy was already a free-market similar as today"

vs

"All price were fixed by the state, no free market, use of slave."

How to do this?

EPNET: A transdisciplinary project to shed new lights and bring quantitative arguments to the historians' debate :

- Historical and Archaeological investigation
- Sparql Ontologie
- Network analysis
- Simulation

Starting Point: A Simple Model

An Agent Based Model mixing two main aspects (WSC – 2015):

1. a simple bartering mechanism,
2. and (cultural) evolutionary dynamics.

Goal

Implement a "simple" theoretical abstract model where economy is seen as a particular cultural attribute co-evolving with other cultural traits:

- theoretical study interaction of those mechanism (evolution-culture-economics) and the dynamics of such interactions.
- test historical hypothesis

The Model

More details about the model :

1. Barter Mechanism

- Agent $\begin{cases} \text{Goods} \\ \text{Value attributed to each goods} \end{cases}$
- Each Agent *produces* one good and *exchange* it with the other goods given their respecting value.
- After the exchange, the agents *consume* the goods and are *ranked* given a shared utility function.

The Model

More details about the model :

2. Evolutionary Dynamics

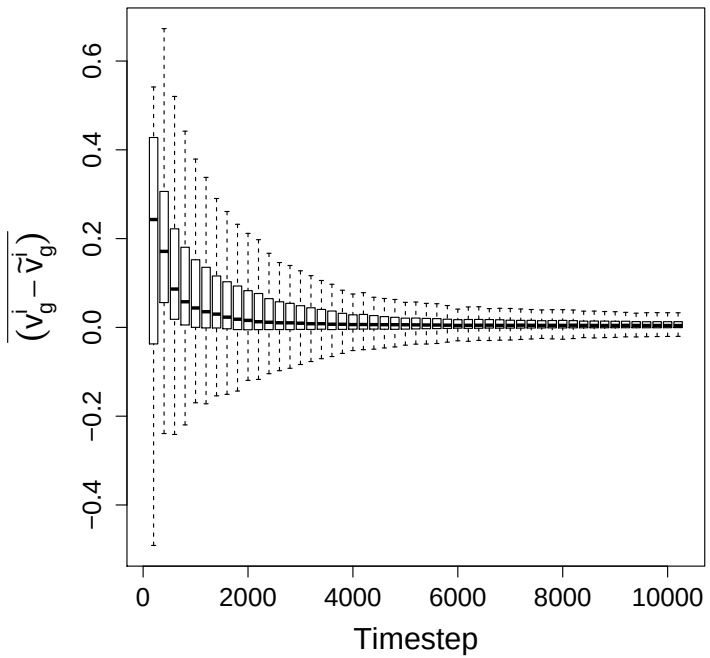
After 10 steps of exchange :

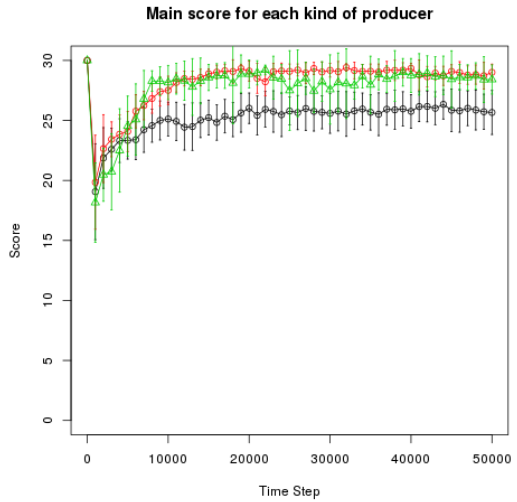
- The less successful (in term of utility) agents copy the set of value of the most successful agent (Biased-Copy/selection).
- Given a probability μ the value attributed to some goods are modified (Innovation/Mutation)

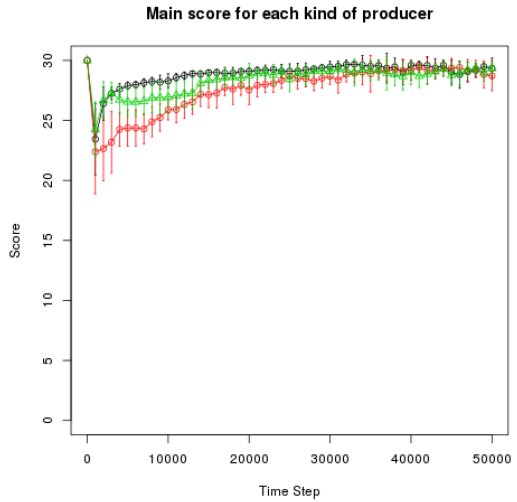
Dynamic of the Model

Result for 3 goods and 500 agents

Without surprise, the system evolves toward an equilibrium where all agents adopt optimal prices (clearing-market prices).







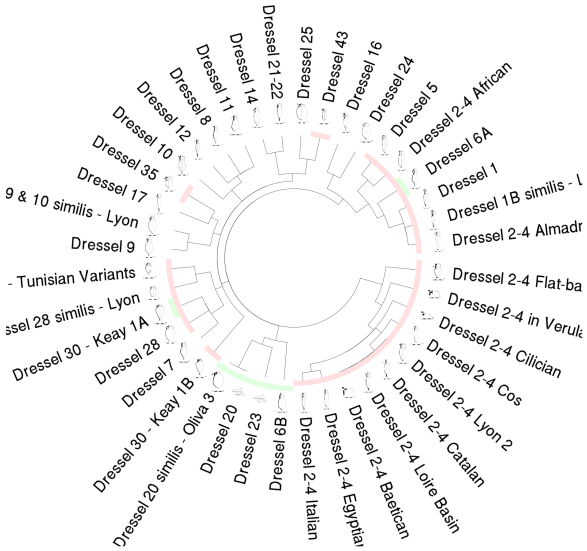
Further Development

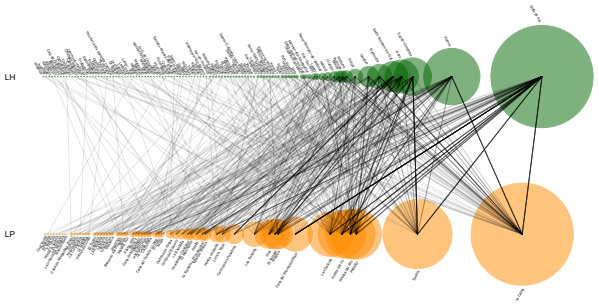
- Network topologies (ongoing)
- Multilevel dynamics (Province vs Economical Agents...)
- Evolution of specialisation
- Economy as a Complex Adaptive System...

Data Analysis

A model itself doesn't have any Historical meaning, it needs to always interact with the data:

- Phylogenetics analyse (using archeometry,amphora typology...),
- Network Analysis (using stamps and titulii pictii...),
- Hypothese generation,
- Model testing...





Some problems that slow us:

- Archaeological & Historical Data
- Transdisciplinarity between Humanities and Sciences.

Along The way

Questions that will remain in the background all that time :

- Is it possible to study History with quantitatives methods?
- What is the link between cultural and Biological Evolution?
- Evolution, an “Historical Science”? or History a branch o Evolutionary Studies?
- How computer model and simulation can bring knowledge and why?
- ...

Thank for you attention!