Modelling the Co-evolution of Trade and Culture

Simon Carrignon, Jean-Marc Montanier and Xavier Rubio-Campillo
contact:simon.carrignon@bsc.es

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Introduction

Cultural change comprises processes that modify spread of information by social interaction within a population [1]. An increasing number of social scientists are using an evolutionary framework to model this [2].
We use this framework to study economic activity. This phenomenon depends on particular cultural traits: the value attributed to each goods. Multiple biases could explain the fact that those value are transmitted more readily than the others. Some of those biases can be explained by the intrinsic properties of a trait (how beneficial it is), while others are simply explained by the frequency of these traits (how popular a it is). It is the impact of such biases on the economy that what we want to study.
To do so we propose a framework that can be implemented in multiple ways depending on the model tested. We show that this model allows us to explore economical and cultural dynamics and the interaction between them in a consistent way with regard to the literature.

Framework

To explore the co-evolution between trade and cultural change we developed a framework where the different agents produce and trade goods. The model is composed of a population Pop of m agents. Each agent i is defined by 2 vectors Q^i and V^i of size n. Q^i store the quantity of each good owned by i and V^i represents the price estimated by i for each of the n good.

Algorithm 1 Model

```
1:  INITIALIZATION:
2:  for i ∈ #Pop do                ▷ Initialize the agent with no goods and a random value vector
3:      Q^i = (0, ··· , 0)
4:      V^i = (v_0^i, ··· , v_n^i)          ▷ The values of v_j^i are selected randomly
5:  end for
6:  SIMULATION:
7:  loop step ∈ TimeSteps
8:      for i ∈ Pop do
9:          Production(Q^i)
10:     end for
11:     for i ∈ Pop do
12:         for j ∈ Pop do
13:             TradeProcess(V^i, Q^i, V^j, Q^j)
14:         end for
15:     end for
16:     for i ∈ Pop do
17:         ConsumeGoods(Q^i)                ▷ All goods are consumed
18:         if (step mod CulturalStep) = 0 then
19:             CulturalTransmission(V)
20:             Innovation(V^i)
21:         end if
22:     end for
23: end loop
```

Given the prices attributed by the agents for each goods (V^i), trade are done or not (l.13). Given the quantities (Q^i) gathered, a score reflecting the "economic success" of each agent is attributed (l.17). Finally the value attributed to each good V^i is modified (l.19-20). We focused on 2 different model implementing this modification:

1. **Neutral Model**: agent randomly copy a V^i among the population.
2. **Trade Model**: agent select a new V^i depending the score of the other agents.

Results

Distribution of Cultural Variants

We first compare the impact of different $CulturalTransmission$ mechanism on the distribution of frequencies of traits (the belief about the price of each goods).

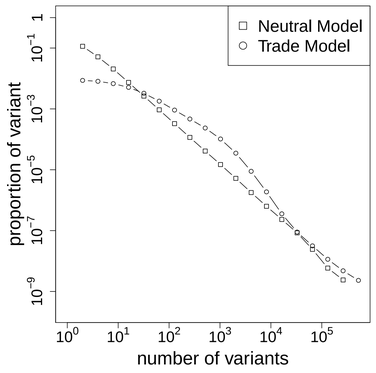

Figure 1: Comparaison of the distribution of frequencies between the neutral and the trade model.

Fig 1 shows that when $CulturalTransmission$ is neutral (agents randomly copy prices) the distribution follow the well know power law [3] but when transmission is not neutral but biased by the economical success of the agents, the power law disappear.

Economic Dynamics & Equilibrium

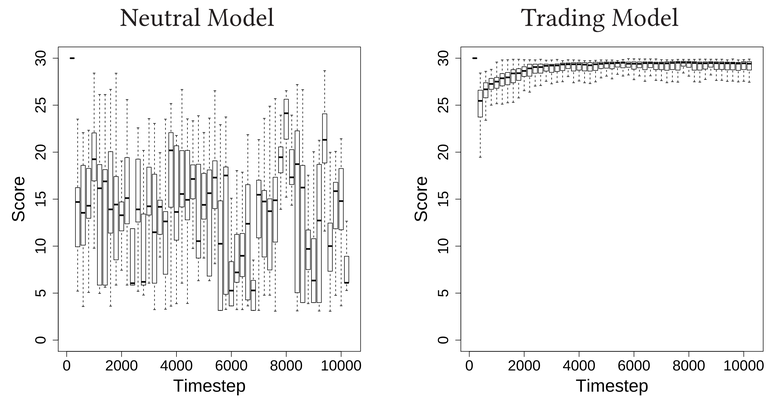

Figure 2: Evolution of the score within the two different models for two typical run with 500 agents and 3 goods evolving during 10000 timestep.

As expected when $CulturalTransmission$ is random (ie, agents modify their belief about the prices randomly), the scores evolve randomly (fig 2, left) wherease with a non random copy mechanism is used score increased toward the maximum score

The raise of the score of the agents comes from the fact that the mechanism of $CulturalTransmission$ biased by the economic success of the agents, allows all the agents to quickly estimates prices that converge toward their optimal value (cf Fig 3). Thus it allow them to make more efficient trade and increase their economic success (see also [4]).

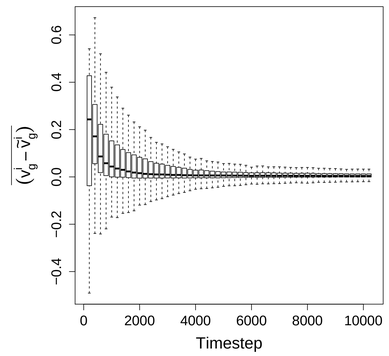

Figure 3: Evolution of prices toward optimum prices.

Concluding Remarks

Integrating cultural and economical dynamics into a evolutionary framework is a good candidate to study such systems. It allows one to study precise mechanisms and to easily test and compare different model of such mechanisms.
In futur work we hope to fruitfully apply that tools to bring different ways to propose, validate and interpret hypothesis about economics and cultural dynamics at work during the Roman Empire.

References

[1] Robert Boyd and Peter J Richerson. *The origin and evolution of cultures.* Oxford University Press, 2005.

[2] Joseph Henrich and Richard McElreath. The evolution of cultural evolution. *Evolutionary Anthropology: Issues, News, and Reviews*, 12(3):123–135, 2003.

[3] R. Alexander Bentley, Matthew W. Hahn, and Stephen J. Shennan. Random drift and culture change. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 271(1547):1443–1450, 2004.

[4] Herbert Gintis. The emergence of a price system from decentralized bilateral exchange. *Contributions in Theoretical Economics*, 6(1):1–15, 2006.

Acknowledgements

Funding for this work was provided by the ERC Advanced Grant EPNet (340828) and the SimulPast Consolider Ingenio project (CSD2010-00034) of the former Ministry for Science and Innovation of the Spanish Government.

http://http://www.roman-ep.net/epnet/