

UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
FACULDADE DE CIÊNCIAS ECONÔMICAS
DEPARTAMENTO DE ECONOMIA

THE ROLE OF INSTITUTIONS IN THE EMERGENCE OF COOPERATION

REIMPLEMENTING AXELROD'S METANORMS GAME IN
OSTROM'S INSTITUTIONAL ANALYSIS AND DEVELOPMENT
FRAMEWORK (IAD)

DANIEL VOIGT GODOY
SABINO DA SILVA PÔRTO JÚNIOR

AGENDA

- INTRODUCTION
- PREVIOUS WORK
- THE PROPOSED MODEL
- SIMULATION
- RESULTS
- CONCLUSIONS

INTRODUCTION

- **INITIAL SITUATION**

- A population of *defectors* exploring a *common-pool resource*

- **CONDITIONS**

- Agents *socially* organized in a *scale-free network*
- Rules in use: Axelrod's *Metanorms Game* (1986)
- Social learning by imitation/*cultural dissemination*
- *Behavior innovation* by random shocks in attributes

- **HYPOTHESIS**

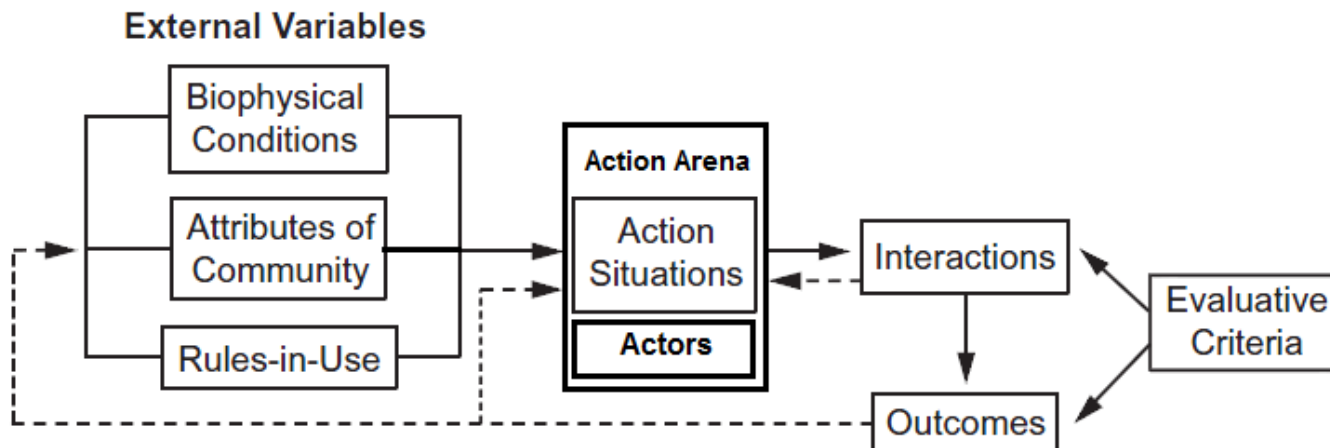
- The introduction of an **institution**, in a “*culturalist*” sense, enables **cooperation** by transforming the attributes of the population

PREVIOUS WORK

- **SOCIAL DILEMMAS**

- *Tragedy of the Commons* (Hardin, 1968)
- Ostrom (1990) – field experiments

- **Institutional Analysis and Development Framework (IAD) – Ostrom (2005)**



PREVIOUS WORK

- **INSTITUTIONS**

- Bowles (2004)
 - *equilibrium* of an underlying game
- Chang and Evans (2005)
 - Instruments to *enable* supra-individual goals
 - *Culturalist* vision
 - *Internalization* of institutional values – conformism

PREVIOUS WORK

- **CULTURE**

- Set of *individual attributes* subjected to social influence, something that people learn from each other (Axelrod, 1997)
 - Model of *Dissemination of Culture*
- Reduced set of *mental models* shared by individuals (Ostrom, 2005)

PREVIOUS WORK

- **AXELROD'S METANORMS MODEL (1986)**
 - Agent's attributes (3 *bits* = 0 to 7)
 - *Boldness*: propensity to *defect*
 - *Vengefulness*: propensity to *punish*
 - Generation: 4 *rounds*
 - Mutation: 1% chance in each *bit*
 - Social network: complete graph
 - Simulation: 20 agents, 100 generations, 5 times
 - Problem: There is *no incentive to punish* an observed defection since it has a *cost*
 - Solution: Second order punishment (to punish for not punishing na observed defection)

THE PROPOSED MODEL

- **MODIFIED VERSION OF AXELROD'S METANORMS MODEL (1986)**

- Model elements/dimensions

- Agents

- Agents are not omniscient (Mahmoud et al, 2012)

- *Population density*

- Common-pool resource

- Geographic space

- Social space

- *Two spaces of interaction: geographic (observation) and social (control) (Canova, 2011)*

- Metanorms Game

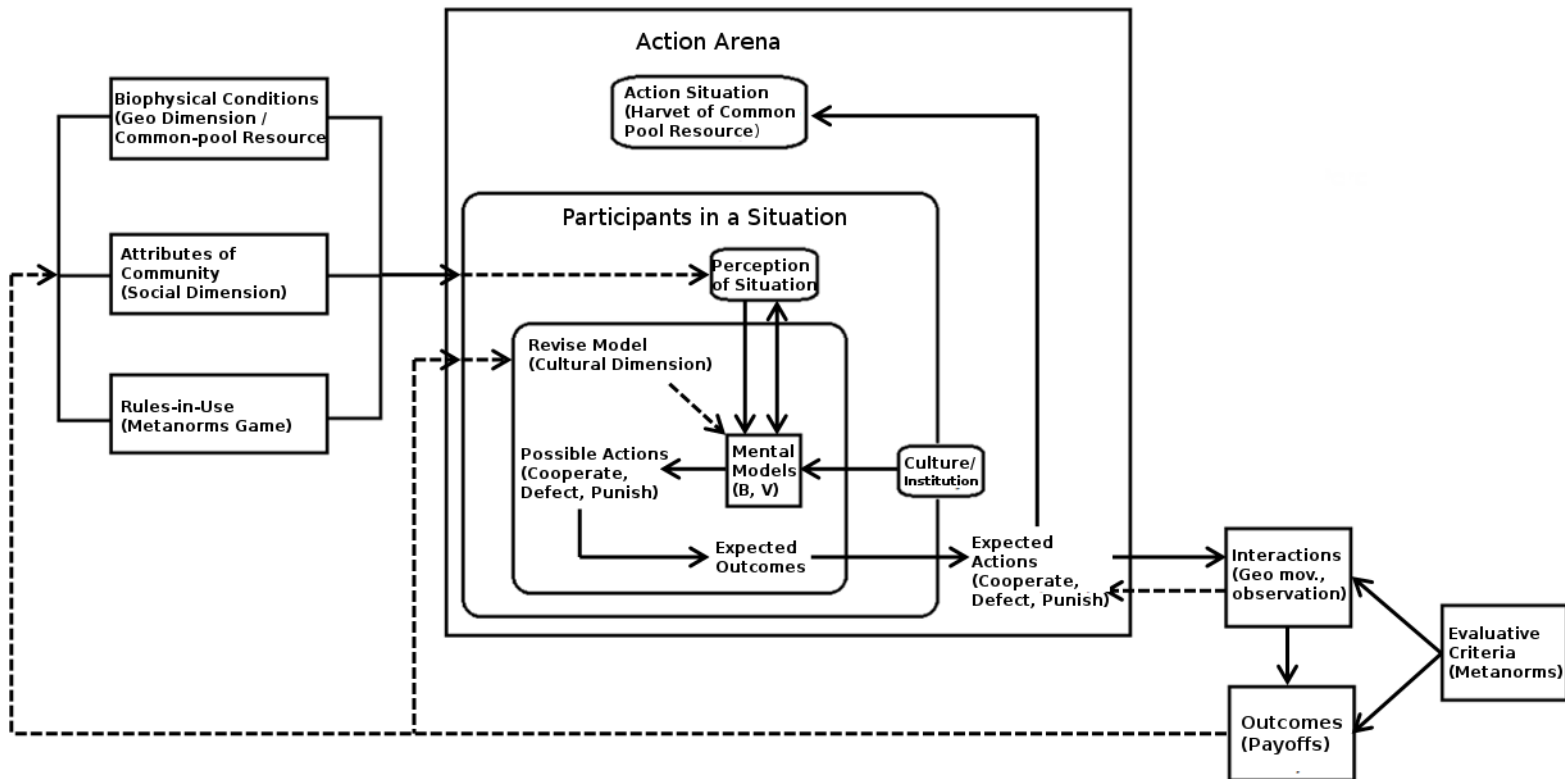
- *Cultural space*

- Learning by imitation/culture (Macy, 1991, Axelrod, 1997)

- The role of institutions (Chang and Evans, 2005, Bowles, 2004)

THE PROPOSED MODEL

- **IAD FRAMEWORK** (Ostrom, 2005) – Integrating elements



THE PROPOSED MODEL

- **CULTURAL SPACE**

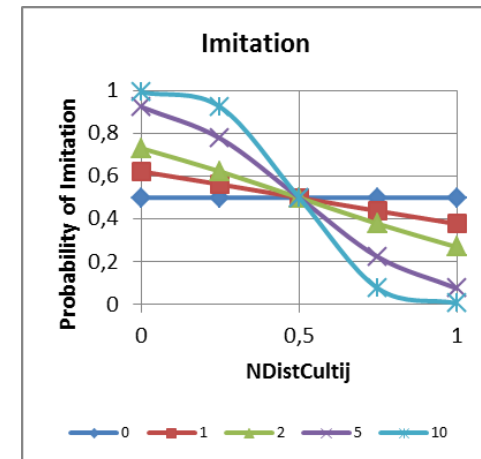
- Cartesian Product: *Boldness* x *Vengefulness*
- *Imitation* (social learning)
 - Selection of “*cultural models*” for imitation/rejection

$$Vis_{AB} = \frac{P_B - P_A}{NDistGeo_{AB}}$$

- Decision of imitate/reject

$$\frac{1}{1 + \exp(\beta(NDistCult_{ij} - 0,5))}$$

- Probability of “wrong” selection ($\omega = 10\%$)



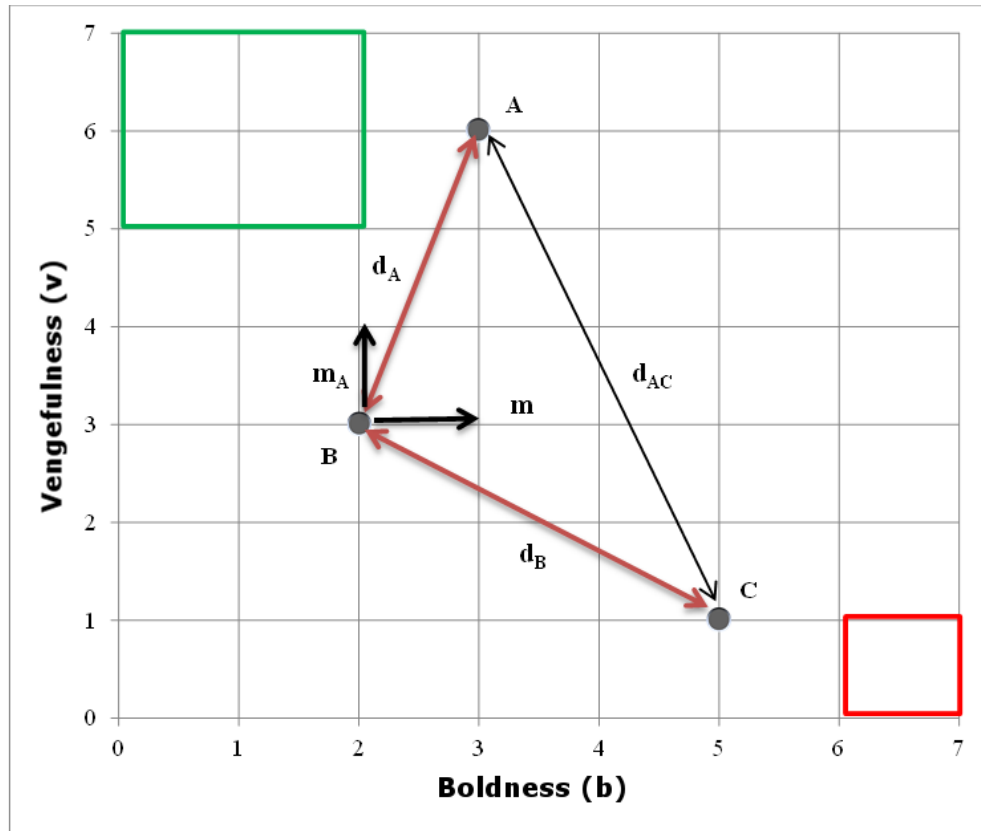
THE PROPOSED MODEL

- **CULTURAL SPACE** (continued)
 - Autonomous random movement – Behavior innovation
 - *Institution*
 - “*Culturalist*” vision (Chang and Evans, 2005)
 - Characteristics
 - Origin (exogenous / endogenous)
 - Power/weight (w_{inst})
 - Range (r_{inst}) and Comprehensiveness/minimum weight ($w_{inst} - r_{inst}$)
 - Strength of imitation (bias)
 - Multi-level selection (Bowles, 2004)
 - Institutional influence in agent’s attributes

$$Prob(inst) = w_{inst} - r_{inst}NDistCult_{i\ inst}$$

THE PROPOSED MODEL

- **CULTURAL SPACE** (continued)



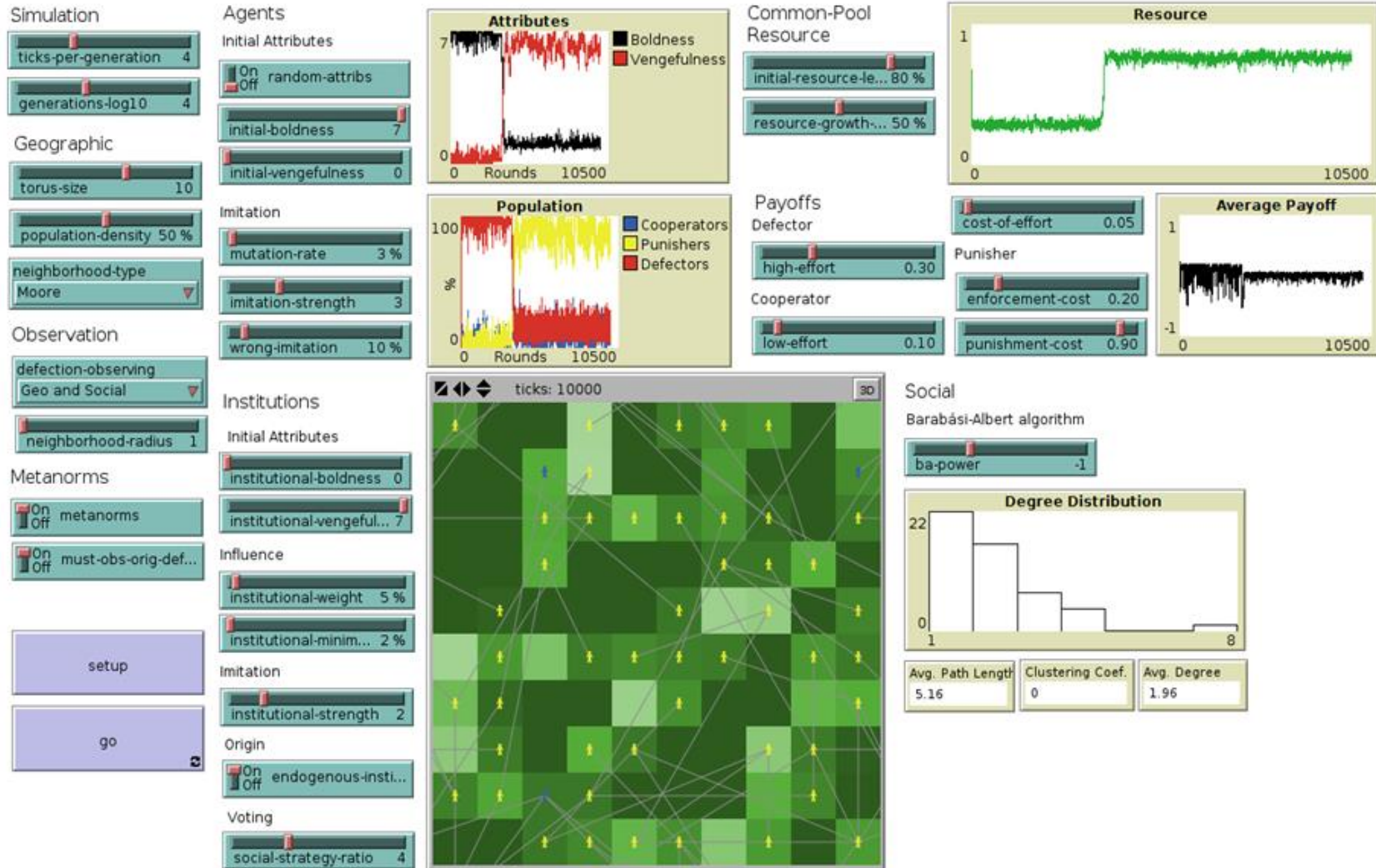
Green: Norm established

Red: Norm collapsed

A and C have no relationship between them but they are both neighbors or socially connected to B.

Vectors m_A e m_C : possible movements of B in the cultural space

SIMULATION



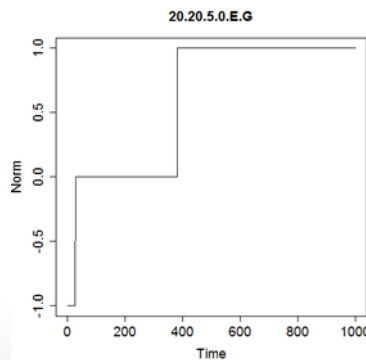
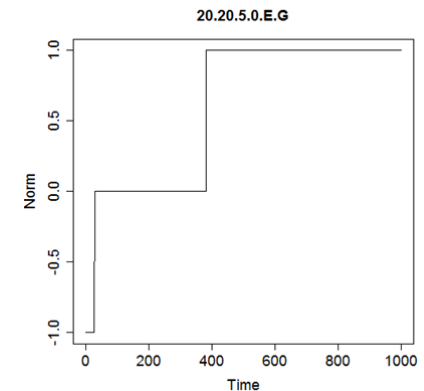
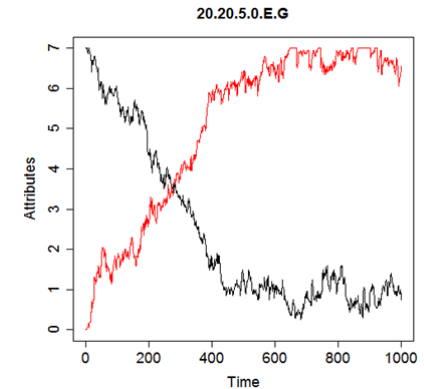
SIMULATION

- **PARAMETER SPACE**

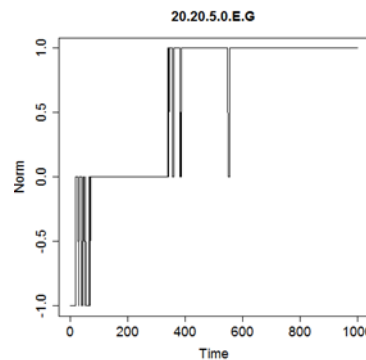
- 222 combinations of 6 parameters
- Identification: *NN.WW.M.S.O.D*
 - *NN* – population density;
 - *WW* – institution's weight (power);
 - *M* – institution's minimum weight (difference between power and range);
 - *S* – bias towards imitating institution;
 - *O* – institution's origin , exogenous (X) or endogenous (E); and
 - *D* – defection observation, geographic only(G) or including social connection (S).

SIMULATION

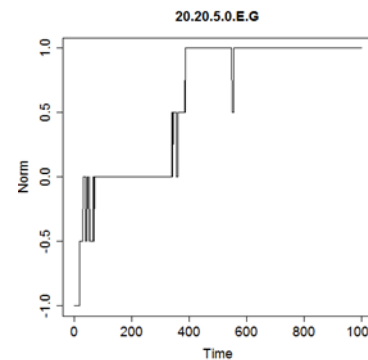
- **Attributes Plot:** each line represents the population average of an attribute – **boldness** in black, **vengefulness** in red;
- **Single Norm Plot:** translates the attributes into 3 possible states – norm established (1), norm collapsed (-1) and undefined (0);
- **Average Norm Plot:** averages single norm plots over different rounds of simulation.



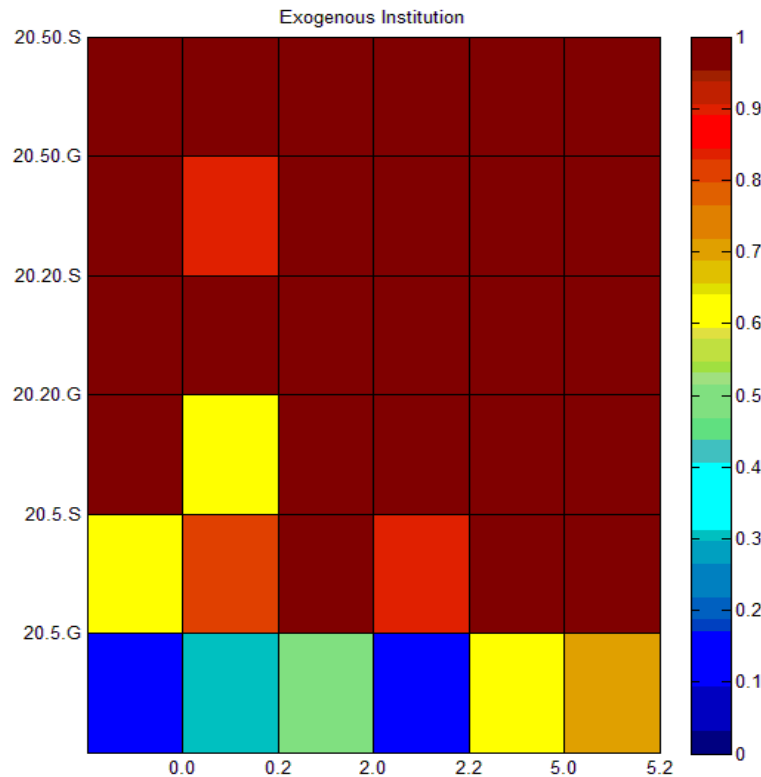
+



=



SIMULATION



Surface Plot: each cell is colored according to the corresponding value of the results obtained at the end of a round of simulations for a combination formed by the values in both axis.

Vertical Axis: NN.WW.G

Horizontal axis: M.S

Title: O

So, for the lower left corner, we have a value of zero (blue) which was the result obtained for the combination “20.5.0.0.X.G” (where X stands for “exogenous”)

RESULTS

- **1^a SEQUENCE OF SIMULATIONS**

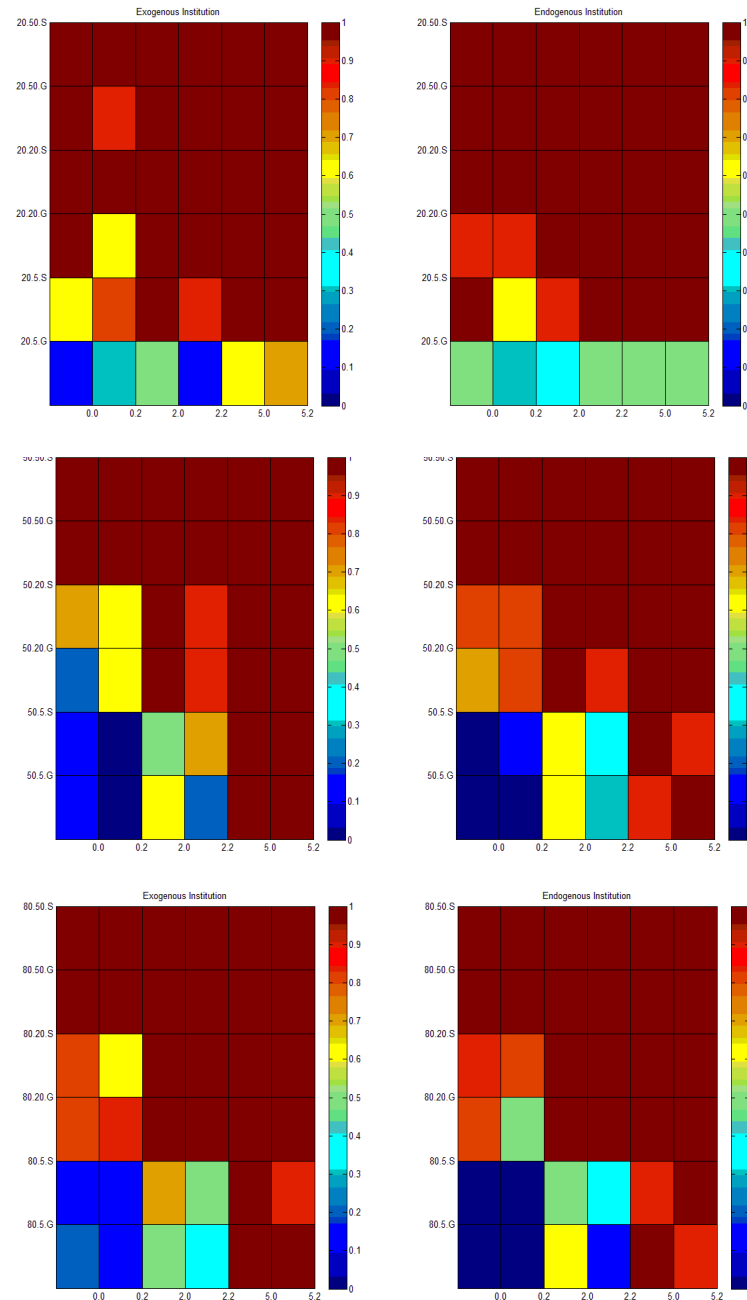
- 222 combinations
- 10 simulations for each combinations
- 1,000 generations each time

- **Social norm collapses**

- Low institutional weight (5%) and minimum weight $\leq 2\%$
- Medium institutional weight (20%) and minimum weight equals zero

- **72 combinations (collapse)**

- 6 combinations (no institution)

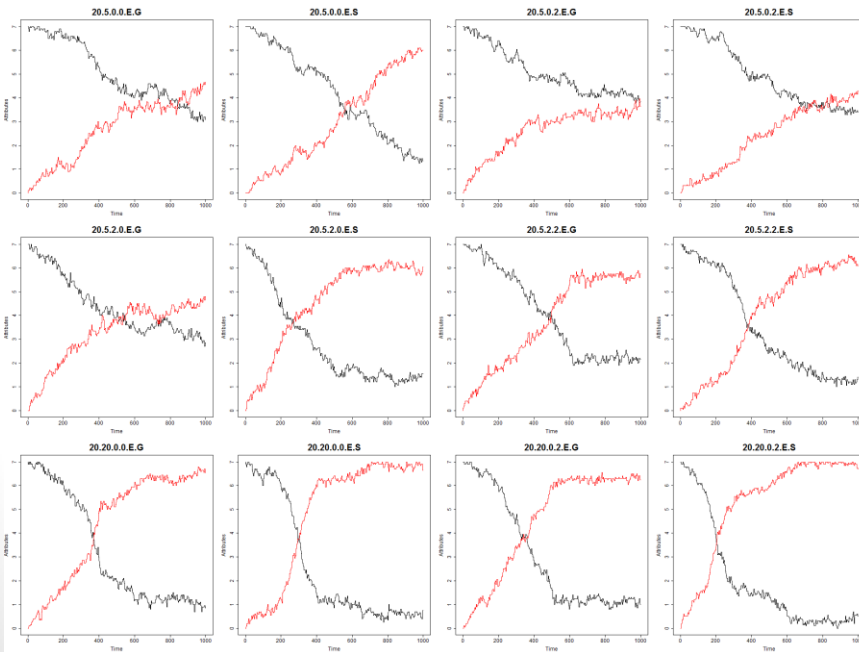


RESULTS

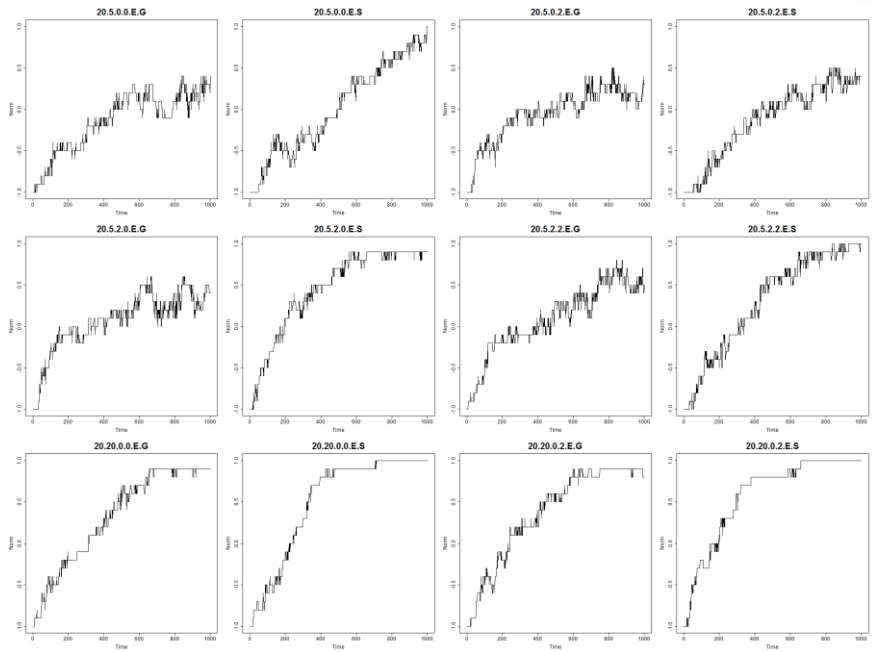
12 combinations

- Endogenous Institutions
- Low population density (20%)
- 1,000 generations
- 10 simulations

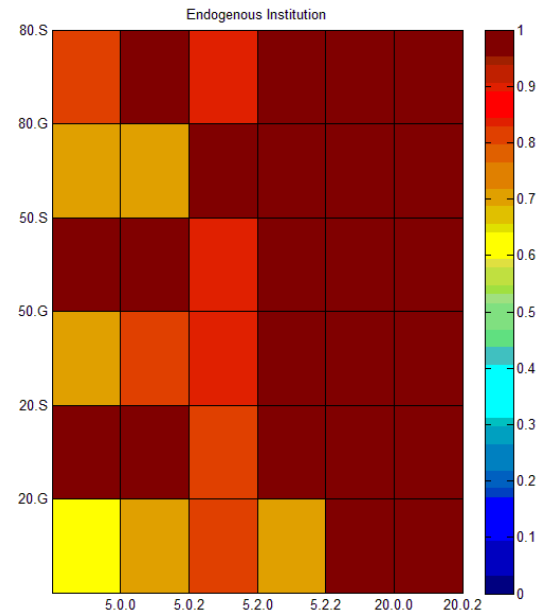
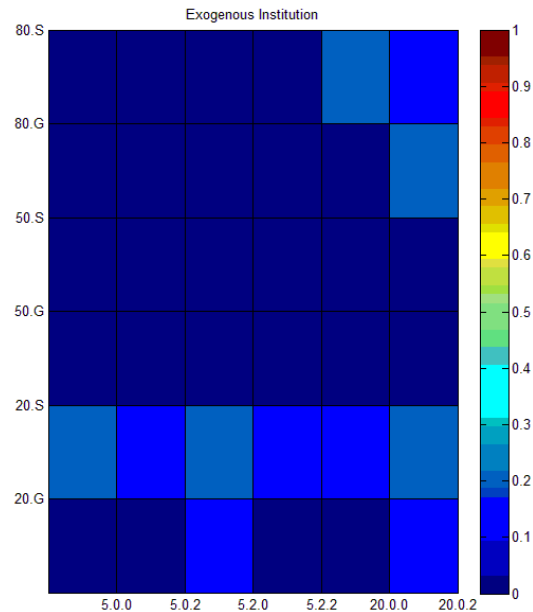
Average Attributes Plots



Average Norm Plots



RESULTS



- **2^a SEQUENCE OF SIMULATIONS**

- 78 combinations
- 10 simulations for each combination
- 10,000 generations each time

- **Norm establishment**

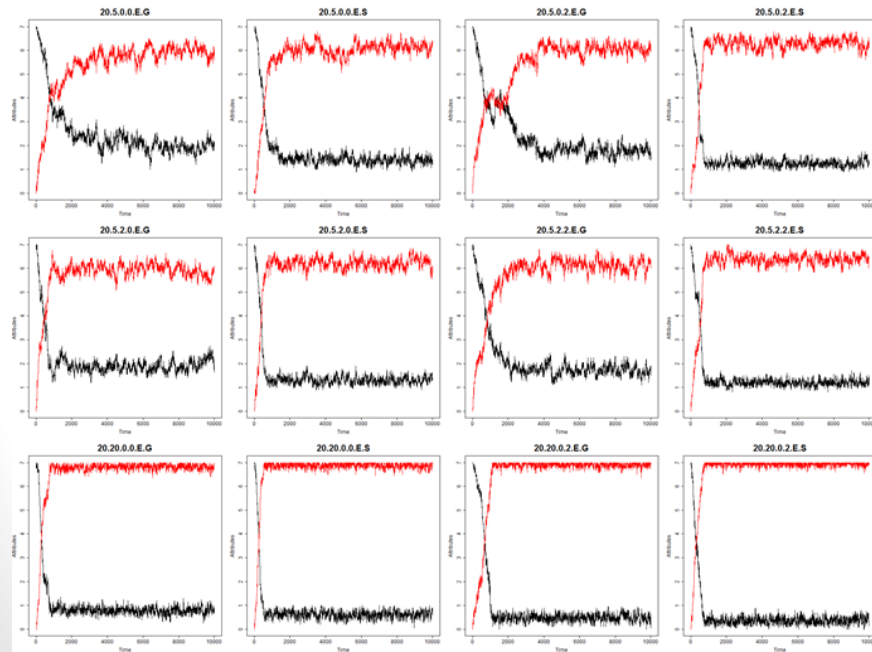
- Advantage: *endogenous* institutions
- *Social control* (odd lines)
- Imitation strength or *bias* (even columns)

RESULTS

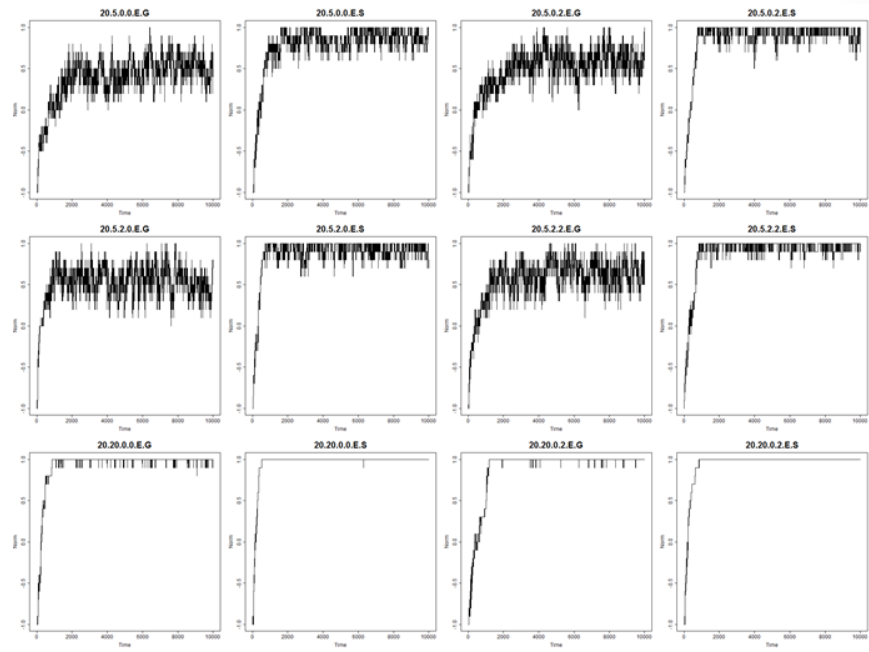
12 combinations

- Endogenous Institutions
- Low population density (20%)
- 10,000 generations
- 10 simulations

Average Attributes Plots



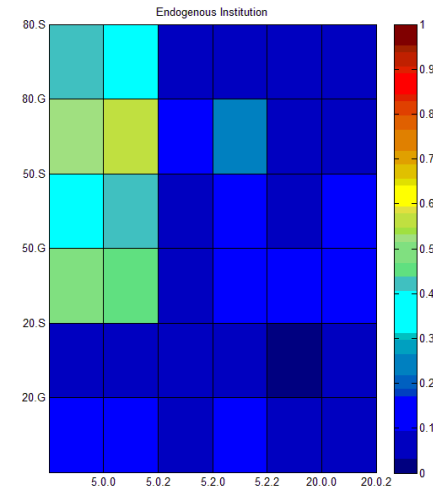
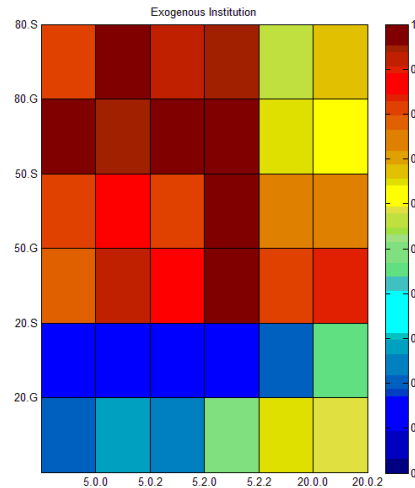
Average Norm Plots



RESULTS

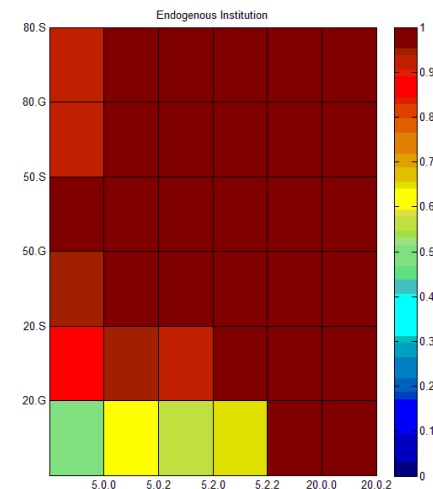
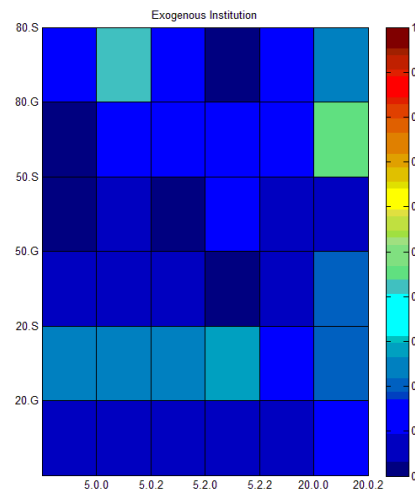
- **Norm establishment speed**

- Medium and high populational densities: *slow*
- Low density: *catalyst*



- **Norm stability**

- Exogenous: *Unstable*
- Medium and high population densities: *Stable*
- Low density: Fragile, *dependent* on the existence of social control



CONCLUSIONS

- The simulated results indicate:
 - a) **Endogenous** institutional arrangements are more **effective**.
 - b) When considering a **weak endogenous institution** with low or zero minimum weight, the results also show that:
 - The possibility of **social control is sufficient** for establishing a norm;
 - **Medium or large communities** are capable of establishing **stable** norms;
 - In **small communities**, the **stability** of a social norm is **dependent** on the existence of **social control**; and
 - **Indifference** to the institutional values is an **obstacle**.
 - c) These results are compatible with those found by Ostrom (1990) in her field experiments.

REFERENCES

- AXELROD, R. An evolutionary approach to norms. American Political Science Review. Vol.80, N.4, 1095-1111, 1986.
- AXELROD, R. The dissemination of culture: A model with local convergence and global polarization. Journal of Conflict Resolution. Vol. 41, N.2, p. 203-226, 1997.
- BOWLES, S. Microeconomics: Behavior, Institutions and Evolution. Princeton: Princeton University Press, 2004.
- CANOVA, G. A. Jogos evolutivos: efeitos de difusão em redes complexas. Monografia de conclusão de curso. Porto Alegre, UFRGS, 2011.
- CHANG, H.J.; EVANS, P. The role of institutions in economic change. In: Reimagining Growth. Londres: Zed Press, 2005.
- HARDIN, G.R. The tragedy of the commons. Science. Vol. 162, p. 1243-48, 1968.
- MACY, M.W. Chains of cooperation: Threshold effects in collective action. American Sociology Review. Vol. 56, n. 12, p.730-47, 1991.
- MAHMOUD, S.; GRIFFITHS, N.; KEPPENS, J.; LUCK, M. Overcoming omniscience for norm emergence in Axelrod's metanorm model. Coordination, Organizations, Institutions, and Norms in Agent System VII. Vol. 7254, 186-202, 2012.
- OSTROM, E. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge: Cambridge University Press, 1990.
- OSTROM, E. Understanding Institutional Diversity. Princeton: Princeton University Press, 2005.