

This report describes the model in more detail using the ODD + D (Müller et al. 2013) standard for describing agent-based models.

MODEL OVERVIEW

PURPOSE

This model is an agent-based model (ABM) of common pool resources (CPRs) management. The ABM simulates the emergence of institutions for the management and use of CPRs. The goal of this work is to show the relationship between inequality and cooperation in managing of CPRs.

This model is an extension of an existing, empirically validated, agent-based model of the emergence of institutions for the management and use of CPRs (Ghorbani et al. 2017).

STATE VARIABLES AND SCALES

The model includes a number of appropriators and one shared resource. Appropriators select an institution at a specific time after the start of the simulation.

APPROPRIATORS

Variable	Description
Wealth	Captures the amount of wealth that the agents currently have. It decreases every tick based on consumption needs, and increases based on appropriation activities.
Current action	How many resource units the agents are consuming/appropriating at this moment
Current condition	Under what condition do the agents take action (e.g. every x ticks)
Cheated	A Boolean variable that shows whether the agent cheated in the previous tick
Cheating profitable	Is the outcome of the decision of the agent on whether it should cheat in this round or not. (Boolean)
Cheating propensity	The probability of cheating

RESOURCE

Variable	Description
Resource Growth (r)	In each round of the simulation, the amount of resource is increased by this value given a particular growth function.
Initial amount (K)	This is the amount of resource given at the beginning of the simulation
Resource type	The type of resource is fishery or irrigation in the model.

INSTITUTION

Variable	Description
Action	The action that has to be executed by every agent in the simulation. This is selected by the agents.
Condition	The condition under which the agents appropriate from the resource (execute action). This is selected by the agents.
Frequency of meetings	The number of ticks after which the institution is formed by the agents
Threshold for institutional change	The threshold needed to establish an institution.
Fine	The amount of penalty paid by agents in case they cheat, and in case their cheating is caught. This is selected by the agents.
Monitoring	The percentage of agents who will be monitored for cheating. This is selected by the agents.

PROCESS OVERVIEW AND SCHEDULING

The simulation model consists of two general processes:

1 The initial appropriation process where in the initialization phase, the agents are created, the network is set up and agents are initialized with a random action and random condition pair as their individual strategy. The agents consume resource units based on their individual strategy. For example, an individual strategy might look like this: eat 5 units of wealth every 2 ticks. In addition, agents consume a fixed amount of wealth in each tick, representing their needs. The resource is renewed in each time step according to a logistic growth function. If agents are not satisfied with their wealth level (i.e., their wealth is negative), they change their strategy. This change of strategy can be completely random (representing innovative behaviour), based on learning, or done by copying successful neighbours.

2 Appropriation based on institutional rules. At specific points in time if a majority of agents are unsatisfied, they come together to vote on an institutional rule, which is basically the most common individual strategy. Once in place, all agents have to follow the institutional rule, although under certain settings they can “cheat” and follow their individual strategy instead. If they cheat, monitoring and fine mechanisms will be applied. The simulation stops if there are no resource units left or simply after a certain number of ticks.

DESIGN CONCEPTS

THEORETICAL AND EMPIRICAL BACKGROUND

The model is primarily based on the concepts proposed in IAD framework for management institutions in CPR system. It uses the ADICO grammar of institutions to build institutions, which follow a pseudo-evolutionary process, i.e., mutation of institutions (innovation), copying behavior, and learning.

INDIVIDUAL DECISION-MAKING AND SENSING

The agents follow a basic decision making process. They look at their wealth level to make decision on their behavior and changes. The agents also decide whether they would comply with the institutional rule, or follow their own strategy. They do this by comparing the potential wealth gain from each and select the most profitable one, depending on the cheating propensity.

LEARNING

The agents have simple learning abilities. They have a memory to store the best strategy, which has led them to the maximum wealth. If the mood of changing strategy is ‘learning’, they check the wealth that they can gain based on a new wealth in comparison with the wealth associated with the best strategy. After that, they choose to go for the new strategy or not.

INTERACTION AND COLLECTIVE ACTION

Each agent is placed in a network (random). The agents may copy the strategy of the successful neighbor in terms of wealth level. Furthermore, the agents come together and collectively vote on the institution by proposing their own strategy. The most common strategy is selected as the new institution.

HETROGENITY

Agents are heterogeneous with respect to their wealth and behavioral strategies.

DETAILS

INITIALIZATION

The model starts by all agents having 1000-2000 amount of wealth. This amount will decrease based on a given constant value (wealth consumption) and will increase (or decrease) based on the strategy that the agent is choosing then following.

References:

Ghorbani, A., Bravo, G., Frey, U. and Theesfeld, I., 2017. Self-organisation in the commons: An empirically-tested model. *Environmental Modelling & Software*, 96, pp.30-45.

Müller, B., Bohn, F., Dreßler, G., Groeneveld, J., Klassert, C., Martin, R., ... & Schwarz, N. (2013). Describing human decisions in agent-based models–ODD+ D, an extension of the ODD protocol. *Environmental Modelling & Software*, 48, 37-48.