This repost 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 of common pool resources (CPRs) management to test hypotheses that were previously generated through a historical dataset. The ABM simulates the emergence of institutions for the management and use of CPRs. The goal of this work is to show how historical hypotheses can be tested with agent-based models. In other words, by comparing emerging patterns from historical datasets to emerging patterns from simulation models, one can explore the plausibility of the underlying mechanisms that have led to those patterns.

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. Furthermore, we introduce two types of shocks in the model: social shock and environmental shock.

APPROPRIATORS

Variable	Description
Yield	Captures the amount of yield that the agents currently have. It decreases every tick based on consumption needs, and increases based on appropriation activities.
Current action	the number of resource units the agents are consuming/appropriating at a point in time
Current condition	Under what condition 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.
Institutional_emergence_start	The trial and error phase of CPR before going to emerge the institutions.

SHOCKS

Variable	Description
Environmental shock interval	The interval that environmental shock happens.
Resource loss percentage	The percentage of resource that will be decreased in each environmental shock intervals.
Social shock time	When a social shock is introduced.
Taxation amount	The amount of penalty paid by agents in each ticks after social shock time.

PROCESS OVERVIEW AND SCHEDULING

The simulation model consists of two general processes which are depicted in Fig. 1:

1 The initial appropriation process: during 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 resource every 2 ticks. In addition, agents consume a fixed amount of yield 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 energy level (i.e., their energy balance is negative), they change their strategy. This change of strategy can be completely random (representing innovative behaviour) 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. While following the institution, the opinion of the agents about their individual strategy is continuously updated. If they cheat, monitoring and fine mechanisms will be applied. If a certain proportion of agents are unsatisfied with the current institution, the meet again to vote on a new institution. In addition to the threshold for satisfaction, another parameter determining the meeting frequency also influences how often the agents change the institution. The simulation stops if there are no resource units left, or when the portion of agents with very low energy is higher than a certain threshold, or simply after a certain number of ticks. Environmental shock and social shock take place during this phase.

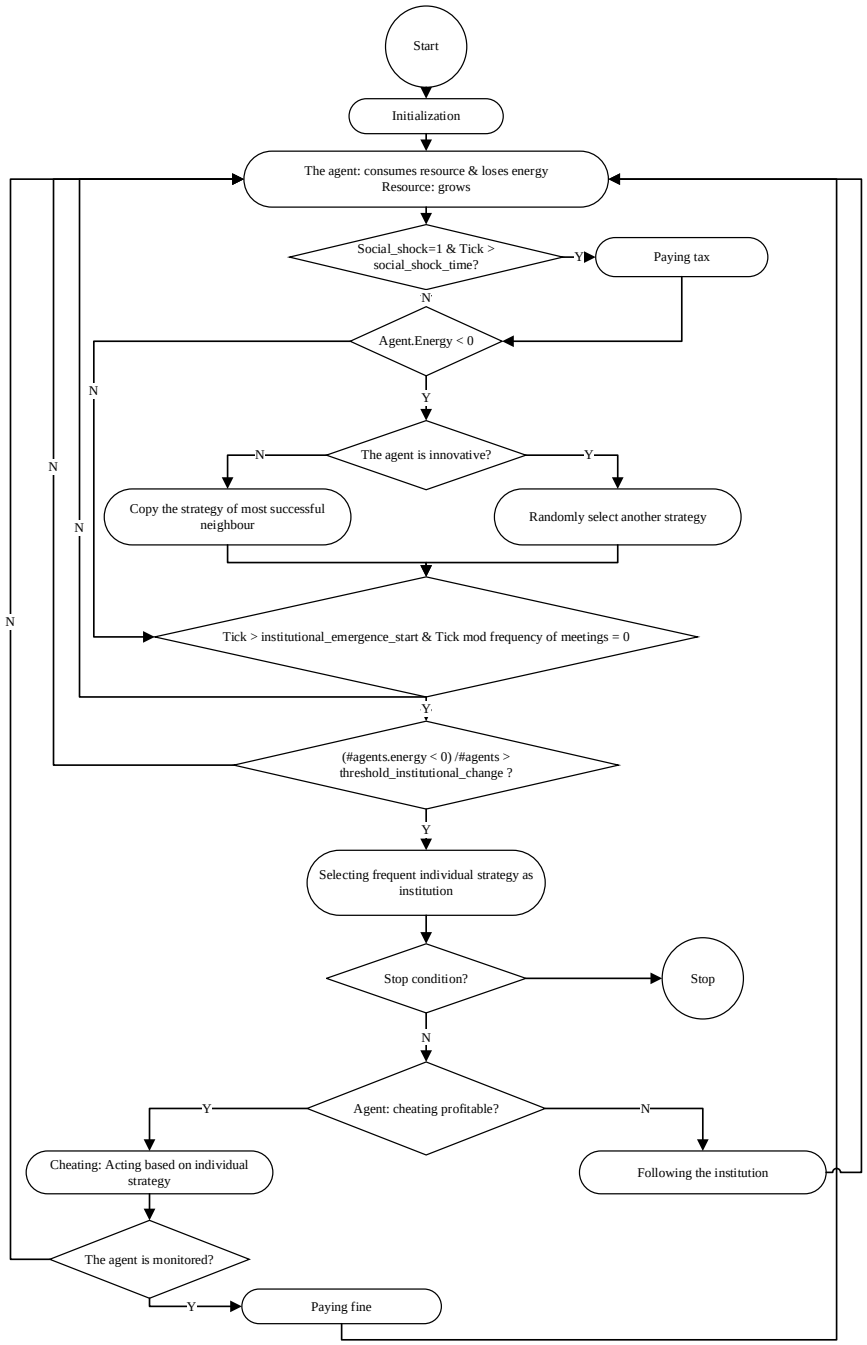

Figure 1 Model overview

DESIGN CONCEPTS

THEORETICAL AND EMPERICAL 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) and copying behaviour.

INDIVIDUAL DECISION-MAKING AND SENSING

The agents follow a basic decision making process. They look at their yield level to make decision. The agents also decide whether they would comply with the institutional rule, or follow their own strategy. They do this by comparing the potential yield gain from each action and select the most profitable one, depending on the cheating propensity. This is also the only "prediction mechanism" in the model.

LEARNING

The agents do not have learning abilities. They only check their current yield level to decide whether they want to continue their existing strategy or select a new one.

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 energy 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 behavioral strategies and homogeneous with respect to all other parameters.

DETAILS

INITIALIZATION

The model starts by all agents having 0 amount of energy. This amount will decrease based on a given constant value (energy consumption) and will increase (or decrease) based on the strategy that the agent is choosing then following.

References:

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.