The evolution of social norms for renewable resource exploitation

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Goal

To develop a model in which social norms evolve that regulate harvesting of a renewable resource.

Background and motivation

This research is motivated by the observation that a lot of renewable resources are severely depleted, while others are conserved very well. Many scientists, inspired by Hardin (1968), have argued that privatization of common-pool resources is the only way to overcome the so-called “tragedy of the commons”. This view has been contradicted in numerous case studies that revealed how government interventions may deteriorate the situation (Somanathan 1991). In fact, neither government intervention nor the property-rights regime alone can explain why certain resources are managed better than others. It seems that local participation is an important factor for success. Hence, some governments are transferring the control of resources back to local communities. The overall results of this policy are mixed (Knox and Meinzen-Dick 2001).

All of those approaches suffer from the assumption that the institutional setting is exogenous. Instead, institutions often evolve together with the resource (Ostrom 1990). The outcome of such a process is difficult to understand and predict, since both the institutions and the state of the resource change over time. Successful policy design is therefore only possible if the different complexities at the resource level and at the community level are understood and taken into account (Baland and Platteau 1996). Concerning dynamics at the community level, a lot of confusion arose due to unclear terminology and fundamentally different theoretical presumptions (Bowles and Gintis 2002). This intellectual ambiguity mostly results from the fact that observed collective behavior is not just the aggregation of individual actions (Coleman 1990). Instead, individuals act differently in a certain group, since imitation and social norms influence choices. When individuals are not entirely sure about appropriate behavior, as a shortcut they may just do what everyone else or a particularly competent individual is doing. When the overall uncertainty is high, this mechanism may lead to herd behavior. This is particularly visible in situations such as riots, escape panics, or financial crashes, but also in fashions or fads (Noelle-Neumann 1974; Granovetter 1978; Dornbusch et al. 2000; Gladwell 2000; Bettencourt 2002; Scheffer et al. 2003). Imitation models often borrow mechanisms that come from the field of epidemiology. These mechanisms are by their nature deterministic and therefore silent about the question why a certain type of behavior evolves in the first place. This brings us to the second mechanism: The evolution of social norms.

Very much like imitation, social norms can be interpreted as a shortcut that helps individuals make the right choices when information is not perfect (Cialdini 2001). A social norm is defined as a customary rule of behavior that is self-reinforcing (Young 2003). It is sustained as individuals fear external sanctions, like punishment or disapproval, or feel internally obliged to follow the norm (Kendal et al. 2006). Norms do of course not emerge randomly, but evolve for a reason. Coleman (1990, p. 241) notes that there must be a certain "demand" for a norm, i.e., the norm may help solving a coordination or externality problem. This point has been made earlier by Arrow (1971), but is not undisputable since certain norms seem to make everybody worse off (Elster 1989). On the other hand, many norms that may look futile now may have been appropriate at the time they evolved. It is important to make two remarks at this point. Firstly, none of the explanations are mutually exclusive. It is very likely that imitation and social norms influence behavior at the same time. Second, these explanations are not necessarily at odds with the concept of rational, profit-maximizing agents. Especially in situations in which information is sparse and uncertainty is high, heuristics may offer a decent outcome, since the alternative would not be a well considered move, but a random guess.

Research questions

The main purpose of this project is to develop a model that sheds light on the following questions:

1. How do social norms for renewable resource harvesting emerge?
2. What determines the sustainability and resilience of an established system of social norms?

The first question can only be answered by taking environmental and social feedback effects explicitly into account. While those feedback effects may lead to countless different outcomes, they are not necessarily unpredictable, because the underlying mechanisms are most likely stable. Therefore, it is an important first step to develop a model in which these general environmental and social feedback effects are defined. Including local differences by adding specific factors that may be environmental, social, or economic, will help revealing why different environmental conditions lead to different norms. Factors that may be of interest are temporal and spatial variability of a resource, or economic dependence on the resource. The second question is especially interesting for policy makers, who try to strengthen a system of local social norms. Factors of interest could be the influx of new agents or changing economic outside options.

Methods and work plan

Will the real model for social norms please stand up?

While there is broad consensus on the importance of social norms for explaining human behavior, science has reached anything but consensus on how to model them. Very often a norm is simply defined as an equilibrium of a dynamic game (e.g., Sethi and Somanathan 1996). While this may be true in some cases, this definition is very broad, as it does not satisfy what Coleman called demand for norms. This confusion is not surprising, since norms operate both at the individual level and at the population level. In this micro-macro transition, aptly described in Coleman (1990, pp. 244), norms are part of a feedback process, as individual actions shape the norm, which in return influences individual choices.

While this is verbally compelling, it is hard to implement in a framework based on evolutionary game theory. First of all, typical models of evolutionary game theory require an a priori defined set of competing strategies, such as cooperation and defection, which is of course a simplification, since an extraction level is in fact continuous. This shortcoming is, however, not the largest problem. Standard models of evolutionary game theory cannot distinguish dynamics at the individual and at the population level. It is impossible to say whether there are indeed two competing norms or if all agents follow the same strategy and defect with a certain probability, since both situations would lead to the same result. This is a general degeneracy of matrix games, as pointed out by (Dieckmann and Metz 2006). Besides, a framework based on unconditional strategies does not allow for institutional change, such as a higher tendency to cooperate if the resource is threatened with extinction (Sethi and Somanathan 1996).

In other models, a certain norm, e.g. inequity aversion, is introduced in the utility (payoff) function of an individual (e.g., Falk et al. 2000; López-Pérez 2006). While these models explain human behavior quite well and do not sacrifice the concept of utility maximizing agents, they are theoretically cumbersome as any norm has to be introduced on an ad-hoc basis. Besides, optimizing agents base their decisions on their objective functions and on the constraints they have. Some authors argue that norms are rather a constraint than an objective (Baland and Platteau 1996, Ch. 6).

Social norms as function-valued traits

We have seen that simple models of evolutionary game theory lose much of their beauty since they cannot separate actions from norms. Another class of models assumes that agents may sacrifice a norm for other objectives or goods. While this is true, it is theoretically ill-defined, since a norm is treated as a commodity or as a constraint, while it is more: It is a certain code of how individuals should behave in certain situations (Akerlof 2007). Therefore it is neither a commodity, nor an action as such, but some kind of rule that translates information into action. While economists have reached and realized this point often, they stop here, as they run out of models. Biologists, on the other hand, deal with this kind of problems very often and have an arsenal of tailor-made tools to analyze them.

The translation rule implied by a social norm is akin to a reaction norm of classical biology, which, for a given genotype, describes the pattern of phenotypic expression across a range of environmental conditions. In the particular case we wish to analyze, agents will choose a certain extraction level. This choice is based on observable information and the social norm, where the social norm is the mediator between action and information. Such reaction norms, or, more general, function-valued traits, will face selective pressures (Dieckmann et al. 2006). The same holds for social norms. It is then examined whether an existing norm, hold by everyone, could be replaced by a different norm. If a new norm will have a higher chance of being adopted than the existing one, the new norm will replace it. In its simplest form, this approach is based on the assumption that the resource dynamics inside the community is at equilibrium when a slightly different norm tries to "invade". Invasion occurs as a result of slight adjustments in the social norms adopted by agents or because new agents arrive from outside the community. The resultant dynamics will be analyzed with concepts that come from the field of adaptive dynamics (Dieckmann and Law 1996; Metz et al. 1996; Geritz et al. 1998).

The translation from information into action

In our planned model, three sources of information serve as input variables:

1. *Resource status;* which reflects the demand for the norm. If it is in the common interest to reduce harvesting effort and if there is a certain need or urgency, an agent may be more willing to do so. As an easy start, we will assume that a resource will grow according to a logistic growth function. A straightforward extension would be to assume an Allee effect. If this effect is strong, the resource will

go extinct when falling below a certain threshold level. If it is weak, the population will remain viable, but will grow at a lower rate. Further extensions would be to include environmental stochasticity, or a growth function that allow catastrophic regime shifts (Scheffer et al. 2001).

2. *Monetary payoffs;* which reflect net profits of different choices. A very basic starting point would be to assume that the profits (π) depend on the effort level (e), which has a certain cost (w), while the harvest (h) delivers a certain revenue determined by the price (p): $\pi = p * h - w * e$ and $h = q*e*x$, where x is the resource stock and q is an efficiency coefficient. It is convenient to assume that w, p and q are exogenous. The linear harvesting function may be too simple for certain resources, for instance, in fisheries interfering nets and queuing vessels may reduce efficiency. Besides, larger fish stocks may lead to decreasing marginal harvest rates, as nets may become congested. A straightforward possibility to account for both would be the use of the following function: $h = f(E) * q * e * x^{\alpha}$, where $\alpha <$ 1 and $f(E)$ is the aggregate effort of all agents that takes values between 0 ((for $E = \infty$) and 1 (for $E = 0$). The harvesting function could also include stochastic effects due to exogenous shocks, such as weather effects. This may be important if agents require a certain subsistence level of income, leaving no other option than excessive harvesting. This may not be the case if cooperation will reduce current risk and variability, since the chance to fall below the subsistence level is then reduced (Swallow 1995). In a similar vein, agents may be more inclined to reduce harvesting if the resource acts as an insurance (Baland and Francois 2005). Furthermore, outside options may incline the agent to harvest excessively (Tarui 2007).
3. *Past actions of other users;* since this determines which behavior is appropriate. Individuals want to avoid being the one sucker that has reduced efforts, while no one else has, but people also want to avoid anti-social behavior when everyone else is cooperative. Evolution of social norms is closely related to conformity (Bernheim 1994), since non-conformity may lead to punishment or loss of social status that reduce an individual's profit. A simple functional form to start with would be to consider the average or the modal effort level of all agents.

Based on these input variables, the agent chooses an appropriate effort level. "Appropriate" in the sense that it is consistent with the social norm the agent holds. While the resource dynamics and harvesting dynamics take place continuously, the updating of the social norms take place in discrete steps. This distinction is due to the assumption that agents may change their behavior frequently, whereas the underlying social norms or opinions change only slowly.

The transmission of social norms

The question whether a resident social norm is replaced by an invading norm depends on the fitness of the resident and the invader. Fitness is usually interpreted as the number of expected offspring, or more precisely, as the long-term per capita growth rate in a given environment – but different definitions and measures are used as well (Metz 2006). In the particular case we plan to analyze, the mechanisms underlying the definition of fitness are less clear, since we are not dealing with reproduction, but with human behavior.

Two transmission mechanisms are prominent: (i) payoff-based transmission that favors the norm that yields the highest payoff, and (ii) conformity-based transmission that copies the most frequent behavior (Henrich and Boyd 2001). Both mechanisms can be combined in a straightforward way, by assuming that the probability of social norm s_i to be imitated is given by $p(s_i) = \pi_i^\lambda / \sum_{j=1}^n \pi_j^\lambda$, where the parameter λ can take any value in the range (0, ∞). If λ is set to zero, the probability of imitation will be equal to the relative frequency with which strategies are represented among agents $i = 1, \ldots, n$. If λ approaches ∞, only the most successful norm will be imitated. For the use of a similar function in a different context, see Egas et al. (2005). The model could be extended by assuming that imitation is not only based on profits, but also based on social appreciation.

Work plan

It will be desirable to start not too complicated, since this project combines theories from different fields and parsimony may induce understanding. One appropriate framework will be an agent-based model; another will be the canonical equation of adaptive dynamics. Instead of using continuous actions, one could also start with binary ones, simply indicating whether or not to exploit the resource. The same could be assumed for the three input variables in the sense that below a certain threshold the agent switches behavior (Posch et al. 1999). This may facilitate interpretation and analysis. This would leave two possibilities for each of the three input variables, resulting in eight different situations an agent could face. The three threshold levels would evolve over time, together with the eight extraction levels the social norm prescribes for the eight different situations. This setup would thus result in models incorporating 3 + 8 = 11 continuous evolving traits.

Relevance and link to EEP's research plan

This research is very close to EEP's project Evolution of Cooperation and, moreover, uses tools developed in EEP's project Foundations of Adaptive Dynamics. Earlier work at IIASA has shown that this synergy can be particularly fruitful. Adaptive dynamics is a relative new concept and is therefore still unfamiliar to most scientists outside theoretical biology. Particularly the economic science is more and more interested in using concepts such as evolution, coevolution, and adaptation, in order to explain economic changes and human behavior. Therefore, it may very well be possible to make an impact there.

Expected output and publications

This work will be part of my PhD thesis and is intended for publication in an international scientific journal.

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