A model of Decision Process Mixing Rational Anticipation and Social Influences : Example of Agri-environmental Measure Adoption by Farmers

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Introduction

Within the research on simulating societies (Doran and Gilbert 1994; Epstein and Axtell 1996), many recent models propose dynamics of decision mixing a rational preference term and an influence coming from interactions with other agents (for instance :(Arthur and Lane 1993)). The present work is original by the use of interactions on continuous uncertain opinions. This choice has been implied by the aim to build a realistic model of a particular opinion dynamics.

The considered case is the adoption of agri-environmental measures (AEM) by farmers[1]. The AEMs have been implemented all over the European Union. They define a list of specifications (requirements for change of practises) and define corresponding payments. Typical examples are reduction of pesticides in order to preserve water quality, different practises favouring biodiversity, landscape improvement, organic farming conversion. All the studies confirm that the rational cost-benefit calculation is generally not the only factor taken into consideration in the decision of adoption (although it is very often important in the decision). It seems that a social aspect, which can be defined as a norm or an image of farming has an influence in the decision.

We propose a model which simulates the interactions between farmers, and the reception by farmers of messages from institutions in this context of AEM adoption. Some messages can modify the anticipations on which the decision is based. On some aspects however, the farmer can have a rational individual reasoning.

Methodology

Decreasing simplification

Modelling social systems is very difficult, and always leads to face the dilemma emphasised in (Lindenberg 1992):

- either to simplify dramatically the problem in order to be able to use analytical and mathematical tools, but in general loose any real link to the problem
- or try to incorporate as much details as possible and loose any generality.

Following (Lindenberg 92), we try to develop of a series of models instead of a single one. The models share a common core (same principles), but are developed at different levels of details.

The main advantage of this approach is to enable the comparisons between the different levels and to ground the choices of the simplifications. Moreover, the analytical study of simplified dynamics gives a better understanding of the more complex levels.

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Data and expertise used

The model uses several types of data collected for 8 studies zones in Europe :

- statistics on farmer populations and farming activities
- adoption of measures in the time
- specific farmer interviews (350 in a first collection and 120 to refine some aspects of the model)
- specific interviews of institutional actors involved in the definition or the implementation of the measure.

These data and the connected expertise led us to make several choices for the model (stages of decision, motivations, anticipation of impacts…).

Moreover, they are used as a base for generating an artificial population of located farms, with realist social networks (Degenne and Forsé 1994) and farming activities.

The core model

In this section, the basic choices of the core model are described. This core model is developed at different levels of details, and the comparison of the results at the different levels brings some understanding.

Farmer agents

The farmers are represented by a set of variables descriptive of the farm and of the decision (motivation, anticipations, state of decision). A set of farmer and institutions to which the farmer is linked is also part of the farmer's description.

Descriptive variables

We consider a population of farmers : $(F_1, F_2, ..., F_N)$.

- $\mathbf{v} = (v_1, v_2, ..., v_n)$ a vector of variables describing the farm and the farmer (farm activity, age of farmer, size of farm, location…)
- $\mathbf{m} = (m_1, m_2, ..., m_p)$ a vector of motivations.
- $\mathbf{a} = ((a_1, d_1), (a_2, d_2), ..., (a_q, d_q))$ a set of anticipations of the consequences of adoption on different aspects (income, workload, biodiversity…), and the associated uncertainties. At the beginning of the simulation (when there is no knowledge about the AEM), the uncertainties (d_i) are maximum.
- A set of farmers associates and a set of institutions with which the farmer has contacts (his social network)

Interactions

Each farmer interacts with other farmers and institutions. The other farmers are in his social network. We consider that the relevant messages transmitted can be coded into a vector of anticipations.

Therefore we consider a farmer *F*, with a set of anticipations (or opinions) $\mathbf{a} = ((a_1, d_1), (a_2, d_2), ..., (a_q, d_q))$ interacting with an other farmer *F'* or an institution having a set of opinions $\mathbf{a}' = ((a'_1, d'_1), (a'_2, d'_2), ..., (a'_q, d'_q))$.

Let Δa_i and Δd_i be the changes of a_i and d_i that occur during the interaction between *F* and *F'*.

The interactions are based on the following principles :

- people who have a strong conviction or certainty are much more difficult to influence,
- when the opinions are too far from each other, they do not influence each other.

More precisely, the changes are given by the following equations :

If $|a_i' - a_i| < d_i$ then : $\Delta a_i = \mu.(a'_i - a_i).\frac{d_i}{d_i + d'_i}$, $\Delta d_i = \mu.(d'_i - d_i).\frac{d_i}{d_i + d'_i}$ with $(0 < \mu < 1)$.

The theoretical properties of these dynamics are under study.

Decision process

From the results of farmer interviews and the literature, we identify 3 different stages in the farmer's decision. These stages are defined by comparing the scalar product **m**.**a** to some thresholds.

- Preattentive stage : the farmer is passive and essentially receives messages from other farmers and the institutions. When $\mathbf{m}.\mathbf{a} > T_1$ the farmer goes in the information search stage.
- Information search stage : the farmer seeks information and intensifies his contacts with other farmers or institutions who could give him information. Once the farmer has been able to contact farmers or institutions which gave him relevant information for the technico-encomic anticipations, he goes into the decision stage.
- Decision and Post decision stage : The technico-economic anticipations (some components of **a**) are calculated as an expert function of **v** (rational reasoning). If $\mathbf{m}.\mathbf{a} > T_2$, then he adopts the measure, otherwise he does not. Then the farmer decreases his contacts (but still answers the requests from others).

Institution agents

The model includes a list of institutions : $(I_1, I_2, ..., I_K)$. The model focuses on the diffusion of adoption among farmers. In this context, the role of the institution is considered only as provider of opinions about the AEM, with an associated conviction, and information provider. The actions of the institutions are ruled by a predefined script, specifying the messages and information transmitted to different types of farmers during the implementation of the measure.

The global algorithm

The global algorithm essentially rules the interactions between institutions and farmers, and among farmers. The interactions between institutions and farmers are ruled by predefined scenarios, while the interactions between farmers are ruled by the interaction frequency matrix and by the stage of the decision process.

Results

The models give us the evolution in time of several variables : the general interest for the measure, the requests to institutions, the anticipations of the different farmers, the role of potential leaders (farmer or institutions)…These results have to be analysed for the different levels of modelling through careful protocols of simulations (to evaluate the robustness of the results). These protocols and results will be presented in the full paper.

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