INRA SCIENCES SOCIALES

N° 4-5 – SEPTEMBER 2008

RESEARCH IN ECONOMICS AND RURAL SOCIOLOGY

Reducing nonpoint source pollution

The stakes in the quality of water resources and human health are such that intensive research on the control of farming nonpoint source pollution has been engaged, as attested by the INRA and CEMAGREF report on "pesticides, agriculture and the environment". Economists provide their own understanding of the public mechanisms of management but this action involves the mobilisation of a wide range of scientific fields.

Society is showing increasing concern about pollution matters. At the European Union level and that of Member States, these issues have led public authorities to set restrictive rules (ban on molecules, review of accreditations, listing of sites, zoning) and create mechanisms encouraging the adoption of more respectful behaviour towards the environment. These tools vary greatly depending on whether the emitter's (polluter's) responsibility is verifiable or not.

Greenhouse gas emissions may be partially attributed to a small number of well-defined firms. In such cases, it is possible to fix a maximum emission standard compatible with the requirements of society and to distribute title deeds corresponding to a socially admissible volume of emission; the firms, according to their needs and to technological innovations, may trade these permits on an emission trading market.

When the people responsible for emissions are very numerous, small-scale and geographically dispersed, checking the responsibility of each person becomes more difficult and significantly more expensive. The lack of monitoring resources encourages cheating, making solely market-based tools inefficient. Quite often, a regulatory approach is the only one possible: a speed limit of 130 km/h on motorways will reduce the CO2 emissions of a large mass of vehicles but will also separate the innocent from the guilty without any ambiguity, as the repression of deviant conduct reinforces the incentive to behave.

Polluting emissions in agriculture belong to both of these cases

The wastes induced by the cleaning of phytosanitary sprays is occasional pollution: it is possible to trace the concentration of polluting materials back to the source equipment and thus to its owner. This ownership means the polluter's responsibility is unambiguous.

Standard recommendations may be enacted; non-compliance may be punished.

The waste induced by the use of organic products in small amounts by a lot of farmers falls under the second type of pollution. The inputs in manure, weedkillers, products to protect against insects, acarids, fungi, even under accredited conditions, create aggravated mass effects in the Mediterranean environment under study (because of the lack of rain, delaying the degradation of active molecules), resulting in runoff which considerably exceeds the permitted concentrations at the water abstraction points. Individual responsibility is only engaged because of the harmful effect of a sum of behaviours which, taken individually, would be acceptable. Sanctioning the consequence requires an understanding of the relationship existing between the individual contribution and the collective norm not to be exceeded. This explains the importance of voluntary procedures (like Fertimieux, in France, also, Becker (1998) would for US-experiences…[1]) in such matters. Although their efficiency is still debatable, they have the advantage of circumventing the question of identification of the people responsible. Since the collective penalty cannot be considered as law, since it punishes the innocent with the guilty, the public authorities must use their imagination to control this lack of information. This is what makes the study of collective performance-based mechanisms very lively among economists.

Management approaches to nonpoint source pollution

In spite of abundant studies, few approaches are available.

[1] R.L.Becker (1998), "integrating the management of weeds and impacts on the environment: High Tech Research or Education Solutions" in *integrated Weed and Soil Management, JL Hatfield, DD Buhler and BA Stewart edit.* 385p.

The first approach is based on a penalty for the use of inputs which are at the source of polluting emissions. If the link between product use and polluting concentration were linear, this measure would be efficient as it is verified in experimental economics. Under this assumption, for a sufficiently elastic demand, a penalty for polluting input is the best public tool to control nonpoint source pollution.

Frame 1: choice of farming practice and transfers of pollutants

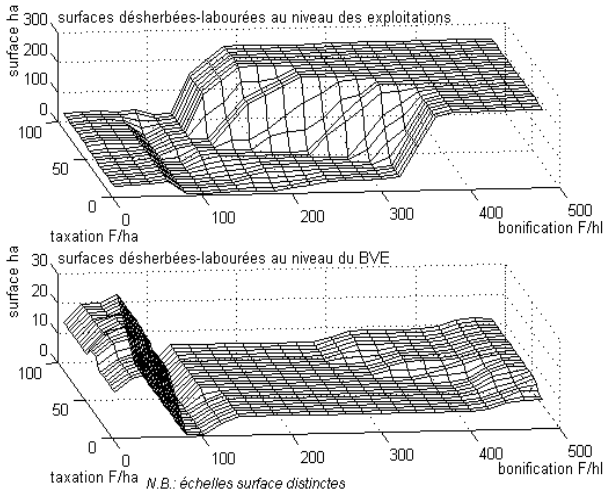
Emitting pollutants is the result of a decision-making problem. If pesticide transfers may be described on the basis of a hydrological model like MHYDAS, the spatial organisation of the ditch network, the hydraulic conductivity at saturation of the ground surface area, the weed killer volume emitted and its date of emission, which are all key parameters in this model, refer to the behaviours adopted by vine growers: integrated organisation of superficial flows, soil work and application of chemical weedkillers.

These two last parameters may be assessed by describing a decision-making model where the vineyard is described as a set of objectives, resources and constraints. This model allows the sensitivity of the vine grower's choices to be assessed with the variation in the value of the key variables such as the inputs price and the remunerations of the products.

By reading these variables according to increasing values, we see the vine growers' strategies change. Let us consider the surface areas, expressed in hectares, which benefit from mixed practice (ploughing in the inter-row and chemical weeding of the row) on the modelled area (27 vineyards of the catchment area of La Peyne (Hérault) with one plot in the elementary catchment area of Roujan) (graph 1).

We observe:

- *A low sensitivity to the increase in weed-killer prices (tax)*
- *A high sensitivity to the increase in the product return*
- *A non-linear answer, the increase in return only being effective if it permits the employment of an additional worker*
- *An answer that specific constraints of plot accessibility (narrow gaps) may impede as we see it for the plots of the catchment's area, called BVE on graph 1).*



Graph 1: answer (in ploughed hectares) to an increase in the remuneration of the wine hectolitre produced and to the tax of polluting inputs (weedkillers).

Unfortunately, this assumption is not usually verified. Pollutants' concentrations depend on improper use (badly adjusted spray pipes, excessively fast moving speed of the equipment), on the characteristics of the plot (which impacts on spatial dispersal in the soil) or on the plant (development stage).

The second approach is based on the idea that a good understanding of farmers' behaviour would provide a good forecast of the emissions (frame 1). This approach in modelling mobilizes economists but also agronomists, hydrologists, and cognitive scientists providing a representation of knowledge (frame 2). At the agronomic level, a number of choice determinants in weeding and soil maintenance practices are well identified. They relate to three levels of the spatial organisation of practices:

Frame 2: Innovation adoption and networks

Adopting new technical propositions is an important stage in the process of reduction of the use of products that are aggressive towards the environment and health.

We used to represent the process of adopting a new technology by supposing two things: (i) the innovative object is well defined and (ii) the beneficiaries are distributed according to their propensity to adopt (pioneer, early or late adopter ...), which explains the diffusion following a S-curve of the innovation among the population.

Sociologists then put forward the translation *processes which help agents use the technique, by modifying the implemented itineraries but also by giving it sense inside the network to which they belong. Allowing these technical and social interpretations of the innovations, the dialogue networks are a key to understanding why the extent of an adopter's strategic choices varies, entailing the presence of a given itinerary in one municipality and the absence in a neighbouring one (the alternation of grassy and weeded inter-rows in Caux and not in Alignan du Vent, for our study case).*

1) The plot: The narrowness of inter-rows hampers mechanical work on the soil and thus favours the use of weedkillers, for instance;

2) The farm: the cost of phytosanitary products, fertilizers, fuels, the availability and the disutility of work but also the product price according to its purpose (quality wine or table wine, proportion of aromatic grapes) will all have an impact on the choice of a farming practice;

3) The territory: the municipality or cooperative winery with which the vineyard may be associated and, more generally, the professional or local network to which the vineyard belongs.

On the economic level, we understand better the points which affect the choices of practices:

- The costs: the prices of fertilizers, phytosanitary products, fuel (a "treatment", particularly for fungicides, is the number of times the tractor passes through the plot)
- The work: its availability, price, disutility (what profit it brings compared with the potential alternative use, leisure time for instance)
- Last, the products: according to their purpose (quality wine, table wine), the potential of the grape varieties (proportion of aromatic grapes) and their remuneration.

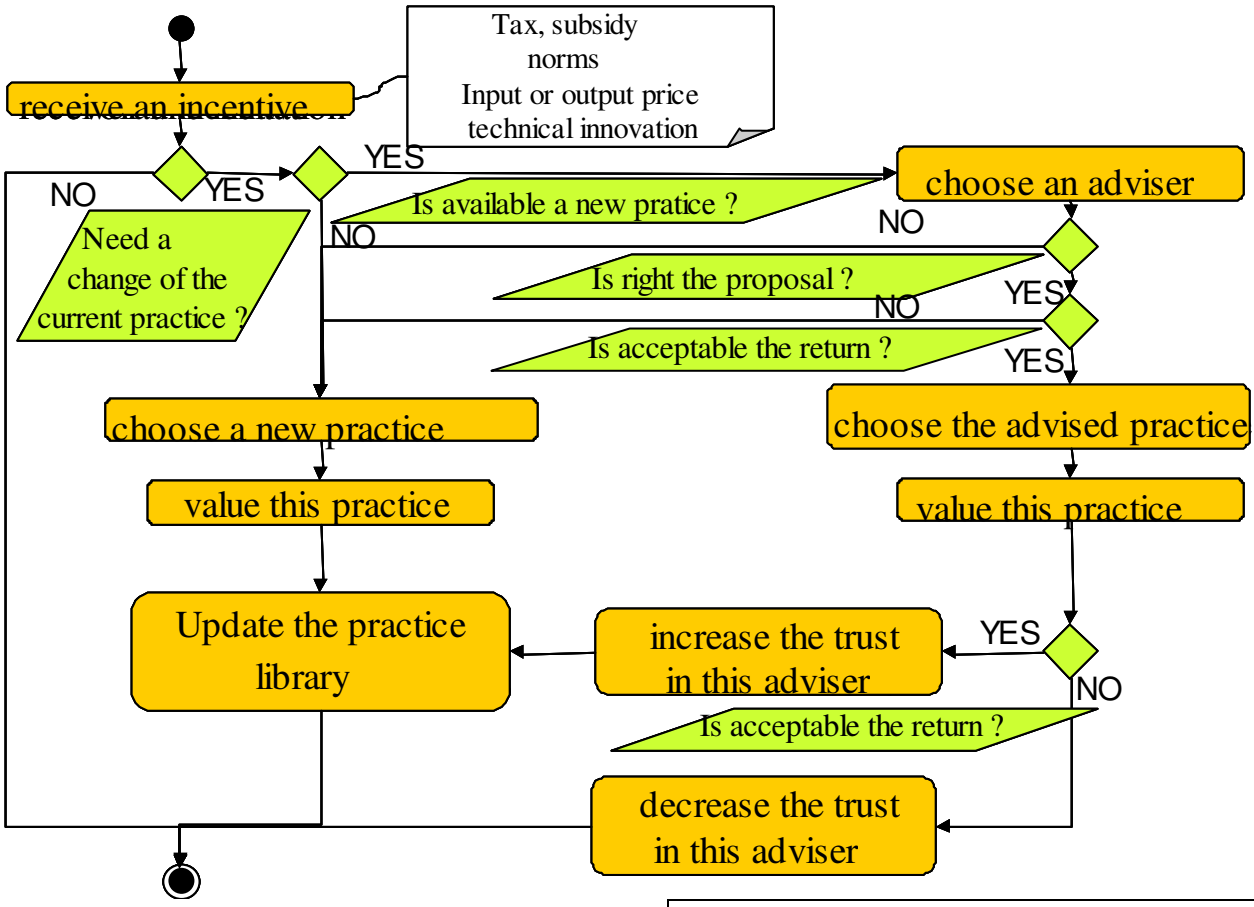
With such a description, we may assess the impact of the various public tools aiming to penalize the practices that are unfavourable to the environment such as inputs taxation, or to encourage the adoption of good practices by means of allowances or bonuses applied to the product.

Developments in this approach are concerned by understanding the farmers' behaviours facing technical or financial risks. The choice of technical itinerary seems to be defined by an objective to limit the variability of yields, via control of the plant's robustness. This objective probably also explain their behaviours relative to prophylaxis. Controlling the yield variability looks like an objective for the farmer, he tries to achieve via the control of the vigour of the plant.
We also attempt to refine the coupling of this decision-making model with the hydrological one, which by simulation will get around the non-observability of individual practices. This research direction also fits into the third approach proposed to help manage nonpoint source pollution.

This third research approach attempts to take advantage of the possibilities of observing the collective behaviour of a group of polluters, such as the sampling of water at the outlet of a catchment area. In this approach, the regulator penalizes or rewards the emitters located in this area in proportion to the difference with a target representing the community objective. To guarantee the deterrent or attractive nature of the process, the rate of penalty-subsidy is set at a very high level. One disadvantage of this mechanism revealed by the laboratory experiments is that an incentive rate leads emitters to overreact pro–environmentally to the extent of not producing (and thereby receive the subsidy associated with the reduction) rather than risk a penalty.

To control this bias, the instrument was limited to the penalty for exceeding the norm. But even then, this mechanism poses a legal problem - it brings into play a notion of collective responsibility - and a problem of efficiency: how do you get an agent who has complied with the public objective to behave once again in such an exemplary manner if the other agents' actions have penalized him? To guarantee the stability of this instrument, a mode of individual involvement must be implemented, in the form of a contract, a bidding process or an allocation of rights to pollute.

However, the approach is risky and these schemes usually present a certain bias: controlling actions is still a problem.



Graph 2: adopting innovation, apprenticeship and network

To understand how a network forms seemed important to study in order to assess the transmission of innovative ideas. Among other parameters, building an agent's confidence in its potential advisers, (see graph 2) more significantly affects the transmission speed of an innovation than the network structure (described by the number of links between members).

Because of the nonpoint nature of the pollution, we have lost every link between the pollution emitted and a title deed on the pollutant.

But restoring this link is possible if the agents themselves must commit to each other to their contribution to reduction: choosing new practices favourable to the environment or acquiring additional rights from other agents. By negotiating the efforts they agree to make, each one is led to reveal what the community objective will cost him. So the search for an equitable allowance leads to equivalences between the marginal cost of reduction and the rights exchanged, which coincides with the setting of the market price that would be obtained.

Conclusion and prospects

The management of nonpoint source pollution remains a difficult exercise, although the group-performance-based mechanisms and the negotiation offer a possibility of encouraging emitters to behave in an environmentally-friendly manner. An assessment of the qualities of the mechanism assumes a good understanding of the dynamics to which the winegrowers are committed and which limit their capacity to change practices, particularly as regards vine protection. This fundamental work is in progress.

Patrick Rio, INRA UMR-LAMETA
rio@supagro.inra.fr

For further information

INRA, CEMAGREF – 2005 – Pesticide, agriculture et environnement
*www.**inra**.fr/l_institut/expertise/expertises_realisees/**pesticides**_agriculture_et_environnement*

Ali M. and P. Rio, (2007), Negotiating the initial permits allocation as a revelation mechanism in nonpoint source pollution, 15th EAERE Annual conference; 2007/06/27-30 ; Thessalonique (GRC)

Biarnès A., P. Rio, A. Hocheux (2004), Analyzing the determinants of spatial distribution of weed control practices in a Languedoc vineyard catchment,Agronomie, vol. 24, n°4, pp. 187-196.

Houdart M., Bonin M., Bousquet F., Rio P.. (2007). Un modèle multi-agents pour évaluer le rôle des réseaux dialogiques sur la dynamique de l'innovation en agriculture, *ESSA'07, 4th Annual Conference of the European social simulation association, Toulouse, France September 10-14,* 11 p.

Rio P., F. Causeret, P. Andrieux, C. Dejean, E. Frot, X. Louchard (2004) Choix de pratique culturale en présence d'incitations à la réduction des émissions d'herbicides : une simulation en milieu viticole méditerranéen, *in* Monestiez, P., S. Lardon, B. Seguin, edit, Organisation spatiale des activités agricole et processus environnementaux Editions INRA Editions, Paris (FRA), pp. 65-78.

Published by the INRA Social Sciences, Agriculture and Food, Space and Environment
Publishing unit: Editorial Director: Bertrand Schmitt– Editor: Didier Aubert (Chief Editor),
Translation and composition: Ariel Gille