Water allocation, crop choice, and priority services

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Agricultural Irrigation in the World

- A major producer: 20% of arable lands, 1/3 of total food production;

- A major user of water, especially in dry/hot seasons;

- Often: very low or non-extant pricing; administrative system of licenses; uniform rationing in case of drought;

- Some recent attempts at creating water markets (California, Chile, Australia).

Agricultural Irrigation in France

- 6% of total arable land, with wide regional disparities (40% for maize);
- 50% of water consumption, up to 90% in summer;
- From a system of individual allowances, with uniform rationing in case of drought ...
- ... to "organismes uniques": local organizations in charge of local sharing of water.

Some questions

- What is wrong with a system of uniform rationing?
- What is wrong with a market system?
- Are there alternatives to markets? (Yes: priority classes!)
- What are the Political Economy effects of a reform?

A simple, local framework

Consider a group of n farmers, indexed by $i = 1 \dots n$.

Initially each farmer has to choose what to grow: vulnerable or robust crop. Let x_i be the vulnerable crop area for farmer i.

Then there is a climate shock s, determining the total quantity of available water $Q(s)$.

Finally institutional rules determine individual allocation $q_1, \dots, q_n$ of water ...

... and each farmer i gets a revenue that depends on x_i, q_i, s, and i (farmers may be heterogeneous).

The uniform rationing system: definition

The rule is:

Total available water is allocated proportionally to individual vulnerable areas $x_1, \ldots, x_n$.

The uniform rationing system: ex-post inefficiency

An allocation of total available water is ex-post efficient if it maximizes the total revenue of farmers, for given choices $x_1, \ldots, x_n$.

Uniform rationing is typically ex-post inefficient:

- An exception is the case of identical farmers choosing the same x_i (still one may prefer to concentrate available water on a subset of farmers);

- In general, with heterogeneous farmers, water should be allocated to those who marginally produce more wealth from water.

The uniform rationing system: ex-ante inefficiency

An allocation of land and of total available water is ex-ante efficient if it maximizes the total revenue of farmers.

Uniform rationing is typically ex-ante inefficient:

- Each farmer chooses to increase x_i so as to benefit from a higher share of water;

- This leads to an over-optimal size of vulnerable crop.

This effect is stronger if water is often rationed.

The uniform rationing system: the case of France

There exists a 'redevance prelevement'; but it is very small, and rigid (around 1c/m3; farmers represent 3% of the total revenue).

For the four years 2011-2014, 8.950 prefectoral decisions to impose uniform rationing in 1320 zones.

50% of zones below 5 decisions; 25% above 10; 3% above 30.

For the 100 french departments: 4 departments got more than 500 decisions.

The uniform rationing system: Political Economy

A lobby is more effective if its members are more numerous and more homogeneous (Olsen, 1965).

Uniform rationing make farmers over-expose to climate risk by investing too much in vulnerable crops.

So the story to be inquired is that of a self-perpetuating situation with too much vulnerable crops, homogeneous farmers, strong lobbies, higher demand for water, and finally more frequent crisis.

The market system: definition

The rule is:

Ex-ante, farmers are given rights on shares of available water (independently from their choices x_i).

Once total available water $Q(s)$ is known, farmers are free to buy or sell rights on a 'spot market'.

The market system is efficient

(Basically, the old but powerful story about the price that equalizes demand and supply $Q(s)$.)

It is ex-post efficient, because water goes to the farmers who are ready to pay the highest price, or equivalently who produce more wealth from water.

It is ex-ante efficient, because farmers anticipate they will have to pay for water, and thus each farmer chooses the right value of x_i.

It is budget-balanced: money is tranferred among farmers.

Comparisons

(under technical assumptions on profit functions):

When switching from uniform rationing to a market system:

• Farmers that use water less productively reduce both their land size x of vulnerable crops, and their water consumption in all states s;

• Farmers that use water more productively increase both x, and their water consumption in all states s;

• the overall exposure to risk is reduced, and global profits are increased.

The market system is not so practical

Water demand is high when water is scarce, and vice-versa.

So ex-post spot prices are very volatile. This creates a need for insurance (or forward markets, options, ...).

In case of drought, all farmers are hurt, and all of them may protest against high prices for water.

Consumptions need to be closely monitored.

Lobbies resist the reform, because the market system maximizes the opportunities for differentiation, and therefore leads to the weakening of lobbies.

Priority services: definition

The rule is:

Ex-ante farmers register their different plots in different priority classes.

Each hectare put into a class requires a payment, that depends on the class.

Ex-post, the total available water $Q(s)$ is allocated first to the highest priority class plots, then to the second-highest, and so on until no water is left.

Priority services: remarks

Thie idea comes from Wilson (Econometrica, 1989), but only for 0/1 demand.

We extend it to more general cases, and show an efficiency result for priority services, under additional assumptions.

Hopefully: such a system is politically less difficult to sustain ex-post in case of drought, and easier to monitor.

Priority services: efficiency result

A priority services system (with many classes) is efficient (or: as efficient as an ideal market system) if

• the efficient quantities a farmer should get under a market system are a function of $Q(s)$ only, and not of s;

• In other words: the climate s should not matter too much per se, once $Q(s)$ is known.

Are priority services consistent with 'organismes uniques'?

Article R211-117-2, Code de l'Environnement :

La redevance comprend une partie forfaitaire et, le cas echeant, une partie variable ...
Une deliberation de l'organisme unique arrete le montant de la partie forfaitaire de la redevance, et, le cas echeant, les elements de la partie variable...
La partie variable est determinee, pour l'annee consideree, a partir soit des superficies irrigables, soit des superficies irriguees, soit du nombre de points de prelevements, soit des volumes ou debits demandes, soit des volumes ou debits communiques par le prefet en application du plan de repartition, soit en combinant ces parametres. Elle est le produit d'un taux applique a l'un ou a plusieurs de ces criteres.

How to design and price priority classes

Based on historical observations:

The highest priority class should gather the right number of plots, in order to deliver water with almost certainty

The second-highest: water delivered 8 years among 10

...and the last priority class typically applies uniform rationing, based on water left.

Priority services with insurance

To take care of insurance considerations, one may jointly buy an access to a priority class and an insurance contract, that pays an indemnity in case this priority class is not allowed water.

Example: for a given hectare, a farmer pays 1000 euros for the highest-priority class (and gets an indemnity of 2.000 euros in case this class is not served);

or 500 euros for a low priority class (and the indemnity is 1.000 euros);

or nothing; but then he would better grow a robust crop.

Conclusion

Work in progress: we'd like to

- extend the results;
- characterize winners and losers when switching from uniform rationing to another mechanism;
- include risk-aversion and insurance;
- proceed to an empirical study in the case of France.