

Appendix A

Concepts of elaboration

Decision-making processes

Winegrowers seek to increase their income and their cultivated holdings. To do so, two solutions are available to them: using the cooperative to distance themselves from market fluctuations and thus guarantee a certain stability of income; or face the market alone, withstand price variations, but have the possibility of earning more than in the cooperative.

For the cooperative, the decision-making process is driven by optimizing its production capacity. At the beginning of a period, it inventories the total area of plots that growers have committed, and then adds 10% to be able to cope with additional unforeseen requests during the year.

Reactivity of agents to external conditions

The winegrowers are the only agents that can be influenced by external conditions. They are aware of the land developments of their neighbors and when a plot is put up for sale, and they may acquire it through the intermediary of the ‘plot exchange,’ symbolized by the village in Figure 3. When choosing a new plot, they privilege neighboring plots, since they do not have absolute knowledge of the entire region. They can also choose to join or leave the cooperative.

Observations

We wanted to observe the effect of the cooperative on the landscape and socio-economic characteristics of the region. For this, we compared simulations with or without cooperatives, then in a complementary manner by changing the values of the following variables:

- A bonus comprised of 0 to 1 € per kilo of grapes, in increments of €0.1 (for the price per kg of grape, see Table 4).
- Malus: as for the bonus, the malus varied between 0 and 1 € per kilo of grapes, in increments of €0.1.
- The level of risk propensity α of winegrowers. We varied the level in two ways, resulting in 6 different contexts:
 - by varying the average of α : we ran the model with risk-prone territories (low α), neutral, and risk-averse territories (high α).
 - by varying the risk-prone percentage of the population: the model was run with a random distribution and allocation set at 50% risk-averse ($\alpha=5$) and 50% risk-prone ($\alpha=1$).

Sub-model

For the *viticulteurs* class of agents (Fig. 2)

Cooperative: For each iteration, winegrowers evaluate their status. Is he or she currently a cooperative member? If so, the grower will evaluate whether s/he is able to leave the cooperative. If the grower’s capital is greater than the tax that must be paid to the cooperative to withdraw his/her plots, to which must be added the price of processing (winemaking) equipment and the production costs for the next year, the grower may consider leaving the cooperative.

To consider this possibility, the grower must recall the variations in his/her capital over the last four years, and assess whether the balance is positive, negative, or neutral. In practice, he/she will operate a linear regression on all values of capital that the person's memory is capable of handling. If the slope of the regression line is greater than the cooperative's output (fixed value for the region), the grower can ask to leave. Otherwise he/she will remain in the cooperative. α refers to each individual's inclination to risk growing their crops alone or in the cooperative. While the threshold of risk propensity is linked to the region, α is bound to the winegrower-agents.

We also examined the regions' risk propensity or risk aversion to account for their inclination towards individual production. The threshold of risk propensity is a value used to define how easy it will be for growers to change from cooperative members to independent growers and vice versa. Growers leave the cooperative if the assumed gap between the gains as independent operators and the gains as cooperators is above a certain threshold. We tested both conditions of the system: risk-prone and risk-averse.

If the balance is negative, the winegrower asks to join the cooperative. To do so, he/she must ask if the cooperative has sufficient volumes to accept their request. If the answer is affirmative, he/she will immediately become a member. However, if the cooperative does not have sufficient space, it will note that the winegrower wants to join the cooperative for the following iteration.

The way in which the capital is updated varies depending on whether the winegrower is a member of a cooperative that guarantees a fixed price for the harvest. If the winegrower is independent, she/he must confront the market alone. To model this difference, independent winegrowers were subjected to a random market governed by a standard law centered on the selling price in the cooperative with a statistical expectation of 0.5. At each iteration, and for each independent winegrower, the price was recalculated.

$$capital = \sum_{i=1}^n g_i \times \sum_{i=1}^n c_i - mo - vi$$

Where: n is the number of plots, g the earnings per plot on the basis of the number of kg of grapes produced, c the production costs per plot with a fixed part and one dependent on the position of the plot, mo the cost of labor if cultivated areas are greater than the production capacity of the winegrower, vi the winegrowers revenues.

Updating the work capacity was done through interviews with winegrowers. It depended on the plot and the variation of the slope under cultivation. Each winegrower assessed the workload represented by each of their plots. This workload depended on the slope of the plot.

$$wk = \frac{\sum_{i=1}^n \frac{1}{\tan s_i}}{100}$$

Where: n is the number of plots and s the plot's slope in degrees; s cannot be less than 5.5 degrees (10%) of slope and wk is the work capacity required on the holding. The value of wk enables us to assess the proportion of winegrowers who have other jobs and the amount of labor the vineyard requires.

Processes related to the *cooperative* class (Fig. 2)

The purpose of calculating winemaking needs and the strategy of the cooperative is to optimize volumes that can be accommodated by the cooperative in relation to the volumes produced by its winegrower-members. To do this, it seeks to determine the volumes expected at a given moment t and those that will be expected at $t + 1$.

The cooperative therefore counts and lists the plots involved in the cooperative, in order to assess the expected yields. In this model, we considered that the plots had homogeneous yields. The transformation from surfaces produced to yield in kilograms is as follows:

$$pkg = surfaces_i \times rp \times rha$$

Where: pkg is the production in kg expected by the cooperative, n the number of plots involved in the cooperative, rp the average yields in the region in hl/ha, and rha the number of kilograms in a hectolitre.

This calculation enables the cooperative to determine what its policy will cost in terms of ‘bonus’ and ‘malus.’ From these values, it will adopt a strategy for adjusting production volumes. It stores the production values of the past 6 years in memory and evaluates the trend for the next iteration using linear regression. This assessment, coupled with the surface areas of winegrowers who have requested to join the cooperative, will enable it to adjust its volumes. If no grower wishes to enter, the cooperative assigns 5% of its volume of wine as an adjustment margin.