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EFFICIENCY OF AGRICULTURAL CONTRACTS: THE CASE OF WHEAT PRODUCTION IN SOUTH-PYRENEES

Contracts play a more and more important role in agriculture. Few microeconomic studies have been made in France and Europe up to now. After analysing all the contracts signed between a cooperative and its wheat producers over four years, the implementation of a structural microeconomic model of contract helps demonstrate that contracts may become an effective tool to favour production of quality by encouraging producers of the best grain to increase their yields.

The evolution of the CAP reducing guaranteed outlets, the increase in characteristic requests for specific products or the increase in requests for traceability speak in favour of an expansion of contracts. However, in France and Europe, few microeconomic studies are dedicated to the economic analysis of agricultural contracts, which remains a top research subject in agro-industrial economics. There are several empirical questions to look at, from the assessment of the importance and diversity of these contractual relations to the analysis of their performances (risk-sharing, incentives, investment) according to regional productions and characteristics.

In the present context of agricultural price fluctuations, formalizing certain productions by contracts may help reduce farmers' income risks. In general, these contracts concern agricultural products of specific quality. By orientating production through incentives, formalization through contracts may be a way to widen the offer, integrating clients' desired qualitative standards and bringing traceability and health guarantees. One of the advantages of production formalized by contract is that the link created between a farmer and another partner (be it a cooperative or any other sort of organisation) helps take into account the distinctive features of the environment in which this production takes place. Even if there happens to be regularity in the contractual forms used over areas, countries and productions, in general, each contract has its specificities and allows adaptation of the terms of exchange to the context and to the parties concerned. Since this heterogeneity affects contractual choices and performances, it is important to proceed carefully to avoid what is called endogenous bias. For instance, one type of contract may superficially appear more efficient than another one, while in fact this superiority comes from the fact that this contract was specifically chosen by the most efficient agents. Economic modelling helps avoid endogenous bias in order to assess the effects of these contractual links and their efficiency according to areas and particular contexts.

In our work, we analysed all production contracts for hard and soft wheat signed between a cooperative and its members. The longitudinal dimension of the data and the precise observation of contracted methods of payment allow the assessment of a structural microeconomic model of contracts with incentive to make efforts (because of the asymmetry of information between farmer and cooperative on growing efforts), that is to say a model integrating the farmers' behaviour.

These contractual links are represented by a structural model of behaviour with information asymmetry of moral hazard type (Dubois and Lavergne (2004)), a notion which refers to the fact that in order to maximize his yield, the farmer under contract undertakes a whole set of actions that the cooperative cannot observe. The empirical results of our econometrical estimations help show better efficiency of these contractual links and measure the importance of these incentives according to every farmer's geographical and ecological characteristics.

Hard and soft wheat production contracts in South-Pyrenees

Cultivations of superior quality, such as superior bread-making wheat of good baking value, are often the object of contracts between storage organisations and farmers. The guarantee of quality, the farmers' loyalty and mastery over supply and collection (among which the use of certified seeds), the orientation of productions and varieties are also recognized advantages. Our survey is based on four years of data on hard and soft wheat contracts in South-Pyrenees (see

frame 1). In the monitoring of these production contracts, the cooperative observes farming methods in detail in order to control them. As a general rule, for example, farmers sow at the end of October. Farmers follow recommended split applications of nitrogen. For hard wheat, supplies averaged 190 units of nitrogen per hectare over three years in four passages and for soft wheat about 170 units of nitrogen per hectare in three passages. As for fungicides, on average they are spread twice on hard wheat and once on soft wheat. However, the best productivity results are noted when farmers make three passages of fungicide for hard wheat and twice for soft wheat. The best yields are observed on deep soils. These empirical facts show that the conditions (lands, quality of soils, exposure and skills) are highly heterogeneous. They also show that the farmers' room for manoeuvre is more on the yield side while as far as quality is concerned the very heterogeneous results are imposed by the fixed characteristics of their plots and the strict technical recommendations of the cooperative (particularly checked by cooperative with plot-visiting and follow-up of cultivation index cards).

Economic and econometrical analysis

Cooperative production contracts stipulate a quite frequent form of payment where the price (per quintal) paid for every delivered quantity depends on the qualitative production characteristics. These types of payment encourage yield in a differential way, according to quality. For all varieties of hard and soft wheat, a unit price depending on various indexes of production quality is paid. The selected quality indexes depend on varieties: specific weight, rate of proteins, of variety pureness, of various impurities, of grain impurity, of crushed grains, of mitadin, Hagberg falling numbers. Such are all the contracts that the unit price is higher if a certain number of quality indexes exceed a threshold determined by contract. For instance, as far as the Brindur variety is concerned, a higher unit price (therefore including a bonus) is given if the rate of protein is higher than 13.5%, the specific weight higher than 76%, the rate of mitadins lower than 56%, the rate of crushed grains lower than 10% and the rate of impurities lower than 10%. Incentives to increase yield are thus stronger if farmers anticipate that they can obtain a quality bonus since those who can get good quality indexes are allowed a price per extra quintal. These questions of discriminations and incentives may be modelled and estimated thanks to longitudinal data on contract characteristics, on given qualities and on productions and yields. Frame 2 describes a microeconomic model assessed using the collected data.

The concept of modelling consists in using the fact that the observation of the quality indexes and exact terms of the contract allow us to observe and find the quality values anticipated and achieved by farmers as well as the unit price (per quintal) finally paid to the farmer.

We consider a moral hazard model on the farmer's production effort since the cooperative cannot observe this effort. Thanks to knowledge of the exact terms of the contract, we can determine what price per quintal is anticipated by the farmer according to wheat quality criteria and therefore take into account the yield incentives provided by the contract. We can, then, assess the effect of the farmer's unobserved effort due to contractual incentives in the unknown terms of the yield equation. Without a structural model, the complete model cannot be identified because of the unobserved effects modifying yields.

The results of the empirical estimations of frame 2, which are not detailed here, clearly show that the discrimination operated by contracts offering unit prices or bonuses according to quality criteria, generate, for contracting farmers, incentives to produce more. Indeed, the regressions show that the higher the unit price per quintal, the greater the effect of the contracted area on the yield. This result can be interpreted by the fact that effort incentives are higher per unit of contracted area when the promised price is higher. Moreover, it is not at all a mechanical effect of scale return which would involve a correlation between contractual area and yield. If this type of scale return is assessed by valuing the effect of the area on yield without having the yield interact with the contractual expected unit price, no scale return is found and the estimated parameter of the contracted area is null.

The presence of unobserved specific effects in the equation (5) shows that the contract incentive effect on yield is much higher for farmers with better quality products than for others, and this over and above the unobserved effects affecting yields and possibly correlated to quality ones. These unobserved specific effects represent all the fixed characteristics related to land and farmer which affect the yield and the grain quality, which can only be identified thanks to the repeated observation of farmers' individual productions over several periods. These unobserved effects represent a certain measure of the farmers' skills and of the intrinsic qualities of their land and location on the performances in term of quality and yield. These unobserved variables may, a priori, be correlated and thus could explain the conditional correlations of yields and indexes of quality. However, structural estimations help show that, even when these effects are taken into account, the contract bonus has an incentive effect on the producer's behaviour.

Contracts meet cooperative objectives well by giving different incentives according to grain quality. Moreover, equations (1) and (5) allow us to assess specific effects (θi and θil). The estimation shows that these effects are positively correlated. In this way, there is no opposition between competences on quality and yield: the best farmers in terms of quality are also the best in terms of yield. There is also no opposition between competences for certain terms of quality in comparison with others.

Empirical results also help assess the geographical distribution of these specific effects as well as their correlation to certain farmers' characteristic variables. An uneven geographical distribution may be observed in such a way that these effects are significantly correlated to town or department indicators. This is how, over three years, the area of Lavaur, Puylaurens and Gaillac seems more adapted to soft wheat cultivation while the area of Castres (where farms are of mixed farming-livestock type) is the least adapted.

Last, after showing that these contracts affect yield incentives in a differential way according to grain quality, we may study the risk-sharing properties of these contracts. The difference (free of storage costs) existing between the

average crop real prices (under contract) and the prices after storage (out of contract) shows that it would be more profitable for farmers to store their production and sell it afterwards. However, in case of storage, most farmers need to manage risks to limit unfavourable price risks and cash-flow development (banking interests to finance storage costs, for instance). Average crop prices determined by contract are on average lower than prices after storage (between 4% and 13% according to years). Therefore, these differences also show that there is a risk premium that farmers implicitly accept to pay through cooperative contracts in order to limit their income risk.

Conclusion

This survey helped show that the contracts drawn up by the cooperative with its members effectively encourage farmers to increase their yields, especially for higher quality productions (fulfilling certain quality criteria defined by the cooperative). The observation of technical performances showed that agronomical and bioclimatological conditions (lands, soil quality, exposure) were decisive and that the farmers' room for manoeuvre is more on the yields side than the quality side, imposed by intrinsic characteristics of plots of land and by technical instructions given by the cooperative. One of the consequences of these effort incentives is that those who obtain quality bonuses have a yield advantage of 1.4 quintal per hectare.

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For further information

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Frame 1: Data

The data collected concerns four years of contracts on hard and soft wheat in the departments of Aude, Ariège, Haute Garonne, Tarn and Tarn-et-Garonne. The practices that have a direct influence on wheat quality and yield are nitrogen inputs and fungicide treatments. Sowing date and treatment dates have an influence on yield and quality. The database includes, for each member and contract, timing of application of nitrogen and fungicides, quantities and types of inputs (fertilizers and plant-care products), land plot characteristics (location), previous crop data and contract characteristics. Cultivation data cards are completed with data on contracts and contributions: areas, foreseen and supplied quantity, quality criteria (specific weight, rate of crushed grains, various impurities, proteins etc.). The price paid to the farmer by the cooperative is calculated according to the type of supply (at crop or after storage at the farm or at the storage organism) and to quality criteria. Basic prices (superior and extra) and quality bonuses depend on such criteria. A documentary bonus is also distributed when cultivation cards are sent back by farmers. Data concerns 1341 "wheat" contracts, engaged by 1081 different farmers through the cooperative from the years 2000 to 2003. Average plot area is about 10ha and average delivered quantity is 50t. Hard wheat average yield is 45 q/ha over three years, specific weight is 80kg/hl, mitadin rate is 18%, protein rate is 13.9%. The most costly inputs are nitrogen fertilizers, then seeds (treatment included) and fungicides. On average, the input cost is 374 €/ha for hard wheat and 317 €/ha for soft wheat. Gross product (basic prices and bonuses) is 536 €/ha and 531 €/ha respectively for hard and soft wheat. Hard wheat gross margin (CAP premium included) is 516 €/ha.

Frame: Model

For every quantity delivered by farmer i at time t, a unit price $\lambda(\mathbf{q}_{it})$ depending on the vector quality indexes of production is paid per delivered quintal. We suppose that the equations determining each of the L quality indexes are of the form:

$$q_{ilt} = \alpha_{lt} + \theta_{il} + X_{it}'\beta_l + \eta_{ilt} \quad \text{pour } l=1,..,L \qquad (1)$$

The parameter α_{lt} translates the specific effects shared by all farmers affecting quality l at time t (such as recorded rainfall). Terms $X_{it}'\beta_l$ allow us to express the effects on quality l of certain observable characteristics X_{it} exogenous and variable in time (such as, for instance, supplies of inputs provided by cooperative). The random effects η_{ilt} are supposed to be independent and not correlated to other variables. Last, every parameter θ_{il} allows us to take into account all the unobserved effects (by econometrician) in relation with the land, the farmer's competence and the steady environmental characteristics which affect the quality l production of the plot. Thanks to sample-collected data we can identify and assess by linear regression all the parameters of the equation (1) for each of the observed quality indexes.

In a second stage, for farmer i at time t, the contract terms are such that his income R_{it} is the product of the price per quintal $\lambda(q_{it})$ and the total delivered quantity $r_{it} S_{it}$

$$R_{it} = \lambda(\mathbf{q}_{it})\, r_{it}\, S_{it} \qquad (2)$$

Where r_{it} is the given yield and S_{it} the contracted area.

Moreover, we suppose that the yield r_{it} depends on an effort endogenous variable μ_{it} per area unit, chosen by the farmer but unobserved by the cooperative. We say we have a problem of asymmetric information type "moral hazard" between farmer and cooperative. The effort cost is supposed to be equal to $C(\mu_{it})=(1/2)\gamma^{-1}S_{it}^{\alpha}\mu_{it}^{2}$ where α is a positive fixed parameter and γ a positive parameter which becomes lower as the effort cost increases. The hectare yield is stated with the following equation:

$$r_{it} = \alpha_t + \theta_i + \mu_{it} + X_{it}'\beta + \varepsilon_{it} \qquad (3)$$

Where the parameter α_t represents the specific effects at time t shared by all farmers, $X_{it}'\beta$ allowing us to take into account all the effects of certain observable characteristics exogenous and variable in time (X_{it}), θ_i represents all the unobserved effects (by econometrician) affecting the yield and ε_{it} is a random shock unobserved and not correlated to other variables.

If the farmer's strategy consists in choosing effort μ_{it} maximizing his net income expectation of the effort cost ($\max E R_{it} - C(\mu_{it})$), where the expectation is considered in relation with the yield uncertainties (ε_{it}) while the future quality is well anticipated by the farmer (the factors unobserved by the econometrician affecting the quality are well-known by the farmer), the choice of the optimal effort for the farmer is then:

$$\mu_{it}^{*} = \gamma\, \lambda(\mathbf{q}_{it})\, S_{it}^{1-\alpha} \qquad (4)$$

and thus depends on the terms of the contract, that is to say on the form of the function $\lambda(.)$ and of the expected quality by the farmer $\mathbf{q}_{it}$. Without any structural model the system of equations (1), (2) and (3) is not fully identifiable since μ_{it} is not observable. However, the explicit taking into account of the farmer's behaviour on the choice of his effort allows us to calculate the value of this unobserved effort μ_{it}^{*} in relation to the contract terms. By replacing (4) in (3), we obtain the following model for a yield equation:

$$r_{it} = \alpha_t + \theta_i + \gamma\, \lambda(\mathbf{q}_{it})\, S_{it}^{1-\alpha} + X_{it}'\beta + \varepsilon_{it} \qquad (5)$$

where all parameters are assessable with the available data since the function $\lambda(.)$ is known and observed.

This equation in particular includes a crossed term between the unit price in relation with the quality $\lambda(\mathbf{q}_{it})$ and an increasing function of the area $S_{it}^{1-\alpha}$ which must have a positive effect on the yield.

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