Strategic outsourcing and precision agriculture: towards a silent reorganization of agricultural production in France ?

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Abstract

In France as in other European countries, farm outsourcing has been developing for the past twenty years. Today, this phenomenon concerns both small and large farms. What is surprising is the growing number of farmers who outsource precision farming operations that involve sophisticated technologies and specialized expertise. This stylized fact is rather counter-intuitive to the known result of transaction cost theory, according to which in the presence of specific assets, ownership prevails over outsourcing. The objective of our study is to analyze the determinants of these new agricultural outsourcing practices associated with precision agriculture. We start with the transaction costs and property rights frameworks, then discuss recent theoretical contributions of relational contracts to explain the possibility of outsourcing in the presence of high asset specificity. Empirical evidences are provided for France using a mixed research methodology. Based on original data from surveys of 1200 farmers and of 20 of medium and large custom operators, our methodology combines an estimation of discrete choice models of outsourcing for different levels of asset specificity and case studies of major farm outsourcing organizational schemes. Our results show that in the presence of high specific assets, outsourcing can be preferred to ownership for strategic reasons. This phenomenon is counter-intuitive from the point of view of transaction cost theory, but is possible when one considers possible *ex-ante* incentive mechanisms (expectation of specialization gains, inclusion of a bonus based on the value of the output in the formal contract, participation of a third party), and informal incentive mechanisms built through repeated interactions.

Key words: Strategic outsourcing, custom farming, specific assets, transaction costs theory, relational contracts, mixed research method, France

JEL codes: D23, L24, O52, Q10

Outsourcing is one of the most common interfirm relationships. It has been proven to be an essential means for companies to reorganize value chains and increase their competitive advantages. In the industrial sector, outsourcing has been developing at a sustained pace since the beginning of the industrial revolution and more particularly since the 1970s in a context of increased outshore competition. Initially focused on the simple use of generic and cheap external resources, industrial companies have quickly developed outsourcing as a "strategic" way of accessing specific assets, and have designed more complex and diverse interfirm relationships (Gereffi and Korzeniewicz, 1994; Milberg and Winkler, 2013).

As in the industrial sector, outsourcing in agriculture is also a widespread phenomenon, even if its development was later on. The most studied form of agricultural outsourcing is that associated with contract farming. Known in the literature as "contract farming" or " farm subcontracting", it is subject to vertical coordination and is characterized, whatever the governance scheme, by an asymmetric arrangement between a farmer and an agribusiness company: the farmer is in a price-taker position, and the incompleteness of subcontracting contracts often works against the latter (Glover and Kusterer, 1990; Eaton and Shepherd, 2001; Wang et al., 2014; Vandergeten *et al.,* 2016). The other form of outsourcing that interests us here is "custom farming" or "farm outsourcing". At the difference of the former, it is characterized by a more horizontal coordination, where a farmer delegates the execution of one or more technical operations to another.

Like contract farming, farm outsourcing has experienced unprecedented development in different parts of the world over the past twenty years (Picazo-Tadeo and Reig-Martínez, 2006; Igata *et al.*, 2008; de Oliveira and Zylbersztajn, 2017; Zhang *et al.,* 2017; Forget *et al.,* 2019). In particular in France, between 2000 and 2016, the number of farms using custom services in a significant way (i.e. more than the equivalent of 30 days of custom services) increased by 53% (Forget et al., 2019). Meanwhile, according to the French National Federation of Custom

Operators[1], the number of agricultural custom companies and the number of custom workers increased by 14% and 65% respectively for a market that represented more than 3 billion euros in 2000. Moreover, observations suggest that in order to meet the challenge of a sustainable agriculture, farmers are increasingly outsourcing to access more sophisticated equipment and specialized expertise associated with precision agriculture (Chevalier, 2007; Lerbourg and Dedieu, 2013; Forget *et al*., 2019). Precision farming practices rely upon the use of specialized technologies and skills to help farmers to make decisions at the right time and in the right place (Zhang *et al*., 2002). The transition towards digital agriculture (GPS machine guidance system, spraying equipment with optical sensors, software to help decision-making, etc.) brings Maurel and Huyghe (2017) to distinguish between precision and digital precision agriculture. They consider the latter as an extension of the former since it involves decision-making at different nested levels from the field plot to the whole farm. This systemic approach of digital precision agriculture requires even more specific assets to respond to three major challenges, namely data collection (via sensors and decision-making software), data management (via information systems) and data valuation or modelling of the whole farming system for decision-making.

Despite its strong growth, there have been relatively few studies on farm outsourcing compared to contract farming or industrial outsourcing. This is all the more surprising as such farm outsourcing arrangements present specific features and raise a major puzzling question. These arrangements are indeed different from those of contract farming not only in terms of the nature of parties, but also in terms of the definition of property and decision rights on assets. In farm outsourcing, the principal is a farmer who owns the land and the crop, and delegates for different reasons the carrying out of operations to another farmer. This latter owns the equipment, provides

[1] http://www.fnedt.org/

the labor, and carries out the work according to the instructions of the principal. The two partners are both agricultural producers and have a relatively more balanced bargaining power than in the case of contract farming. Both parties can compete with each other and the risks of opportunistic behavior are likely to increase as farming operations mobilize specific assets. However, it is largely recognized from transaction cost theory that the presence of specific assets leads to hold-up and lock-in phenomenon, and that the optimal governance that minimizes transaction costs is integration, i.e. ownership of assets (Williamson, 1985; Williamson, 1991; Milgrom and Roberts, 1992). So how to explain the rapid development of farm outsourcing with high asset specificity?

This study adds to the literature that explores the issue of agricultural outsourcing in the presence of specific assets. In the first section of the article, we highlight some stylized facts about changes in farm outsourcing in France based on a descriptive analysis of secondary statistics. Then to understand the new outsourcing practices, we develop theoretical propositions based on the transaction cost & property rights framework. We start from Allen and Lueck's (2002) model of control over agricultural assets to show that under certain conditions, outsourcing is possible even in the presence of specific assets but it is not a first-best solution. This leads us to discuss the contributions of Baker *et al*. (2002; 2008); Gibbons and Murphy (2011) and Ruzzier (2012) on relational contracts, according to which informal incentive mechanisms can explain outsourcing relationships with specific assets. In the third section, we provide empirical evidences for France by using a mixed methodology combining qualitative and quantitative approaches. Finally, we discuss conclude lessons learned in terms of public policy and the scope of this study.

Background on the evolution of farm outsourcing practices in France

When placed in a historical perspective, the development of agricultural outsourcing in France appears to be closely linked to technical progress but also, as in industry, to the economic

situation of the sector. Using secondary data on the creation of farm outsourcing companies since 1945, data from the agricultural census, and macroeconomic branch data, figure 1 shows that the first outsourcing companies were created in the inter-war period, with the modernization of agriculture and the arrival of the first combine harvesters. For a long time, farm outsourcing was adopted by small family farms that did not have the financial and human resources to carry out the harvest themselves. However, the growth of the French outsourcing market really took place only in the 1980s when the agricultural sector has entered a long period of economic and social uncertainty and the Common Agricultural Policy (CAP) started to introduce major policies to promote sustainable agriculture. The peaks in the creation of outsourcing companies indeed reflect not only the downward trend in the number of family farm workers but also successive reforms of the CAP in 1992, 2000 and 2013: on the one hand, like in other European countries, French farmers are working increasingly alone on the farm and need to make greater use of external labour (Gasselin et al., 2014; Nye, 2018); on the other hand, the many environmental policies and the multiplication of quality standards require farmers to adopt new practices. The agro-ecological transition project for French agriculture also implies another process of knowledge construction, more tacit and less explicit, which will modify, as we will see later on, the farmer's relationships with the actors likely to participate in this process (Wolf and Zilberman, 2012; Coquil *et al.,* 2018; Lacombe *et al*., 2018).

FIGURE 1 HERE

According to the French national statistical INSEE data, for cropping operations alone, the growth in outsourcing expenditures by French farmers has been 3% per year since 1994, whereas it was only 1.5% per year between 1979 and 1994. These expenses would now exceed more than €4 billion, that is more than 9% of the value-added excluding subsidies of the crop production

branch in France. Data from the 2016 National survey of farm structure nearly show that 7% of French farms outsource heavily (i.e. more than the equivalent of 30 days of subcontracting). These farms account for 5.5% of the total value of agricultural production and 4.6% of agricultural labor force (Forget *et al*., 2019). What is surprising is that outsourcing concerns nowadays mostly the medium and large farms[2] since they represent 70% of the farms that outsource. It is also interesting to note that their number increased by more than 103% between 2000 and 2016, while the number of small farms that outsource decreased by 3% over the same period. In addition, among the farms that outsource significantly, one-third reported that they outsourced all cultivation work. This practice, commonly referred to by practitioners as "A to Z" or "complete worksite", was until recently considered as totally new (Harff and Lamarche, 1998; Anzalone and Purseigle, 2014).

Thus, not only are French farms increasingly outsource, but the phenomenon is now also affecting medium to large farms that have the capacity to do the work themselves. According to existing studies (Hébrard, 2001; Chevalier, 2007; Anzalone and Purseigle, 2014; Lerbourg and Dedieu, 2016; Forget *et al.,* 2019), two main reasons could explain this unprecedented use of outsourcing in France: re-organization of work on the farm around "core business" activities for those farmers who are still active, management of productive assets for those who retired without a farming heir or for those who have an off-farm job. But whatever the motivation, all of the farmers expect from outsourcing to contribute to improving their farm's overall performance and value, just like for any other enterprises. To this end, farms are increasingly outsourcing tasks which require efficient technologies and specialized skills, in particular those related to precision agriculture. With the transition to digital precision farming, outsourcing would be a mean for smaller farmers to overcome a lack of capacity. But for larger farmers, it would be a way to test new technologies

[2] Medium and large farms are those with an annual production value of more than €25,000.

and acquire knowledge and skills to operate those before possibly making the investment. In France, in 2017, according to the Observatory of Digital Agriculture[3], more than two-third of the grain farms, representing a total area of almost one million hectares, use remote sensing for fertilization, seeding and phytosanitary treatments, with technologies based largely on satellite imagery (85% of the area) and more marginally on drones (15% of the area). But less than one-third of the farms are equipped. Many of those started to develop an outsourcing activity as part of their farming system in order to amortize costly equipment before making it a business. Like the industrial enterprises, we assume that agricultural enterprises, despite their specific characteristics, are nowadays also developing "strategic outsourcing" to create value at the farming level (Harrison and Kelley, 1993; Arnold, 2000; Holcomb and Hitt, 2007).

Theoretical framework of agricultural outsourcing with specific assets

Underlying the outsourcing relationship, there is basically a transaction characterized by a disjunction of property rights from decision rights and a redefinition of the latter. Transaction Cost theory (TC) (Coase, 1960; Williamson, 1985) and Property Rights theory (PR) (Alchian, 1965; Grossman and Hart, 1986) provide both powerful analytical frameworks for studying this type of transaction and the resulting organizational choices. According to Williamson (1975, 1985), the trade-off between alternative modes of organization is based on three attributes of the transaction: frequency, uncertainty and the degree of asset specificity. But for Williamson, asset specificity is probably the most important because its control generates quasi-rents and consequently increases moral hazard[4]. There are five specific types of assets (Williamson, 1983; Malone et al., 1987):

[3] http://agrotic.org/observatoire/

[4] The uncertainty associated with the transaction can also be considered a major attribute but it is much more complex to characterize and measure (Ménard, 1997).

physical, human, site-specific, time-specific, and dedicated. All can be found in farm outsourcing relationships and can lead to various situations of "hold-up" and "lock-in". Among the situations reported by the individuals surveyed, we can take the example of the outsourcing of seeding operation using a precision seed drill. In one case, because he could not sell his production at a satisfactory price, farmer X renegotiated ex-post the payment of the contract downwards and caused losses for contractor Y, who invested time in adjusting the seed drill to X's growing conditions and hired qualified workers to assist the seeding operation. But X could also lose in the future if he does not find a contractor with that specific assets. In another case, X is a farmer who was reluctant to invest in a precision seed drill and sought to test the technology and acquire expertise by hiring Y's service. As Y was not in a position to properly assess X's intentions, he did not mobilize all of his expertise in the operation in order to prevent X to become a potential competitor later on. But in other cases, the relationship worked out well and both, the farmer and the contractor, gain in expertise through collective learning. In a one-shot relation, the decision to outsource is not self-evident, especially since the effects of contractual hazards and positive spillovers can only be observed ex-post.

Allen and Lueck's (2002) general framework of asset control provides an easy and tractable first approach to understand outsourcing decision. In the model, V is the value of the governance structure and depends on the assets and efforts involved in production q. Assets are modeled as a set of variable and alterable attributes. Moral hazard applies to attributes k that are not valued, and its cost v is assumed to be included in the attributes l that are valued at price r. The k/l ratio is a good indicator of the quality of asset. Two types of moral hazard are thus considered, one referring to the use of attributes (k, l) and the other to the effort e provided by the farmer valued at price w. The incentive mechanism appears through diminishing marginal cost of labor and assets as their specialization increases (better use of labor and of equipment). Farmers' expectations of

specialization gains also reveal their strategic motives as they search for specialized capabilities to create value that cannot be realized through integration (Arnold, 2000; Holcomb and Hitt, 2007). In Allen and Lueck's model, asset specificity appears only through time specificity. There is a timeliness cost t when a contractor does not do the job on time. To account for the other specificities, we introduce a dependency cost d which is an increasing function of the k/l ratio.

The problem with the optimal choice of arrangement (e, l, k) is to maximize the expectation of the value of the governance structure for different states of nature θ distributed according to x(θ):

(1) $$\text{Max } V(e, l, k) = \int_{\theta} x(\theta)\, q(t, \eta)[h(e, l, k) + \theta - we - rl - vk]$$

The principal incentive mechanism relies upon the gains from asset and effort specialization. When those are fully exploited, w=w* and r=r*. The baseline case is when the farmer owns the equipment, provides labor and does the work himself. Like Allen and Lueck (2002), we suppose that the farmer does not do the job as well as the contractor who detains the specialized equipment and expertise. In the case of ownership, the farmer does not fully exploit the gains from labor and asset specialization, so that e° and l° are not first-best choices: e°<e* and l°<l*. Since he owns the asset, there is no asset moral hazard (v°=v*). The value of the ownership structure is thus V°(e°, l°, k*).

In the case of low asset specificity, Allen and Lueck (2002) show that outsourcing service is likely to dominate ownership when the farmer has to borrow to pay for assets and is likely to dominate renting the equipment as asset moral hazard increases. Now, in the case of high asset specificity, the first order conditions are as follows: priced asset moral hazard is eliminated since the farmer does not own the asset (l^c=r*), but not unpriced asset moral hazard so that v^c>v* and there is a need for the farmer to monitor that makes w^c>w*. The choice of k and e are not first-best.

The value of the outsourcing governance structure is $V^c(e^c, l^*, k^c)$ (figure 2). Moreover, the timeless and lock-in costs remain. The first-best input level implies that the timeliness costs t is the lowest and the choice of k/l is such that the lock-in cost d is minimum.

FIGURE 2 HERE

Comparative statics show that adding additional costs due to high asset specificity does not fundamentally change Allen and Lueck's prediction about custom farming. In the presence of high asset specificity, the outsourcing contract is likely to be chosen only as the gains from effort specialization increases. Both agents can devote their time on their core activities. But, the outsourcing contract may not fully exploit asset specialization. In France, outsourcing contracts are usually a fixed price per unit area or per unit of time worked that varies according to the type of technical operation. Therefore, in a one-shot relationship, the contractor may retain his use and expertise of the specialized equipment. Moreover, as the timeliness and lock-in costs increase, the more likely ownership will be chosen. Those costs are all the higher as the market of custom services is limited and that farmers do not have a wide choice of contractors and vice-versa. Therefore, in the presence of high asset specificity, for outsourcing contracts to dominate over ownership (without borrowing), we have to introduce either a third enforcing party or self-enforcing incentive mechanisms.

In their study of strategic alliances, Baker *et al.* (2008) focus on mainly spillover effects rather than hold-up costs and come to similar conclusions when considering spot relationships. Such spillover effects in farming outsourcing could be gains in expertise from collective learning for both the farmer and the contractor, or gains in reputation for the contractor. They model in particular a simple unstructured collaboration governance structure which is similar to our farming outsourcing situation and demonstrate that such a governance structure is not first-best since there are states in which the project cannot be implemented (states in which the sum of one party's

spillover plus his payoff when implementing the project is negative). When the relationship involves contracting over payoffs without transfer of decision rights (what they call royalty contract, that is a royalty rate of the joint payoffs is contractually defined and paid to the parties after implementation), the unstructured collaboration structure is more efficient but still not first-best. Baker *et al.* (2008) indeed demonstrate that any strategic alliance can be second-best, but none is first-best. This inefficiency is due to the one-shot nature of the relationship, which does not allow for self-enforcing mechanisms. Notice that Allen and Lueck's model is a one-shot governance model in which the principal incentive mechanism in a custom relationship entirely depends on the asset ownership structure and allocation of decision rights (i.e. the ex-ante formal characteristics of the contract): the farmer decides to outsource, then (e^c, l*, k^c) are chosen, then q is realized and so V, and at last the farmer honors the contract regardless of the outcome, the relationship fails otherwise.

These primary theoretical results bring us to extent the standard TC-PR framework and consider the inputs of Relational Contract (RC). Since it focuses on repeated interactions and non-contractible outputs, this latter makes possible efficient self-enforcing incentive mechanisms without having to change the property structure and decision rights allocation. In the context of repeated interactions, "informal promises" made on non-contractual outputs can constitute sufficient incentives to avoid opportunistic behavior insofar as the value of short-term defection is lower than the discounted value of long-term arrangement (Baker *et al.,* 2002). In the example of a custom nitrogen fertilization service on wheat, the traditional contract is based on a flat rate per hectare that pays an average working time and not the quality of the service (possibly measured by the yield obtained and the protein content in wheat grains). However, to ensure that the wheat harvested is of quality and can be sold at the better price, the farmer can promise a better payment Δp if the subcontractor mobilizes precision technology and all of his expertise:

(2) $\Sigma_t(Vc + \Delta p)(1 + r)^{-t} > V°$ where r is the discount rate

Our surveys also show that outsourcing companies also make similar promises: with our technology and know-how, we guarantee a better yield in volume and quality for the same level of input. But these promises from both the farmer and the contractor are only credible if the market is competitive and if there are alternative options (which is equivalent to a low lock-in cost). This is formally demonstrated by Ruzzier (2012) by introducing into the repeated bargaining game model of Baker *et al.* (2002) both high asset specificity and outside options: since a specific asset lose its value on alternative uses, stakeholders would have no interest in defecting. It should be noted that these informal promises are not only monetary but can, in the framework of RC, also be intangible promises such as the knowledge accumulated about both the operation and the parties, or reputation built in time. For example, in precision farming, the quality of the work done depends not only on the technical performance of the equipment but also on the knowledge of the local conditions that allow contractors to adjust the equipment and operations to be carried out at the right time. Therefore, the farmer may want to work with different contractors but by doing so, he may lose the expertise that a loyal contractor can acquire by working on a long-term basis. In addition, he must support the cost of working with a new contractor. Reputation can help but may not be sufficient. Thus, the sole promise based on the value of the output and the reduction of learning costs then become sufficient for an outsourcing relationship with high asset specificity to dominate.

We summarize the above theoretical considerations into two hypotheses as follows:

1. An outsourcing relationship may be preferred to ownership when the farmer cannot afford to invest in specific factors of production (cases of small to medium farms) or when he expects gains in specialization (cases of medium to large farms), but this choice is not optimal.

2. In the presence of specific assets, an outsourcing relationship can be optimal when it incorporates informal incentive mechanisms, such as reputation, trust and learning benefits, which are sufficient to make alternative options unattractive and engage stakeholders in a long-term relationship.

Empirical evidences for France

Mixed methodology and data

Our empirical approach aims to study the determinants of outsourcing decision for different intensity of asset specificity. We use a mixed methodology which consists in combining quantitative and qualitative methods to study an emerging phenomenon for which few studies exist. The qualitative approach helps to better define the set of independent variables used for the empirical regression models and to deepen the analysis of contractual schemes and some of the determinants of outsourcing choices, in particular those related to informal incentive mechanisms difficult to measure quantitatively.

The qualitative approach relies upon case studies of 20 contractors conducted between 2013 and 2018[5]. The methodology used is the one commonly used in business sciences, which consists in characterizing a company as precisely as possible and analyzing its overall consistency through systematic data collection (Dul and Hak, 2007). In agricultural economics, this approach has been used to study agroholdings (Chaddad and Valentinov, 2017; Chaddad, 2014). The data collected include the company's history, its growth strategy and its organizational and governance structure, the outsourcing operations, the operational organization and governance of the outsourcing relationships (stakeholders, formal contracts and informal arrangements between stakeholders,

[5] Several case studies of the largest custom companies can be found in XXX.

decision-making processes) and the agents' perception of the advantages and disadvantages of outsourcing.

The quantitative approach uses data from a survey conducted in 2017-18 on outsourcing practices (nature of subcontracted work, reasons for subcontracting, criteria for selecting subcontractors, farm characteristics, opinion on the development of subcontracting) with 1200 farmers in southwestern France, chosen randomly within a list of farmers provided by different farmers organizations. This region not only exhibits a large diversity of farming systems, but it is also a region where outsourcing is significantly developed, particularly outsourcing practices involving highly specific assets, such as "A to Z". Based on the postal code of the addresses, data of contractors from the French National Company Registry were merged with those of the farmers surveyed in order to characterize the local outsourcing market. All statistical calculations were performed with the R software.

To empirically analyze the determinants of outsourcing, we used the logistic regression commonly adopted for the study of discrete agricultural outsourcing choices (Houssou *et al*., 2013; Ji *et al*., 2017; de Oliveira and Zylbersztain, 2017; Mottaleb *et al.*, 2017). We also add a negative binomial count model to look at the determinants of outsourcing of one operation and more, with the assumption that the outsourcing of one operation and more follows a mixed Poisson-gama distribution. Several tests were performed on the residuals to validate our choice of the model (standard deviance residuals, standard Person residuals and Cook's distance). This latter model allows us to study the effect of the intensity of asset specificity, considering that this latter is positively correlated with the number of operations outsourced. Following the definition of precision farming by Maurel and Huyghe (2017), we consider "A to Z" outsourcing to be the practice with the highest asset specificity, since it involves the management of the whole farming system. For the logistic model, the dependent variable is zero when operation i is not outsourced

and one when it is. For the negative binomial model, the dependent variable refers to the number of operations outsourced, ranging from zero to seven operations including "A to Z". For both models, the explanatory variables refer to five sets of determinants:

1) Variables to capture asset specialization: those are some of the characteristics of the farmer and of the holding which influence the gains in specialization. Through these variables, we seek to measure labor constraints and therefore the possible gains in labor specialization, as well as surface constraints (surface too small to amortize specialized equipment) and therefore the possible gains in physical and human asset specialization.
2) Variables to capture the perceived benefits of outsourcing. Four main areas were identified during the in-depth interviews for the case studies of subcontractors and their clients: access to specific equipment (physical asset specificity), the possibility of refocusing on the core business, optimal organization of work on operations (time asset specificity), access to specific skills (human asset specificity).
3) Variables to capture farmer's intention to pursue outsourcing or not. These variables refer to the farmer's project for the next coming years. Farmers who are already outsourcing are likely to keep on re-organizing labor on the farm, to develop a new activity on the farm, to search for an off-farm job, or even to outsource more. This latter variable also helps to approach the repeated nature of the interaction.
4) The variable "number of custom companies having the same postal code as the farm" captures the state of the local outsourcing market (appendix 1). This variable results from the merging of our original database with information from the National Company Register. We consider that the more contractors there are, the lower the timeliness and lock-in costs will be. Moreover, following Balland's *et al.* (2015) and Brailly's (2016) research in economic geography, we consider that geographical proximity is also a good proxy for the relational

dimension of contracts: everything is known when operating within a radius of about 10 to 25 kilometers, those who work well or poorly, those who pay correctly or not.

5) The variables "age", "crop types", "member of a machinery cooperative" and "number of machinery cooperatives having the same postal code as the farm" are introduced as control variables. We assume that a younger farmer will be less likely willing to use custom services. Outsourcing operations may indeed differ according to the type of culture, both in terms of their nature and the assets involved. Moreover, if the farmer shares a common equipment with other farmers within a machinery cooperative, it is very likely that he will not outsource.

Descriptive statistics on outsourcing practices[6]

Within the survey sample, 851 farmers (71%) are outsourcing one operation or more (808 outsource up to 7 operations and 43 contracted "A to Z") with in particular precision practices for seeding and phytosanitary application. Those farmers are divided relatively evenly into four size classes: 186 very small farms from 0 to 37 hectares[7], 225 from 38 to 61 hectares, 229 from 62 to 99 hectares and 211 very large farms over 100 hectares, with a regional average of about 60 hectares.

Outside of harvesting, we note a significant proportion of farmers who outsource operations that they used to do themselves, such as ploughing, seeding, phytosanitary treatment, fertilizer application and irrigation. According to the in-depth interviews, these operations, unlike harvesting, are traditionally those that are not outsourced because they have a strong impact on crop yield and require a certain know-how. They are also strong symbols of the farmer's identity.

[6] More descriptive statistics on the sample of farmers surveyed and their practices can be found in XXX.

[7] 1 hectare is equal to 2,47 acres

It is important for a farmer to be seen seeding by his neighboring farmer. To outsource those, a farmer needs to have good reasons.

Among the easily observable criteria for choosing contractors, the four main ones are in order of importance: specialized technical skills (for 60% of the 1200 farmers surveyed), geographical proximity (48%), the price charged (38%) and specialized equipment (37%). The type of contract is considered important by only 1% of the farmers because, in a very large majority of cases, the contract is an annual contract with a flat-rate payment per hectare and per type of operation. It is interesting to note that among the farmers who outsource, 43 (3,4%) practice "A to Z", in other words they outsource all of the cultivation operations. Most of them are farmers between 35 and 65 years-old and own a grain farm (cereals and grain leguminous). According to the in-depth interviews, the "A to Z" can in some cases result in the transfer to the contractor of all decision-making rights when, in addition to all cultivation operations, the contractor also takes charge of the administrative management of the farm (decisions on crop rotation and technical itinerary but also on input purchase and output marketing, filling in CAP declarations, etc.). The outsourcing companies that provide the "A to Z" service, are usually large and can operate in networks. They are most often equipped with a large fleet of specialized machinery in precision agriculture and a skilled workforce with technical, agronomic and managerial expertise. Some of them also offer agronomic and strategic business consulting service in addition to simple outsourcing. The addition of such service plays a important role in building loyalty in the outsourcing relationship, as we will see thereafter.

Results of the logistic estimation of outsourcing choices

Table 1 presents the maximum likelihood estimates for the logistic regressions and the results of the negative binomial model. We will first focus more specifically on the outsourcing of

seeding, phytosanitary treatment and fertilizer application operations, which are the ones that require the most sophisticated equipment. As expected, a farmer who seeks to access to high-performance equipment and specific skills, or to have an off-farm job, is more likely to outsource. An average-sized farm is more likely to outsource than a very small or very large farm. In the study area where wheat and maize are the dominant crops, seeding is considered as a critical operation because it impacts yield in particular at the first stages of the crop growth (emergence and weed control). Unless he seeks to increase the crop performance or to test new practices before making the investments, the farmer will likely not outsource especially if he is a member of a machinery cooperative. Moreover, the presence of local contractors does not seem to have an impact on the probability of outsourcing. This does not mean that our second hypothesis is not validated since a farmer who are currently outsourcing will likely pursue. These last two results may suggest that for seeding operations, the number of local contractors is not a good proxy for the relational dimension of the contract whenever the farmer outsources.

TABLE 1 HERE

Unlike seeding, for the outsourcing of phytosanitary treatments, the greater number of local contractors increases the probability of outsourcing. A wine farm would contract all the more as the wine area is small. The surveys conducted indeed suggest that farmers now tend to outsource phytosanitary treatment because this operation is becoming more and more restrictive. To avoid pollution problems and protect the health of populations, French regulations now require not only to comply with treatment standards (type and quantities of products used, treatment conditions) but also to have a certificate guaranteeing the possession of precision equipment and a certain level of technical expertise. Farmers who have small areas, do not want to bother and prefer to delegate this operation to a third party. On the other hand, neither access to specialized equipment nor the search for specific skills appear to be significant explanatory variables, contrary to what is expected. This

can be explained by the fact that all contractors offering treatment custom services now have the certificate required by the regulations, so that the possession of precision equipment and specialized skills is no longer a criterion for farmers when choosing contractors. However, at the difference of seeding, for phytosanitary treatment, both the variables "number of local contractors" and "intention to pursue outsourcing" are significant. This suggest that informal attributes of the transaction, such as the reputation of the contractor, play a role when it comes to delegate an operation that may raise nowadays neighborhood conflicts.

It is then interesting to note that for the harvest operation, a practice that we thought was different from the others because many farmers used to outsource harvesting and because it seems to require fewer specific assets, the acquisition of specific skills and the optimal organization of work, as well as the presence of contractors nearby, appear as factors that can significantly and positively impact the probability of outsourcing. Again, in-depth interviews with contractors and farmers suggest that while farmers have always delegated harvesting, they now expect custom harvesters to be more efficient, harvesting at the right time and as quickly as possible to optimize yield, especially with varieties of maize with shorter growth cycle.

Finally, the results of the negative binomial regression model (table 1) tend to support our first and second propositions, since the access to precision equipment and the expectation of labor specialization gains increase the probability of outsourcing an increasing number of operations, including those considered as strategic by the farmer. The repeated characteristic of the transaction captured through the fact that farmers are willing to outsource in the future also impacts positively the probability to increase the number of operations outsourced. But as with seeding, contrary to what is expected, the proximity variable is not significant. In table 2, we compute the average distance as well as the standard deviation of the distance separating the farmer and his contractors for all of the outsourced operations and for different characteristics of the contractor (known by

work habit and other long-term relationship, recommended by a trustful person, known by direct solicitation, known by reputation, other). On average, a farmer can work with a contractor who is nearby (average distance of 9 km) and whom he knows well, as well as with a more distant contractor who would have been recommended to him (average distance of 19.5 km) or whom he knows by reputation (average distance of 18.9 km). For example, a farmer who practices "A to Z", the most innovative form of custom farming and the most intensive in specific assets, may not find a contractor who offers this service and who is suitable nearby. We will get back in the discussion section on the choice of proxy variables and more generally on the empirical estimation of the relational determinants of contracts.

TABLE 2 HERE

Case study of outsourcing contractual schemes

This qualitative study of contractual arrangements aims to shed further light on the quantitative results on the respective roles of formal and informal incentive mechanisms. For this purpose, we compare traditional outsourcing contracts with "A to Z" contracts, based on the written contracts collected and on in-depth surveys of contractors. In a very large majority of cases, when it is formalized (which is not always the case), the outsourcing relationship is based on an annual written contract tacitly renewed which specifies the nature of the operation carried out and a flat-rate payment per hectare and per type of operation. For farmers and contractors alike, the simplicity and the flexibility of such a contractual relationship are important, but they recognize that it does not provide the right incentives. Both parties often cite mutual trust and reputation as key factors of the success of the outsourcing relationship. However, it seems that these informal devices are not always sufficient especially since their effects cannot be observed *ex-ante* (Williamson, 1985; Lorenz, 1999; Williamson, 2008). They need to be built through work habits for them to become

credible. This is probably the reason why in the case of "A to Z", all contracts include a bonus based on the value of the output. This bonus is somewhat equivalent to a promise made in relational contracts. The observed formal contracts are thus composed of a fixed part (about 75% of the average total bill) and a variable part (25%) in the payment. The fixed part can vary from 400 to 500 euros/hectare, depending on the state of the outsourcing market but also on the services provided in addition: agronomic and economic expertise (for example, advices on crop rotation and technical itinerary given market outlets or CAP incentives), input purchases, crop marketing or administrative service. Contractors often include these three latter services in the contract because this gives them the possibility to better negotiate sale contracts with equipment manufacturers, input suppliers and downstream food industries. The variable part of the contract is indexed on the net margin of each crop. By doing "A to Z" for several clients, a contractor can optimize both the cropping system and labor organization since he can manage all the plots as a single large entity.

According to the interviewers, such “A to Z” contractual schemes were designed to spread production and market risk between the service provider and the customer, and to encourage the former to optimize his performance not only in the management of the farm, but also in the management of relations with upstream and downstream stakeholders of the supply chains. In a few cases, farmers have hired a third party (advisor employed by a consulting company, crop manager employed by an agricultural cooperative). In Belgium and England, such intermediary between the farmer and the contractor is named "land manager" and his main role is to help design the contract and to control its execution. This last multi-partner governance scheme could indeed prevail over all of the other modes of governance, especially since the land and the crops are highly valued.

Discussion

Table 3 summarizes all outsourcing practices and incentive mechanisms according to the intensity of specific assets highlighted in our study. In the following discussion, we will focus on two aspects in particular, firstly on the test of the second theoretical proposition and secondly on the comparison with other empirical studies on the subject.

TABLE 3 HERE

First, the empirical evidence seems to globally validate the theoretical propositions, except for one central aspect, namely the measure of the role of informal incentive mechanisms in relational contracts. For Baker *et al.* (2008), these informal mechanisms may include observable and measurable monetary promises of payment or threats of sanctions, but also others that are more difficult to quantify, such as trust and reputation. To approach these latter, we used a spatialized variable based on the concept of proximity (Balland et al., 2013). The results of our regressions are not always as expected, as in the case of custom seeding. Our approach can undoubtedly win by integrating an essential temporal dimension to consider the repeated interactions that underlie any relational contract and make informal incentives credible (Gibbons and Henderson, 2011). Macchiavello and Morjaria (2015), for example, considered the duration of the rose auction relationship in Kenya to test the role of sellers' reputation.

Second, it is important to notice that, unlike for the industrial sector, there are few studies addressing the issue of outsourcing with asset specificity in agriculture. Our results are in line with the qualitative results of Allen and Lueck (2002). In the presence of tile specificity, Allen and Lueck (2002) show that the probability to outsource increases as timeliness costs decrease and specialization gains outweigh these costs. Quoting Isern (1981), the authors also argue that, in a context where contracts are mainly verbal, reputation and proximity can help to contain these costs. However, for Allen and Lueck (2002), outsourcing remains a second-best solution in the presence

of specific assets. De Oliveira and Zylberstztajn (2017) studied more specifically the adoption of outsourcing with asset specificity in the case of coffee cultivation in Brazil. Using data from 105 surveys of coffee farmers and probit regressions to estimate a discrete choice model, they sought to test the hypothesis that the probability of outsourcing the coffee harvest decreases as asset specificity increases, for 4 types of specificity (physical, human, site, time). The evidence from Brazil shows that in the presence of specific assets, the tendency is more towards integration except when the farmer has a sufficient level of education to negotiate and manage the contract in his favor. Using case studies, Chaddad (2014), Chaddad and Valentinov (2017) also show that the integrated and hierarchical mode of governance adopted by large corporate farms, such as Brazilagro, which in 2013 held 8 farms for a total area of 180,000 hectares, makes it easier to develop an appropriate combination of intra-firm incentive and sanction mechanisms to address the problems of moral hazard and hold-ups associated with the presence of specific assets (equipment with expensive technologies, employment of qualified managers, etc.). Nevertheless, these studies do not call into question our results because all organizations are embedded in institutions and their surrounding economic and institutional context play indeed a major role in the arbitration of governance modes (Slangen *et al.* 2008; Scott, 2014; Ménard, 2017). In the United States, custom farming appears to depend heavily on farm size. It gives to small producers an opportunity to adopt a new technology, while large ones will prefer ownership because they can afford the investment (Gandonou *et al.,* 2006). In France, we found that farm size is not a major determinant. French agriculture is characterized by a downward trend of labor force and farms. The CAP reforms continue to promote family farms of a certain size and sustainable agriculture. In such a context, outsourcing may have more advantages than ownership (Ball, 1987; Nye, 2018). The farmer can keep the ownership of the land, its products, and the benefits of production subsidies, without having to bear the high costs of investment, hiring and controlling the work of

agricultural hired workers. The contractor can manage larger areas, break-even and partially benefit from usufruct without having to bear the exorbitant cost of acquiring the land.

Conclusion

Over the past two decades, France has experienced an unprecedented expansion of agricultural outsourcing. Ownership of assets is no longer the dominant choice as it was during the modernization period from 1950 to 1980. Growing economic uncertainties as well as difficulties to transmit farms are leading farmers to postpone investments. And this is all the more so as the latter are becoming ever more expensive with the transition to triple-performing and digital precision agriculture. We observe the development of outsourcing of operations that involve more and more specific assets (equipment with digital technologies, software to help decision making not only at the field level but also at the farm level, agronomic expertise but also expertise in strategic business management, etc.). This phenomenon is counter-intuitive from the point of view of transaction cost theory, but is possible when one considers possible *ex-ante* incentive mechanisms (expectation of specialization gains, inclusion of a bonus based on the value of the output in the contract, participation of a third party), and informal incentive mechanisms built through repeated interactions.

Our study aimed to highlight the determinants of agricultural outsourcing for different levels of asset specificity in the French context. There are relatively few studies on the issue and our contribution is mainly empirical. Results for France tends to validate the hypotheses, but only partially, and opens up research perspectives for measuring informal incentives in outsourcing arrangements with high asset specificity (Gil and Zanarone, 2018) and for understanding the interactions between these latter and the different institutional layers with which they are embedded (Ménard, 2017). The main challenge is both theoretical and methodological: how to explain the

observed changes in farm outsourcing practices and organization? This question calls for a more general framework of interactions between organizations and institutions (Slangen *et al*., 2008; Scott, 2014), and for a shift from a static to a dynamic conceptual framework (Hobbs, 2017). Experimental and computational economics can then be useful to complement econometrics and to model contractual repeated interactions in a game theoretical logic (Miranda and Fackler, 2002; Just and Wu, 2009).

Finally, we believe that it is important to highlight the social and economic issues surrounding the development of custom farming. The latter can contribute to improving the overall performance of farms in a context of increasing uncertainty or to maintaining the productive capacity of those without heirs or a hired farm manager. The rise of farm outsourcing has indeed a significant impact on the organization of agricultural production at the territorial level and, more broadly, on the country's food security. It also seems to support the emergence of new businesses and markets, particularly in the areas of strategic consulting, site and land management. However, while agricultural outsourcing offers advantages, it nevertheless raises questions about the definition of the status and profession of farmer, and therefore that of policies to support the traditional family farming model. The other major issue directly related to assets control concerns the management of data produced by precision farming technologies and the re-organization of the advisory service: what would be the optimal allocation of property rights of and the rights to use the many data generated from the field plot to the entire farm? While this work focuses specifically on France, custom farming is also developing rapidly in other European countries (Vernimmen *et al*., 2000; Picazo-Tadeo and Reig-Martínez, 2006; Nye, 2018) and other regions of the world (Igata *et al.*, 2008; Houssou *et al*., 2013; Ji *et al*., 2017; de Oliveira and Zylbersztain, 2017; Mottaleb *et al.*, 2017; Belton *et al.*, 2018), and thus deserves attention.

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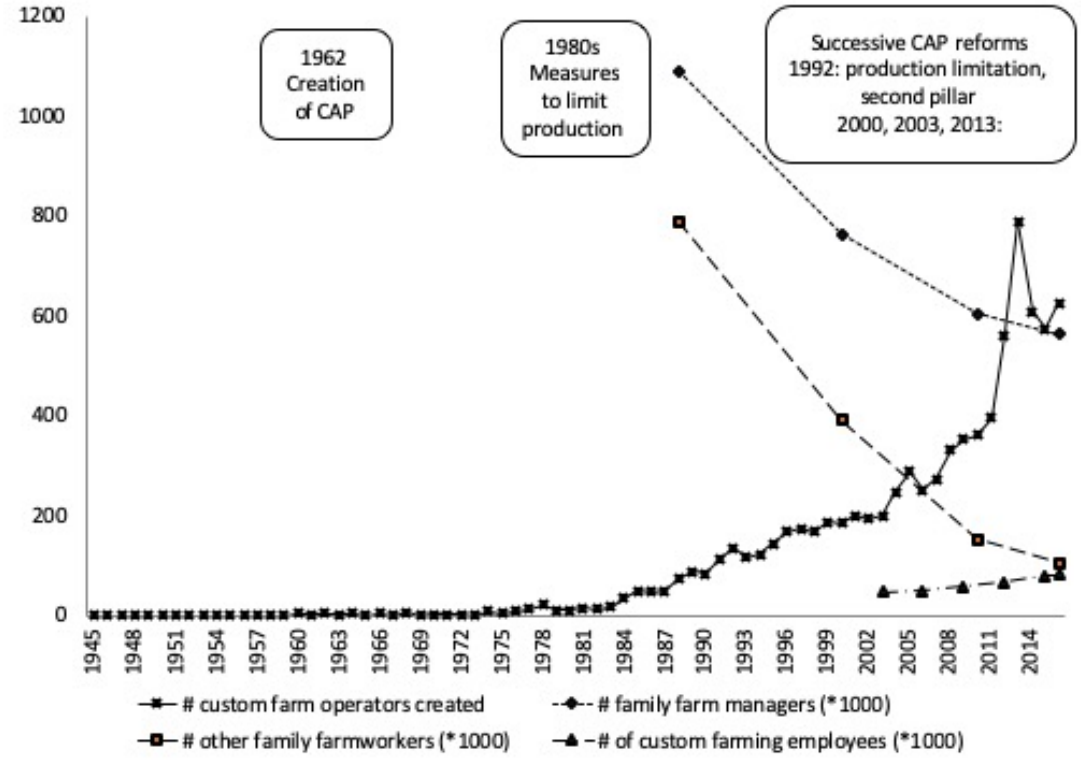
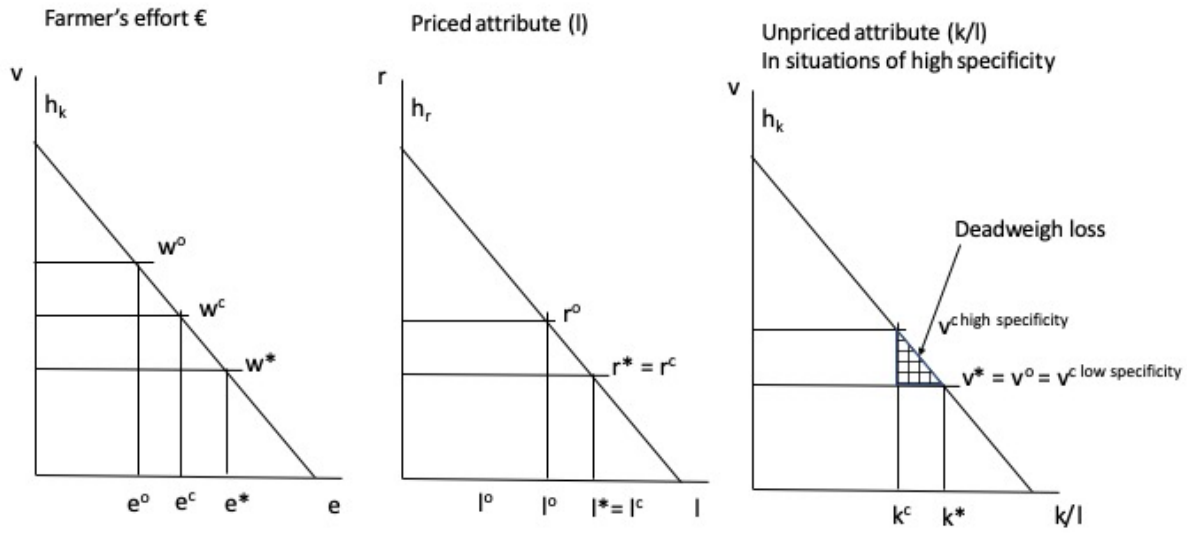
Figure 1. Trends in Custom Farm Operators and Family Labor, 1945-2016



Note: Graph done by authors with data from the French National Agricultural Census and the National Federation of Agricultural Custom Operators

Figure 2. Optimal Choice of Governance Structure (Ownership or Outsourcing)



Note: Based on Allen and Lueck (2002), p. 145

Table 1. Estimation Results for the Logistic and Negative Binomial Models of Outsourcing

Variable	Logistic Discrete Choice Models						Negative Binomial (Count) Model
	Ploughing	Seeding	Pesticide & Fertilizer applications	Pruning & Haying	Harvesting	Storage	No. of custom operations
Constant	-2.81*** (0.51)	-2.57*** (0.42)	-1.88*** (0.34)	-2.55*** (0.47)	-0.44 (0.34)	-3.27*** (0.60)	0.47*** (0.11)
Proxies for Physical and Human Asset Specializations							
Off-farm job (Yes)	-0.54 (0.40)	0.45 (0.28)	0.42 (0.26)	-1.63*** (0.47)	0.13 (0.29)	-0.61 (0.53)	0.35*** (0.08)
No. of associated family managers	-0.16 (0.16)	-0.17 (0.12)	0.05 (0.10)	0.22* (0.12)	0.03 (0.11)	0.06 (0.17)	-0.03 (0.03)
Hired employees (Yes)	1.00*** (0.33)	0.14 (0.27)	0.12 (0.23)	-0.05 (0.29)	-0.51** (0.24)	0.02 (0.40)	-0.08 (0.08)
Non-family hired manager (Yes)	0.74* (0.39)	-0.34 (0.40)	0.25 (0.34)	0.10 (0.38)	-0.21 (0.33)	-1.52 (1.09)	0.002 (0.11)
Diversification on-farm activities (Yes)	0.75** (0.32)	0.32 (0.26)	-0.05 (0.24)	-0.39 (0.30)	0.61** (0.26)	0.50 (0.38)	0.21*** (0.08)
No. of small farms]38, 62 hectares]	-0.42 (0.36)	0.69** (0.29)	0.31 (0.25)	-0.07 (0.32)	0.22 (0.28)	-0.63 (0.46)	0.07 (0.08)
No. of medium farms]62, 100 ha]	-0.82* (0.42)	0.66** (0.33)	0.24 (0.27)	-0.11 (0.35)	-0.17 (0.29)	-0.17 (0.46)	-0.04 (0.09)
No. of large farms [100 ha and more)	-0.33 (0.56)	0.53 (0.47)	0.14 (0.34)	0.71 (0.48)	-0.76** (0.37)	-0.67 (0.61)	0.02 (0.11)
No. of breeding ativities	-0.54 (0.33)	-0.01 (0.20)	0.14 (0.17)	0.33 (0.20)	-0.16 (0.18)	0.31 (0.27)	0.07 (0.06)
Reasons for outsourcing							
Access to specialized equipment (Yes)	-0.07 (0.43)	0.57* (0.31)	0.08 (0.30)	0.89*** (0.32)	-0.49 (0.30)	-0.42 (0.64)	0.49*** (0.08)
Need to focus on "core activities" (Yes)	0.86*** (0.30)	-0.48** (0.21)	-0.45** (0.19)	-0.03 (0.23)	0.42** (0.20)	0.30 (0.33)	-0.08 (0.06)
Need to re-organize labor on the farm (Yes)	-0.63** (0.31)	-0.18 (0.24)	0.34 (0.21)	0.58** (0.27)	1.07*** (0.21)	0.56 (0.40)	0.16** (0.07)
Access to specialized skills (Yes)	0.27 (0.32)	1.05*** (0.25)	0.29 (0.21)	-0.29 (0.25)	0.89*** (0.21)	-0.02 (0.37)	-0.02 (0.06)

Farmer's project for the coming years							
Re-organizing labor on the farm	-0.18 (0.29)	0.10 (0.21)	-0.001 (0.18)	0.26 (0.22)	0.52*** (0.20)	0.68** (0.31)	-0.07 (0.06)
Develop a new on-farm activity	0.43 (0.30)	0.26 (0.22)	0.09 (0.19)	-0.12 (0.26)	0.20 (0.21)	0.03 (0.33)	0.10 (0.06)
Develop an off-farm activity	0.62* (0.38)	0.62* (0.33)	0.41 (0.31)	0.39 (0.35)	-0.04 (0.33)	-0.40 (0.65)	0.20** (0.10)
Enlarge the farm's cultivation area	-0.60* (0.36)	-0.32 (0.26)	-0.08 (0.22)	0.14 (0.27)	-0.26 (0.23)	-0.15 (0.37)	-0.11 (0.07)
Maintain the farm as it is	-0.20 (0.29)	-0.10 (0.21)	0.37** (0.18)	0.46** (0.23)	-0.19 (0.20)	-0.43 (0.33)	-0.01 (0.06)
Keep and develop outsourcing	1.81*** (0.42)	1.33*** (0.37)	0.96*** (0.35)	0.78* (0.45)	-0.25 (0.40)	1.31*** (0.47)	0.56*** (0.10)
Proxy for the state of the local outsourcing market and inter-knowledge							
No._operators with same postal code	0.03 (0.02)	0.03 (0.02)	0.04** (0.02)	-0.02 (0.02)	0.03* (0.02)	0.04 (0.03)	0.01 (0.01)
Control variables							
Age	0.003 (0.16)	0.08 (0.12)	0.07 (0.10)	0.08 (0.13)	0.02 (0.11)	-0.12 (0.17)	0.003 (0.03)
Area cultivated with cereals (hectares)	-0.46 (0.32)	-0.35 (0.26)	0.13 (0.11)	-1.28*** (0.33)	0.22 (0.16)	-0.06 (0.26)	0.04 (0.03)
Area cultivated with vegetables (hectares)	-0.35 (1.70)	-0.54 (1.54)	-0.12 (0.18)	-1.94 (3.09)	0.19 (1.05)	-0.01 (0.30)	-0.05 (0.03)
Area cultivated with fruit trees (hectares)	0.08 (0.12)	0.03 (0.10)	-0.04 (0.10)	-0.01 (0.10)	-0.12 (0.10)	0.08 (0.17)	-0.02 (0.03)
Vineyard area (hectares)	0.02 (0.12)	-0.14 (0.17)	-0.41** (0.17)	0.26* (0.13)	-0.39*** (0.14)	-0.53 (0.41)	-0.02 (0.04)
Area cultivated with special crops: flowers, etc. (hectares)	-0.07 (0.15)	-0.26 (0.31)	-0.09 (0.12)	-0.27 (0.31)	0.08 (0.14)	-0.18 (0.46)	-0.02 (0.02)
Membership of a machinery cooperative (Yes)	-0.11 (0.28)	-0.35* (0.20)	-0.09 (0.18)	-0.27 (0.23)	-0.29 (0.19)	0.12 (0.30)	-0.15*** (0.06)
No. of local machinery cooperatives	0.06 (0.04)	0.01 (0.03)	-0.02 (0.03)	-0.01 (0.03)	0.001 (0.03)	-0.05 (0.05)	-0.01 (0.01)
No. of observations	808	808	808	808	808	808	851
Adjusted R2	0.1756	0.0959	0.0622	0.1843	0.2598	0.079	0.2241
Log Likelihood	-224.31	-365.89	-452.29	-313.52	-401.58	-188.90	-1,424.70
Akaike Inf. Crit.	506.62	789.78	962.59	685.03	861.16	435.80	2,907.41

Note: 1 hectare is equal to 2,47 acres. In parenthesis are robust standard errors and asterisks denote the following: *p<0.1; **p<0.05; ***p<0.01

Table 2. Distance Separating a Farmer and His Contractors

Characteristics of the custom operators	Number of observations	Average distance (kilometers)	Standard deviation of the distance
Known by work habits or other long-term relationships	501	8,7	15,4
Recommended by a trustful person	476	19,5	28,1
Known by direct solicitation of the custom operator	68	20,4	27,4
Known by reputation	83	18,9	24,2
Other (magazine, internet search, etc.)	83	28,9	109,1
All	n.a.	15,3	36,2

Note: This table shows the results to the survey question: "Please, list all of the custom operator with whom you contract and for each one, indicate his address and the way you knew him". Each farmer who is outsourcing several operations can contract with different custom operators.

Table 3. Summary of Incentive Mechanisms of Outsourcing Contracts with Asset Specificity

Nature of outsourcing	Type of formal contract	Formal incentive mechanisms	Informal incentive mechanisms
"Simple" operation without specific assets: harvesting	Standard contract (fixed price per surface area)	Expected gains on priced physical and human asset Proximity Possible timeliness cost	Proximity
Operation with specific assets (precision agriculture): seeding		Expected gains on priced physical and human assets Possible timeliness cost	Expected gains on unpriced human asset (expertise) Reputation, trust, recommendation
Operation with specific assets (precision agriculture): phytosanitary treatment		Proximity Possible costs of moral hazard on physical and human assets	Proximity Reputation, trust, recommendation
All operations with high asset specificity (precision agriculture + managerial quality): "A to Z".	Contract with a lump sum payment and variable payment based on the quality of the work done	Possible scale economies Increased negotiation power for the purchase on inputs and the marketing of harvest Role of land manager	Expected gains on unpriced human asset (expertise) Proximity Reputation, trust, recommendation

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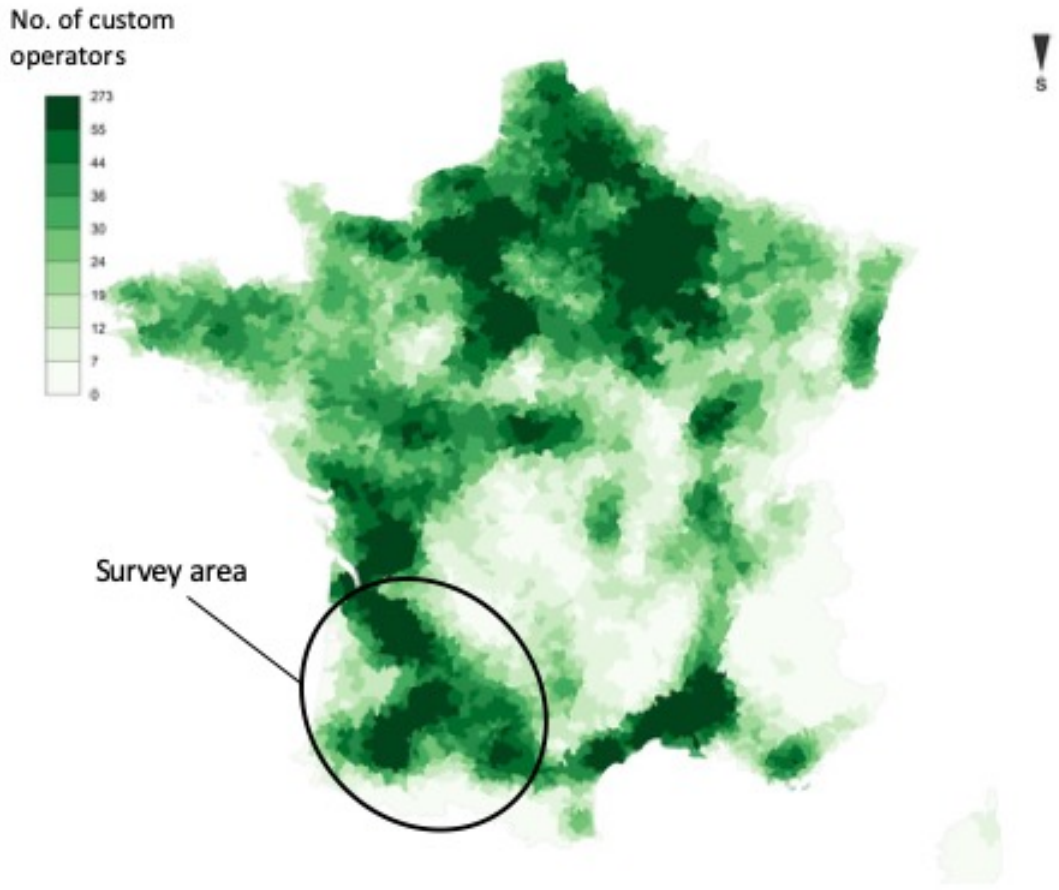
Appendix 1. Number of custom operators having the same postal code as farmers



Note: Map made by authors using data from the French National Company Registr