HOW DO AGRICULTURAL POLICIES INFLUENCE FARMLAND CONCENTRATION? THE EXAMPLE OF FRANCE

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Abstract

Over the last decades, the number of farms has decreased while average farm size has increased in industrialised countries. We investigate whether these two concomitant trends have resulted in higher farmland concentration or not in the case of France. Deriving Gini coefficients as a measure of concentration from the estimation of parametric Lorenz curves, we show that this is not systematically the case at the sub-national scale of "départements". When studying the role of possible explanatory variables for farmland concentration, we find that milk quotas, CAP 2^{nd} pillar subsidies and so-called structural measures (settlements and early retirement grants) have a significant impact. However, the availability and the price of agricultural land appear to be the most significant factors.

Keywords: Farmland concentration, Farm structures, Agricultural policies, Gini coefficient, France

1. INTRODUCTION

It is widely recognised that over the last decades the number of farms has decreased while average farm size has increased in industrialised countries. The main reasons found in the literature are technological innovations, relative prices or general economic conditions (Weersink and Tauer, 1991). Government intervention is also thought to have played a large role. For example, Butault and Delame (2003) explain that the introduction, in 1992, of the European Union's policy encouraging farmers' early retirement has been decisive in the farm disappearance process. Also, public subsidies granted on an acreage basis have in general favoured large farms. Evidence of a positive effect of government commodity-related payments on farm size in the United States (US) is provided by Ahearn *et al.* (2005) and Key and Roberts (2007). The first authors find that payments have increased the share of large farms over the 1982-1996 period, while the second authors report a weak but positive impact of payments on farm size between 1987 and 1997.

However, farm size growth does not automatically imply higher land concentration. For example, Butault and Delame (2003) indicate that, between 1988 and 2000 in France, farm size increase has affected all size categories, and therefore has not favoured larger farms' concentration to the detriment of small farms. Hence, one must clearly separate farm size growth from farmland concentration.

This is particularly important when dealing with agricultural policy assessment and design. In the specific case of the European Union (EU), a large debate took place at the end of the 90es when a new reform of the Common Agricultural Policy (CAP) was envisaged. At this stage, in order to make explicit the common principles that should drive the future CAP reforms, the concept of a European Model of Agriculture (EMA) was laid down. The EMA closely relies on the concept of multifunctionality. According to the latter, in addition to competitive production of food, fibre and energy, farming also provides services to the society such as balanced regional development and rural employment, maintenance of rural landscapes, biodiversity, protection of the environment, etc. As European farmers provide these multifunctional services to the benefit of society without market return compensation, it is justified to reward them through public funds. Maintaining the EMA has thus become a key objective of the CAP and an essential driver of the last CAP reforms.

As measuring the flows of multifunctional services provided by European agriculture is not an obvious task, it is not so easy to evaluate the extent to which the CAP actually contributes to strengthen the EMA. Understanding farmland concentration process and detecting its main determinants, with a special emphasis on the role of CAP measures, can help to this regard. A key element in the EMA is that different production models should co-exist along each other. As natural conditions and production costs vary considerably within and between the EU Member states, the provision of above mentioned multifunctional services by farmers in each Member state requires the co-existence, on national territories, of differentiated farms in terms of size, types of production, production patterns, localisation, etc. Investigating how land concentration has evolved in a country can provide some information on how farm heterogeneity changes over time: do the various types of farms survive? or do they converge towards a single type? or is a dualistic structure emerging with two extreme farm categories co-existing as some authors claim (Ahituv and Kimhi, 2006)? Clearly, such information, together with the main factors which are responsible for this evolution, is crucial as regards CAP assessment. This is the objective of this paper to extract such information from available data for the specific case of France.

Hence, the paper aims at investigating the factors behind farmland concentration in France over the past 40 years and in particular the role of agricultural policies. The role of government intervention on agricultural land concentration has been investigated by Roberts and Key (2008) in the US during the period 1987-2002 using agricultural census data. The authors compare changes in land concentration across small regions (defined by zip codes) differing in the payments received per acre of land. They calculate farmland concentration as the acre-weighted median farm size and fit a semi-parametric generalised additive model to their data in order to control for other variables than policies that could affect land concentration. The main finding is that there is a strong positive association between government payments and change in land concentration. To our knowledge, no other studies exist on the relationship between farmland concentration and public policies. However, an issue in the approach adopted by Roberts and Key in their 2008 paper is that they qualify concentration with the help of an indicator of average farm size but not in term of inequality in the repartition of land among farms, what we aim at doing here. The present paper will therefore bring a major contribution to the literature understanding the links between agricultural policies and farm structural change. The use of an extended time period will also provide valuable insights into the change in agricultural land concentration in France, that has been investigated so far only by Butault and Delame (2003) between 1988 and 2000.

The rest of the paper is organised as follows. Section 2 describes the implemented methodology. Section 3 provides details on the data used and the explanatory variables considered as well as their expected effects on farmland concentration. Section 4 reports the empirical results. Finally section 5 draws some directions for future research.

2. METHODOLOGY

A time-honoured approach to study distribution and concentration issues in the field of economic research consists in building so-called Lorenz curves from which a number of inequality measures can be derived (Kleiber and Kotz, 2003). We implement this approach using empirical data which split up the number of holdings and the number of operated hectares by farm.[1] From these data we estimate the corresponding Lorenz curve by fitting a parametric function, using the now classical form proposed by Rasche *et al.* (1980):

$$L(h) = \left(1-\left(1-F(n)\right)^{\alpha}\right)^{1/\beta} \tag{1}$$

[1] For our purpose it is not necessary, nor interesting, to specify whether the land operated is owned or rented in by the farmer. Hence all along the paper, we concentrate on the land operated by farms, whether owned or rented in.

where $L(h)$ is the cumulative distribution of the operated area, h; $F(n)$ is the cumulative distribution of the number of farms, n; and α and β are the parameters to be estimated, with $0 < \alpha, \beta \leq 1$. As suggested by Chotikapanich (1993) and Kleiber and Kotz (2003), the fit is achieved through non-linear least squares.[2]

The popular concentration ratio, or Gini coefficient, is then easily obtained (Rasche *et al.*, 1980):

$$G = 1 - \frac{2}{\alpha} B\left(1/\alpha, 1 + 1/\beta\right) \tag{2}$$

where $B(.)$ is the Beta function.

It is not our purpose here to discuss the Lorenz ordering properties of the Rasche *et al.* (1980) functional form expressed in equation (1), that is to say the conditions under which one Lorenz curve can be said to reflect a more concentrated or non-egalitarian situation; in this respect, the reader is referred to the relevant literature, Kleiber and Kotz (2003) being a good starting point. Rather, we shall simply retain the two following rules in comparing two Lorenz curves L_1 and L_2:

(i) the higher the associated Gini coefficient, the more concentrated the Lorenz curve; in other words, $G_1 \geq G_2 \Rightarrow L_1 \geq_\ell L_2$ where $\geq_\ell$ denotes the Lorenz ordering which can be understood as "more unequal";

(ii) L_1 will be said to be "more in favour of the smallest (respectively largest) farms" than L_2 if the share of hectares operated by the 50% first, smallest, farms is greater (resp. smaller) under L_1 than under L_2; or, mathematically, if $L_1\left(F(.5)\right) > L_2\left(F(.5)\right)$ (resp. $L_1\left(F(.5)\right) < L_2\left(F(.5)\right)$).

Regarding condition (i), it can be shown from the derivatives of equation (2) that, given β (respectively α), G is strictly decreasing in α (resp. β). Condition (ii) will be especially useful in situations where two Lorenz curves have the same associated Gini coefficient but

[2] Kleiber and Kotz (2003) suggest that the non-linear least squares estimation can be performed with or without a preliminary logarithmic transformation but do not specify whether one way is preferable. Here, we performed a direct estimation, *i.e.* without a preliminary log-transformation.

cross each other. Similarly as for condition (i), it can be shown from the derivatives of equation (1) that, given β (respectively α), $L(F(.5))$ is strictly increasing in α (resp. β).

Figure 1 illustrates the two above statements. In both panels 1.a and 1.b the cumulative number of farms (ordered according to increasing size) in percentage is reported on the horizontal axis while the cumulative number of operated hectares in percentage is reported on the vertical axis. Curve L_1 is the Lorenz curve corresponding to case 1 while curve L_2 is the Lorenz curve relating to case 2. The area between L_1 and the diagonal measures the Gini coefficient observed in case 1 (*i.e.* G_1) while the area between L_2 and the diagonal measures the Gini coefficient observed in case 2 (*i.e.* G_2). Hence, panel 1.a depicts the situation corresponding to condition (i): the Gini coefficient G_1 is greater than the Gini coefficient G_2, implying that farmland concentration is higher in case 1 than in case 2. On the other hand, panel 1.b figures the situation described under condition (ii): the Gini coefficients derived from both Lorenz curves are equal while these curves cross each other at point *E*. Therefore, farmland concentration is similar in both cases but more oriented towards smaller farms in case 1 relative to case 2: the 50% smallest farms (*i.e.* $F(.5)$) operate $L(F(.5)) = 18\%$ of the total area in case 1 as compared to 10% in case 2.

[insert Figure 1]

As already pointed out, the method described above is widely followed in the economic literature investigating distributional issues. In the field of agricultural economics, it has been used to study the distribution of subsidies, income, wealth, operated land or land ownership across farms (*e.g.* Wunderlich, 1958; El-Osta and Morehart, 2002; Butault and Delame, 2003; Allanson, 2006; Vollrath, 2006; Mishra *et al.*, 2009; Sinabell *et al.*, 2009). Researchers then analyse the role of several factors on the concentration ratio with the help of concentration ratio decomposition (*e.g.* El-Osta and Morehart, 2002; Mishra *et al.*, 2009), or a second-stage regression of the concentration ratio on several explanatory variables (*e.g.* Quan and Koo, 1985; Roberts and Key, 2008). In this paper, we use the second approach, namely the two-step estimation procedure. In a first stage parameters α and β are estimated by replacing them in equation (1) by their expressions given by equations (3) below, and used in equation

(2) to calculate the concentration ratio G. In a second stage the calculated concentration ratio is regressed over a set of explanatory variables, as described by equation (4) below.

Parameters α and β of equation (1) are expressed as follows:

$$\begin{cases} \alpha_{it} = \alpha_0 + \alpha_t .t + \sum_j \alpha_j .DEP_j + \sum_j \alpha_j^t .t \times DEP_j + u_{it} \\ \beta_{it} = \beta_0 + \beta_t .t + \sum_j \beta_j .DEP_j + \sum_j \beta_j^t .t \times DEP_j + v_{it} \end{cases} \quad (3)$$

where t represents time; DEP_j are "départements"[3] dummies with $j = \{2..90\}$ and $DEP_j = 1$ for $j = i$ and 0 otherwise; $\{\alpha_0, \alpha_t, \alpha_j, \alpha_j^t\}$ and $\{\beta_0, \beta_t, \beta_j, \beta_j^t\}$ are parameters to be estimated; u_{it} and v_{it} are error terms. In order to assess the resulting impact of both "départements" fixed effects and time on concentration, we regressed the calculated concentration ratio $\hat{G} = 1 - \frac{2}{\hat{\alpha}} B\left(1/\hat{\alpha}, 1 + 1/\hat{\beta}\right)$ on the same variables:

$$\hat{G}_{it} = g_0 + g_t .t + \sum_j g_j .DEP_j + \sum_j g_j^t .t \times DEP_j + w_{it} \quad (3')$$

where $\{g_0, g_t, g_j, g_j^t\}$ are the parameters to be estimated and w_{it} an error term.

In the second-stage $\hat{G}$ is regressed over a set of explanatory variables $X = \{X_l\}$:

$$\hat{G}_{it} = \gamma_0 + \sum_l \gamma_l X_{il} + \varepsilon_{it} \quad (4)$$

where $\{\gamma_0, \gamma_l\}$ are parameters to be estimated and ε_{it} an error term.

In order to deal with potential endogenous bias (*e.g.* while one may expect that government payments act as an incentive to enlarge farms, the reverse causality may be true, namely that farm enlargement decisions may also result in higher received government payments), most explanatory variables are entered in the model in their one-period lagged form.

[3] The "départements" correspond to the French NUTS3 regional level where NUTS is European geographical classification; we only consider metropolitan ones. Moreover, (i) the two Corsican "départements" 2A and 2B are considered as a single one (labelled 20), and (ii) Paris and the surrounding "départements" (91 "Essonne", 92 "Hauts-de-Seine", 93 "Seine-Saint-Denis", 94 "Val-de-Marne" and 95 "Val-d'Oise") are aggregated into a unique region (labelled 75). Finally, "département" 01 ("Ain") is used as a reference.

3. DATA AND EXPLANATORY VARIABLES

The data used are aggregated data at the French NUTS3 regional level (French "départements") between 1963 and 2007.[4] As data are derived from agricultural censuses or structural surveys, we do not have observations for all years. Observations for a total of 12 years are available, and, for each year, for 90 "départements" regions.[5] Lorenz curves are fitted based on the numbers of farms in several size categories observed over the period: for 9 years out of 12, we use 11 size classes, while for 2 years we use only 8 classes and for 1 year we use 13 classes (see Table A1 in annex).

Table 1 shows the global evolution of farm number and size for France between 1967 and 2007. We first note that the number of farms has decreased by more than 70% in 40 years, which is equivalent to an average net exit rate of around 3% per year, this net exit rate being higher on average for the 1988-2007 period (-50% in 19 years or -3.6% per year) than for the 1967-1988 period (-40% in 21 years or -2.4% per year). In the meantime, the total number of hectares used in the agricultural sector also steadily declined, but at a far smaller, yet stable, rate (-0.24% per year).

[insert Table 1]

As a result, the average size of French farms more than tripled over the period, from 17.8 ha in 1967 to 54.0 ha in 2007, that is to say an average annual growth rate of 2.8%. Comparing the average farm size evolution across "départements" shows that this increase in size took place everywhere and that it was stronger in "départements" characterised by relatively smaller structures (1st deciles compared to 9th deciles). The comparison across size classes shows that this evolution is not systematic though: while farms greater than 20 ha experienced an increase in size on average (+48% for farms between 20 and 100 ha, +61% for farms over 100 ha), farms with less than 20 ha saw their average area shrink from 7.7 ha to around 6.0 ha, that is to say a decrease of more than 20%. Accordingly, the share of hectares operated by smaller farms globally decreased to the benefit of larger ones.

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[4] Note that 1967, rather than 1963, has been used as the "initial" year ($t = 0$) because data are missing for some explanatory variables in 1963 for the "départements" around Paris.

[5] See footnote 3 for more details about the "départements" included.

However, the analysis of this trend is more complicated when dealing at the “départements” level and when the more detailed size categories of Table A1 are considered. It is therefore not straightforward to conclude whether it is a general and systematic feature that land concentration has increased in France over the last 40 years, calling for an econometric approach as the one we propose here.

The econometric analysis can also help shed light on the main factors, including agricultural support policy, that have contributed to such an evolution of farm size and farmland concentration. Many factors might have played a role in this process and it is not so easy to point out which ones had a significant and unambiguous impact. In order to help detect the potential key determinants of farmland concentration in France, let’s consider Figure 2. Panel 2.a. corresponds to an initial situation where the 90 available hectares are split across 9 equal size farms; thus, in this initial situation, the average size of farms is 10 ha while the Gini coefficient equals zero. Panels 2.b. and 2.c. depict two alternative final situations; in both panels, 3 farms have disappeared during the period considered. In Panel 2.b., the area left by these 3 farms is equally split between the 6 remaining farms. As a result, the 6 remaining farms enlarge proportionally so that in the final situation the average farm size is higher (an increase from 10 to 15 ha) but the Gini coefficient, hence the concentration of farmland, is unchanged. At reverse, in Panel 2.c., 3 farms have remained unchanged while 3 farms have enlarged (thanks to the area left by the 3 farms that exited) during the period. Hence, in this final situation, the average size of farms has also grown from 10 to 15 ha but the Gini coefficient has increased as well, indicating that farmland has become more concentrated. Our objective is to detect what are the main factors that can explain such movements as illustrated by the shift from Panel 2.a. to Panel 2.b. on the one hand, and from Panel 2.a. to Panel 2.c. on the other hand. Factors contributing to the first movement clearly act against farmland concentration while factors behind the second movement clearly favour farmland concentration. However, one must be aware that there are a number of factors which, although clearly affecting the number of farms and the average farm size, have not an obvious impact on the farmland concentration process. In other words, such factors are necessary for farmland concentration to emerge but are not sufficient for this process actually to take place.

[insert Figure 2]

3.1. Main factors driving the changes in the number of farms and the average farm size

It is clear from Figure 2 that the shift from the initial 9 farms of Panel 2.a. to the final 6 farms of Panels 2.b. and 2.c. requires first that some farmers exit the sector. Such a movement may simply result from demographic trends (old farmers retiring) or be the outcome of the decision by the farmer to leave farming either to benefit from an early retirement programme or to find a new job in the non-agricultural sector. Hence, we hypothesise as determinants of farmland concentration in France, with a potential positive effect: i) the share of farmers aged more than 50 years over the period; ii) the whole budget of the French successive early retirement programmes (which have been in force during the whole study period with a significant change implemented in 1992); iii) the ratio of the whole economy's value added to the agricultural value added, as a proxy of the relative profitability and attractiveness of non-agricultural sectors and/or of job opportunities outside agriculture.

In the same vein, one guesses easily from Figure 2 that the final situation closely depends on the number of farmers entering the agricultural sector during the period considered. Attractiveness of the agricultural sector and government support for farm settlement are both factors that are likely to favour farmers' entry. Thus, we hypothesise as determinants of farmland concentration with a potential negative impact: i) the ratio of the agricultural added value to the whole economy's added value, as a proxy of the relative profitability and attractiveness of agriculture; ii) the number of public grants allocated to young farmers to settle.

Farmers' entry and exit movements result essentially in a changing number of farms. In order to capture the final impact of entry and exit movements on farmland concentration, we also consider a variable capturing the net effect of these movements. For that purpose, we hypothesise that the decreasing rate of the number of farms observed during the period studied is likely to have a negative impact on farmland concentration (meaning that an increase in the speed of net exit is likely to increase farmland concentration), thus a positive sign of the coefficient is expected.

Finally, it can also be deduced from Figure 2 that the shift from Panel 2.a. to Panels 2.b. and 2.c. requires that farm enlargement is profitable (for all remaining farms in Panel 2.b. and for only some of them in Panel 2.c., see below). Technical progress, as a source of economies of scale, is very often advocated as a driver of farm enlargement. Therefore, we hypothesise that technical progress is a determinant of farmland concentration with a potential positive impact.

As usual, and even if we recognise that this is a fairly poor proxy, a time trend is used to capture the impact of technical progress.

At this stage, we must remind that if the process of farmland concentration closely depends on farmers' entry-exit and on the profitability of enlarging farms, these conditions are not sufficient to depict specifically the concentration process. As shown by Figure 2, although the same entry-exit movements together with the same increase in average farm size are observed when shifting from Panel 2.a. either to Panel 2.b. or to Panel 2.c., the final situation depicted by Panel 2.b. implies no change in farmland concentration while the final situation illustrated by Panel 2.c. results in an increase in farmland concentration.

3.2. Main factors alleviating farmland concentration

As illustrated by Figure 2, the shift from Panel 2.a. to Panel 2.b. not only requires that 3 farmers leave the sector while no additional farmer enters, but also that the area left by the exiting farmers is shared equally among the 6 remaining farmers. Clearly, the degree of competition on farmland markets is a key factor as regards the relative ability of the various farmers to acquire additional land for enlarging their farm. Lower competition on farmland markets is likely to favour more equal access conditions to additional land among farmers. Hence, we retain two variables to measure the degree of competition for land in French "départements": the average agricultural land price and the share of utilised agricultural area in the total "département" area. Both lower land price and higher ratio of agricultural area indicate less competition on land markets which, we hypothesise, would act as alleviating farmland concentration. Therefore, the average agricultural land price is expected to have a positive impact on farmland concentration, while the ratio of utilised agricultural area in total "département" area is expected to affect negatively farmland concentration.

Obviously, structural policy measures are of key importance here since, at least in France, one of their objectives is to limit "excessive" farmland concentration. It is out of the scope of this paper to describe in details the French structural policy, which was first implemented at the end of World War II through the "statut du fermage" (tenancy regulations) and subsequently complemented by the successive "Lois d'orientation agricole" (framing agricultural laws). Let's only recall the main objectives and the main policy instruments of this complex policy. Modernizing farms while promoting the family farm model is the key objective of the French policy for agricultural structures. For that purpose, implemented measures are expected to favour new farmers' settlement, to help consolidate smallest farms and impede "excessive" farmland concentration. In addition to a lot of intricate policy measures (such as the formerly mentioned early retirement and young farmers settlement support programmes or land consolidation programmes), the key policy instruments of the French structural policy are two institutional bodies working at the “département” level: the SAFER (“Société d’Aménagement Foncier et d’Etablissement Rural”) and the CDOA (“Commission Départementale d’Orientation Agricole”). Both bodies control farmland transactions (sales and renting) and may modify transactions so that the latter become more compatible with pursued objectives (for instance, SAFER and CDOA can impede a land transaction that would favour the enlargement of a large farm to the detriment of the settlement of a young farmer).[6] Clearly, the activity of SAFER and CDOA has an impact on farmland concentration. This impact is likely to be negative since both bodies have as one objective to limit “excessive” farmland concentration. Unfortunately, we could not find data describing the activity of SAFER and CDOA in “départements” in a satisfactory way during several years. We could only find few data providing some information about the activity of the SAFER at the national level. More specifically we found data on the area of land acquired by the SAFER in “départements”, aggregated at the national level over the study period. As the SAFER has the right to pre-empt land in order to force the seller to reconsider the transaction, such data can be considered as a proxy of the SAFER activity at the national level. This is however an imperfect proxy since land pre-emption is the very last stage in the negotiation process between the SAFER and the seller: most often the SAFER and the seller find an agreement before this last stage so that land pre-emption is not necessary. In order words, a change in the land area acquired by the SAFER does not imply a change in its level of activity. However it may indicate a change in the influence of the SAFER and pressure on farmland transactions. Hence, a large share of the overall impact of the SAFER and CDOA activity in “départements” on farmland concentration is likely uncovered by our explanatory variable and remains embodied either in other explanatory variables (such as “départements” dummies) or in the error term.

3.3. Main factors favouring farmland concentration

As it can be deduced by comparing Panel 2.b and Panel 2.c, the final situation 2.c is more likely to appear provided that it is more profitable and/or easier for some farmers relative to others to enlarge their farms on the one hand, and that such farmers are more able to acquire

[6] For more details on the functioning of farmland markets in France, see Latruffe and Le Mouël (2006) and Latruffe *et al.* (2008), for example.

additional land than others on the other hand. In other words, the higher the heterogeneity across farmers and their farming conditions, the more likely the emergence of the final situation 2.c. Numerous factors contribute to make farmers and farming conditions more or less heterogeneous within and across French “départements”, but we cannot include all of them in this analysis. Moreover, these factors are very often correlated. Finally, for many of these factors, data are not available at the “départements” level so that national series should be used instead, erasing the interest of using corresponding variables as to measure heterogeneity across farmers and their farming conditions within France.[7] We tested numerous variables that we considered as potentially capturing the degree of heterogeneity of farmers and farming conditions across French “départements” and over time. Finally, we retain as potential determinants of farmland concentration with a positive hypothesised impact: i) the agricultural net income per unit of family labour observed in each “département”, as a proxy of the relative profitability of enlarging farms; ii) the share of consolidated area (through public consolidation programmes) in the total used agricultural area, as a proxy of the easiness of farm enlargement.[8]

3.4. Income support policies

The objective of the paper is to pay a specific attention to the impact of agricultural support on farmland concentration. Hence, several variables representing the income support policy which has been in force in France during the period studied 1963-2007 were first considered. Some of these variables were finally withdrawn from the analysis because they apparently were not able to capture the effects we expected, in particular due to the fact that they were highly correlated with other explanatory variables. This was the case of: i) the output price indices which were expected to reflect the impact of the price support policy that was in force until the 1992 CAP reform and that has been progressively replaced by a direct payment programme since then; ii) the dummies introduced as to account for the major CAP reforms (*i.e.*, 1992, 2000 and 2003). Finally, the following variables were retained: i) the level of the so-called CAP first-pillar direct payments, which have substituted to price support and are positive in latest periods only; ii) the level of the payments under the so-called CAP second

[7] This is the case, for example, of the variables relating to the level of education of farmers (that could depict the relative ability of farmers to manage larger farms) which are available at the national level only.

[8] Unfortunately, data for this variable are available at the national level only. Hence, the variable we use cannot account for the varying conditions in terms of land consolidation faced by farmers across “départements”. It can only account for the evolution of such conditions over time.

pillar, which have been substantially increased following the last CAP reforms; iii) a dummy equal to 1 for years after 1984 and 0 before, to consider the effect of the introduction of milk quotas; iv) the milk quota dummy is, in addition, interacted with a dummy for mountainous dairy "départements" (such as the ones in the Massif Central area for example) to take into account the fact that the milk quota implementation has potentially affected differently the various French dairy regions according to their prevailing livestock system.

The impacts of first- and second-pillar CAP payments remain ambiguous. On the one hand, such payments may help some less productive farms to survive, decreasing the rate of farmers' net exit from the agricultural sector. Such a movement is likely to contribute to reduced farmland concentration. But, on the other hand, first-pillar payments may provide an incentive to enlarge farms, as they may alleviate credit constraints as hypothesised for example by Roberts and Key (2008). As for second-pillar payments, which are more specifically designed to compensate farmers for the multifunctional services they provide to society, they could contribute to increased heterogeneity of farms in terms of size, types of production, production patterns, etc. As a result, both first- and second-pillar payments are also in a position to provide conditions for an increasing farmland concentration. Finally, following Roberts and Key (2008) who find a positive impact of government payments on farmland concentration in the US over the period 1987-2002, we hypothesise a positive effect of the first-pillar CAP payments on the farmland concentration process in France, provided that these first-pillar CAP payments are closer to US payments than second-pillar payments are. For the latter, however, we cannot conclude as regards their overall effect on the French farmland concentration process.

As far as milk quotas are concerned, a negative impact on farmland concentration is expected, since the quota instrument and the way it has been implemented in France (implying a strong link with land and rather strict restrictions on quota transfers between farms) clearly contribute to freeze dairy farms structures and thus farmland concentration, at least within the French dairy sector.

3.5. Controls

Land concentration may be stronger for specific farm specialisations. For example, commodity-supported programs have for long primarily targeted crop productions, such as wheat or maize, by encouraging farms to enlarge in order to receive more area-based payments (Roberts and Key, 2008). There may also be economies of scale in specific crop productions that have given incentives to concentrate land on large holdings (Vollrath, 2006).

To control, at least partially, for this effect, the share of CAP direct payments (first and second pillars) in the total value of agricultural production of each “département” is included. Moreover, the “département” dummies introduced in the first-stage estimation also control for part of the farm specialisation effect. To capture the potential effect of differing initial conditions across “départements”, the initial average farm size, that is to say the average farm size observed in 1967, is included in the regression.

Table 2 lists all previously described explanatory variables. As noted in Table 2, for several of these variables, data are unfortunately not available at the level of the “départements”. In such cases, national series are used, implying a homogenous impact across all “départements”.

[insert Table 2]

4. RESULTS

4.1. “Départements” fixed effects and the impact of time

As shown in Table 3, with an adjusted R² over 0.999, the estimation of the model composed of equations (1) and (3) yields an overall highly satisfactory fit. Results indicate a positive (respectively negative) mean effect of time on α (resp. β), both being significant at the 1% level. Moreover, $\hat{\alpha}_t$ is smaller than $\hat{\beta}_t$ in absolute term (+0.003 against -0.005) resulting in a global slight increase in the Gini coefficient over the period, as illustrated by panel 3.a. of Figure 3: on average for all “départements”, it starts from a value of 0.529 in 1967 and ends up with a value of 0.566 in 2007, that is to say a +7.0% increase over 40 years or +0.17% per year. In the mean time, $\hat{L}(F(.5))$ decreases more sharply from 0.143 to 0.109 (-24.2% or -0.69% per year). In summary, results show that, on average, concentration slightly increased to the detriment of smaller farmers. However, as it was already considered in section 2, panel 3.b. of Figure 3 confirms that the relationship between G and $L(F(.5))$ is not unambiguous since a given value of $\hat{G}$ may correspond to several values of $\hat{L}(F(.5))$ and vice versa.

[insert Table 3 and Figure 3]

Panel 4.a. of Figure 4 shows that in 1967 “départements” are heterogeneous in terms of concentration, with $\hat{G}$ ranging from relatively low levels, indicating low farmland concentration ($\hat{G} \leq 0.50$), to rather high levels, suggesting high concentration ($\hat{G} \geq 0.70$). The resulting map presented in panel 4.b. highlights that concentration is relatively higher around the Mediterranean sea, with a maximum $\hat{G}$ of 0.80 in “Alpes-Maritimes”, in the South-East, and in the “départements” such as “Marne”, “Gironde” or “Haut-Rhin”, that is to say “départements” which are quite heterogeneous with the coexistence of production systems operating at a small scale in terms of cultivated area (such as horticulture, fruits and vegetable production or viticulture) and production systems operating on quite large areas (such as sugar beet or maize production in “Marne”, “Gironde” or “Haut-Rhin”, or sheep and goat breeding in “Alpes-Maritimes” or “Pyrénées-Orientales”). On the other hand, concentration is smaller in more homogeneous “départements”, be them specialised in cattle breeding (such as in the “Limousin” and “Massif Central” areas), milk production (in the “Bretagne” region) or in cash crop production (such as in “Eure-et-Loire” or “Pas-de-Calais”).

[insert Figure 4]

Panel 4.c. of Figure 4 results from the estimation of equation (3’) (see also Table A2. in annex). It shows that the evolution of farmland concentration differs from one “département” to the other: 64 out of 90 (or 71%) have become more concentrated while 26 out of 90 (or 29%) have become less concentrated. Panel 4.d. of Figure 4 shows that the relationship between becoming more or less concentrated and the initial average farm size is not unambiguous; for example: “Aisne” and “Aube” experienced opposite trends in terms of concentration though their average farm size in 1967 was in the same range; “Seine-et-Marne” and Corsican “départements” experienced a similar de-concentration process while their initial average farm size was relatively large for the former and relatively small for the latter.

These results confirm that farmland concentration is not only a matter of average farm size growth but the result of an intricate play between the number and the relative size of farms entering and exiting, the rhythm of enlargement of farms staying in place and the decay in the total available agricultural area. This is why we now turn to the results regarding the impact on farmland concentration of the factors which are susceptible to influence these processes.

4.2. The impact of factors influencing farmland concentration

Table 4 reports the estimation of parameters γ in model (4). The adjusted R^2 is 0.43.

Several variables exhibit insignificant effects. Most of them correspond to those variables that we described in section 3 as necessary for the farmland concentration process to emerge but not sufficient for this process actually to take place. This is the case for the share of farmers over 50 (PCPL50ANS), the decreasing rate of the number of farms observed during the period studied (TXVARMOYN) and the ratio of agricultural added value over total added value (PCVABAGR_1). Therefore, the fact that these variables most probably affect farm number and farm size, but cannot on their own actually drive the farmland concentration process, is confirmed by these empirical results.

At reverse, both the whole budget of the early retirement programmes (PRERETR_1) and the number of public grants allocated to young farmers' settlement (DJAINST_1) have a significant impact on farmland concentration. This means that not only these French structural programmes have affected the farm number but they have also contributed to the farmland concentration process. As expected the early retirement programmes, which favour farmers' exit, have a positive effect while the young farmer settlement programme, which favours farmers' entry, has a negative effect on farmland concentration.

As expected, the share of agricultural land in total land of each "département" (PCSURFDEP_1) has a strongly significant negative impact, while the agricultural land price observed in each "département" (PRIXTA_1) exhibits a strongly significant positive effect on farmland concentration in France. These results suggest that higher competition in farmland markets act as increasing farmland concentration. As a consequence, increasing urban pressure, which is currently observed in France and which results in a continuous decrease in the French agricultural area, is likely to positively contribute to farmland concentration, especially in highly urbanised zones.

Also, as hypothesised, the farm income per unit of family labour (REV2UTA_1) has a positive impact on farmland concentration in France which is significant at the 10% level. In other words, conditions that improve the profitability of enlarging farms increase farmland concentration. Similarly, the share of consolidated area in the total used agricultural area (REMEMBR_1), a proxy of the easiness of farm enlargement, affects positively farmland concentration. However, this effect is not significant. This result may be due to the fact that our REMEMBR_1 variable is defined at the national level and not at the "départements" level. Hence, it is not able to capture the heterogeneity of farms as regards the consolidated area conditions across "départements".

Among the considered control variables, the initial average farm size (SAUMOY67) and the share of total CAP direct payments in the value of agricultural production (AID2PRO_1) both have a significant negative impact on farmland concentration in France. Hence, our empirical results suggest that: the lower the initial farm size, the greater the potentialities for further structural adjustments and the higher farmland concentration; the lesser the dependence of farm revenue on total CAP direct payments, the higher the farmland concentration.

While we expected a negative impact of the SAFER activity on farmland concentration, Table 4 reports a positive coefficient for our "SAFER variable" (ACQSAFER_1). However this estimated coefficient is not significant. This is not so surprising since, as already mentioned, our variable is a poor proxy of the SAFER activity.

Finally, among policy variables, only 2 out of 4 have a significant impact on farmland concentration in France. It is worth noting that first pillar CAP payments (AIDEPIL1_1) exhibit a negative effect; in other words, we do not recover the positive link between this type of payments and farmland concentration as emphasised in Roberts and Key (2008) for the US. Nevertheless, in our case, this relationship is not statistically significant. Second-pillar CAP payments (AIDEPIL2_1) affect significantly and negatively farmland concentration in France. This suggests that the negative impact of this variable, potentially resulting from its contribution to increased farm heterogeneity, overcomes its positive impact potentially due to its contribution to the increase in the number of farms. Furthermore, this empirical result suggests that the second-pillar CAP payments actually act as promoting the EMA, at least in France, through their positive effect on farm heterogeneity. Surprisingly, the milk quota dummy variable (DUMQUOLAIT) exhibits a positive effect on farmland concentration; however, this effect is statistically significant at the 10% level only. This result suggests that, contrary to our expectation, milk quotas would have not impeded farm structures to adjust in France, this structural adjustment resulting, in average, in an increased farmland concentration. Such a positive effect of milk quotas, which is observed at the national level, results from antagonist impacts in mountainous *vs*. plain "départements". Indeed, Table 4 shows that the milk quota variable has a significant negative effect when it is crossed with dummies of "départements" belonging to mountainous zones (DUMLAITZMM). This suggests that milk quotas have specifically affected farmland concentration in French mountain areas, where they have contributed to alleviate the concentration process by freezing dairy farms structures.

[insert Table 4]

Finally, several general findings can be deduced from our empirical results. First of all, some surprising results clearly reveal the complexity of the farmland concentration process and the difficulty to find variables allowing for consistently disentangling the impacts of the numerous factors that potentially drive this process. Second, our results suggest that the main non-policy factors driving the farmland concentration process in France are the initial farm size, the early retirement and the young farmer settlement programmes and the degree of competition on farmland markets. Third, as regards agricultural policy, only the second-pillar CAP payments and milk quotas in mountain areas clearly act as alleviating farmland concentration in France. First-pillar CAP payments do not significantly affect the French farmland concentration process. This may suggest that credit constraints are not important constraints for farms in France or that French farms do not in general exhibit increasing returns to scale, two hypotheses that were brought forward by Roberts and Key (2008) to explain the positive impact of payments on farm concentration in the US. Fourth, our results show that it is really a hard task to assess the overall effects of the CAP as well as of the French policy for agricultural structures on farmland concentration.

5. CONCLUDING REMARKS

Our findings show that land concentration as measured by the Gini coefficient is a characteristic of the French agricultural model that is quite complex to study, because of its multidimensional nature. Indeed, it summarises at least three components: i) the evolution of the number of farms, ii) the evolution of the number of available hectares, and iii) the evolution in the repartition of these hectares among these farms. However, our study provides interesting insights complementary to more traditional approaches studying the evolution of the average size of farms. It also raises potential directions for future research on this issue.

First, the availability of data limits the analysis, and further research could concentrate on obtaining more precise data. For example, more explanatory variables should be defined at the "départements" level in order to better capture the heterogeneity across "départements". As previously mentioned, some of the variables we used could then exhibit higher significance.

Second, from an econometric perspective, we acknowledge the limit in our model specification, in the sense that it relies on a first-stage analysis which roughly aims only at estimating the Gini coefficient that is later used to regress the impact of explanatory variables. A more robust approach would be a single-stage approach which would consist in estimating the α and β parameters with respect to the explanatory variables, and then directly compute the marginal effects of these variables on G from the derivatives of the Rasche *et al.* (1980) formula with respect to α and β. Not only this would be an original method with respect to what can be found in the literature, but it would also lead to a more robust and potentially more fruitful estimation of the impacts of the various considered factors on farmland concentration.

Finally, further research could concentrate on the effects of public policies on farm wealth concentration in France, such as farm income or owned agricultural land. Indeed, besides maintaining various agricultural production systems on the European territory, another objective of the CAP in the frame of the EMA is to maintain fair standards of living for EU farmers. Although the general view is that CAP subsidies have accelerated farm wealth concentration and income inequalities among farmers, the specific French structural policy and regulations on the land market may have mitigated the effect in France.

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Table 1. Total number of farms, total used agricultural area, average farm size and distribution of farm sizes in France between 1967 and 2007

Year	1967	1988	2007
Total number of farms (N)	1,689,919.0	1,016,755.0	506,920.0
Total used agricultural area (H)	30,102,071.0	28,595,796.0	27,355,829.0
Average farm operated area (N/H)	17.81	28.12	53.96
Average farm size by "départements"			
Mean	20.65	31.61	59.76
Standard deviation	11.28	15.39	26.95
1st deciles	9.79	14.73	26.54
9th deciles	38.34	57.13	99.07
Farms with less than 20 ha			
Number of farms	1,208,495.0	556,725.0	211,305.0
Share of total	*72%*	*55%*	*42%*
Used agricultural area	9,305,287.0	3,757,243.0	1,282,407.0
Share of total	*31%*	*13%*	*5%*
Average area	7.70	6.75	6.07
Farms between 20 and 100 ha			
Number of farms (% of total)	372,076.0	377,680.0	161,178.0
Share of total	*22%*	*37%*	*32%*
Used agricultural area (% of total)	11,270,590.0	14,754,223.0	7,208,363.0
Share of total	*37%*	*52%*	*26%*
Average area	30.29	39.07	44.72
Farms with more than 100 ha			
Number of farms (% of total)	109,348.0	82,350.0	134,437.0
Share of total	*6%*	*8%*	*27%*
Used agricultural area (% of total)	9,526,194.0	10,084,330.0	18,865,059.0
Share of total	*32%*	*35%*	*69%*
Average area	87.12	122.46	140.33

Source: authors' own calculations based on 1988 agricultural census and 1967 and 2007 farm structures surveys

Table 2. Considered explanatory variables

Variables	Names	Definition and unit	Unit	Lagged	Definition scale	
					National	"départements"
Time trend	t	Time elapsed since 1967	years	No	X	
Fixed effects	DEPDUM	"départements" dummies	binary	na		X
Initial average farm size	SAUMOY67	Total number of farms in the "département" in 1967 / total number of operated hectares	ha	No		X
Farmers ageing	PCPL50ANS	Share of farm holders over 50 years old	%	No	X	
Net exit rate	TXVARMOYN	Average annual net exit rate between each pair of successive years in the database	%	No		X
Farm income	REV2UTA_1	Average gross farm income per unpaid labour input unit	€/FWU	Yes		X
Milk quota dummy	DUMQUOLAIT	0 before 1984, 1 after 1984	binary	na	X	
Mountainous area	DUMLAITZMM	0 before 1984, 1 after 1984 for "départements" significantly located in a mountainous area	binary	na		X
CAP 1st pillar	AIDEPIL1_1	Total CAP 1st pillar payments received	Mio€	Yes		X
CAP 2nd pillar	AIDEPIL2_1	Total CAP 2nd pillar payments received	Mio€	Yes		X
Level of support	AID2PRO_1	Sum of CAP 1st and 2nd payments / total value of production	%	Yes		X
Settlement grants	DJAINST_1	Number of new settlement grants	files	Yes	X	
Early-retirement grants	PRERETR_1	Total payments under the early-retirement policy	Mio€	Yes	X	
Consolidated area	REMEMBR_1	Total new consolidated area	1000 ha	Yes	X	
SAFER's activity	ACQSAFER_1	Total area acquired by the SAFER	1000 ha	Yes	X	
Agricultural added value	PCVABAGR_1	Share of agricultural value added in total value added	%	Yes	X	
Agricultural area	PCSURFDEP_1	Share of used agricultural area in total "département" surface	%	Yes		X
Agricultural land price	PRIXTA_1	Average price of arable land	€/ha	Yes		X

Note: na = not applicable; FWU = Family Work Unit; CAP = Common Agricultural Policy; SAFER = "Société d'Aménagement Foncier et d'Etablissement Rural" (society for land management and rural establishment)

Table 3. Estimation results of model (1)-(3)

	Estimate	Robust Std. Err	t stat.	P>|t|
α_0	0.73156	0.01883	38.86	0.000
α_t	0.00307	0.00084	3.65	0.000
α_j		*see panel A1.a. of Figure A1 in annex*		
α_j^t		*see panel A1.b. of Figure A1 in annex*		
β_0	0.49712	0.02212	22.48	0.000
β_t	-0.00489	0.00085	-5.73	0.000
β_j		*see panel A1.c. of Figure A1 in annex*		
β_j^t		*see panel A1.d. of Figure A1 in annex*		
Adjusted R^2	0.9993			
Number of obs.	11520.0			

Source: authors' own estimates

Table 4. Estimation results of model (4)

	Estimate	Robust Std. Err	t stat.	P>|t|
Constant	0.1035709	0.4607447	0.22	0.822
SAUMOY67	-0.0007522	0.0002561	-2.94	0.003
PCPL50ANS	0.8554284	0.6542553	1.31	0.191
TXVARMOYN	-0.0852655	0.0741984	-1.15	0.251
REV2UTA_1	0.0000003	0.0000002	1.56	0.119
DUMQUOLAIT	0.0712375	0.0420450	1.69	0.091
DUMLAITZMM	-0.0392254	0.0069944	-5.61	0.000
AIDEPIL1_1	-0.0000507	0.0000916	-0.55	0.580
AIDEPIL2_1	-0.0009356	0.0003651	-2.56	0.011
AID2PRO_1	-0.1616249	0.0474510	-3.41	0.001
DJAINST_1	-0.0000191	0.0000107	-1.79	0.073
PRERETR_1	0.0003713	0.0001953	1.90	0.058
REMEMBR_1	-0.0002859	0.0002043	-1.40	0.162
ACQSAFER_1	0.0022338	0.0017889	1.25	0.212
PCVABAGR_1	1.2399170	1.0250420	1.21	0.227
PCSURFDEP_1	-0.2575128	0.0180525	-14.26	0.000
PRIXTA_1	0.0000163	0.0000019	8.58	0.000
Adjusted R^2	0.4335			
Number of obs.	988.0			

Source: authors' own estimates

Figure 1. Farmland concentration: Lorenz curve and Gini coefficient

Panel 1.a. Illustration of condition (i) | Panel 1.b. Illustration of condition (ii)

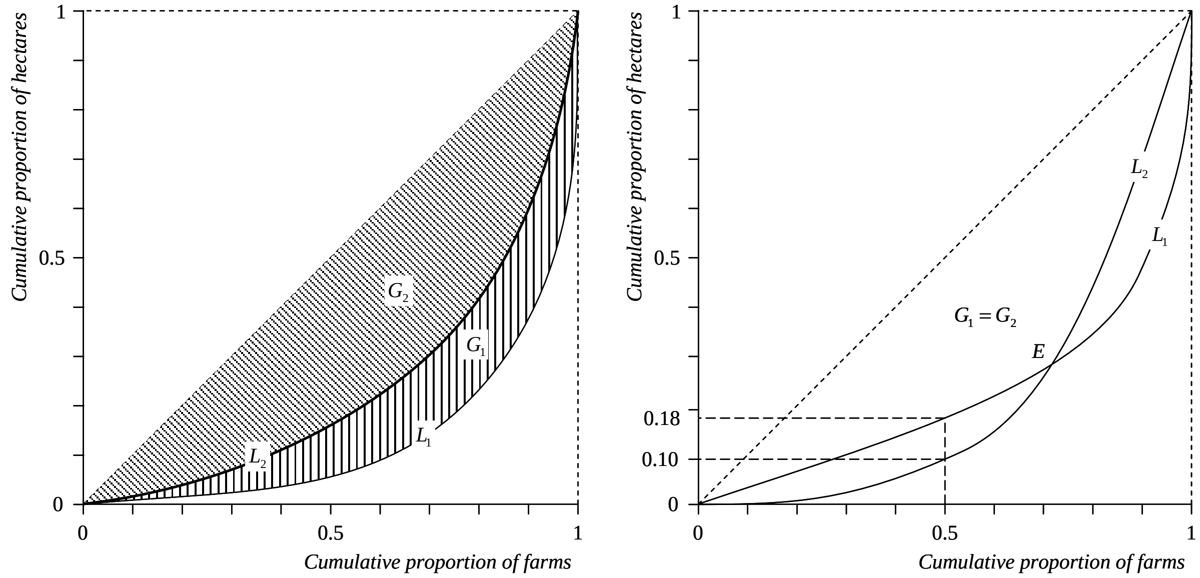
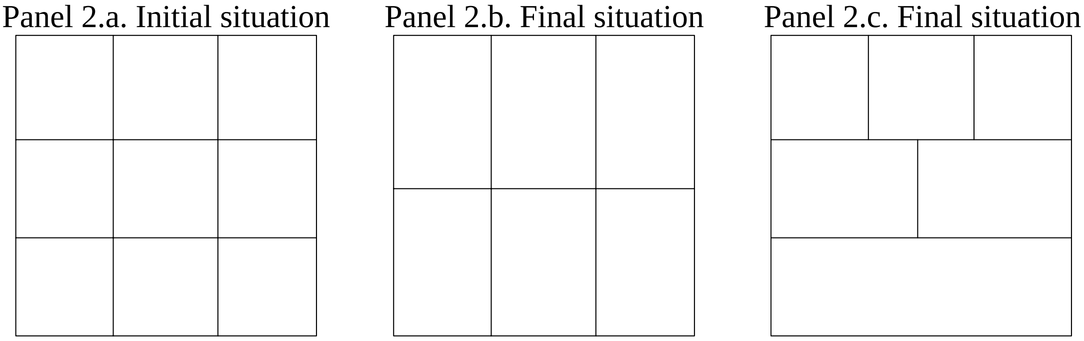


Figure 2. Farmland concentration: A graphical illustration

Panel 2.a. Initial situation | Panel 2.b. Final situation | Panel 2.c. Final situation



Unchanged concentration | Higher concentration

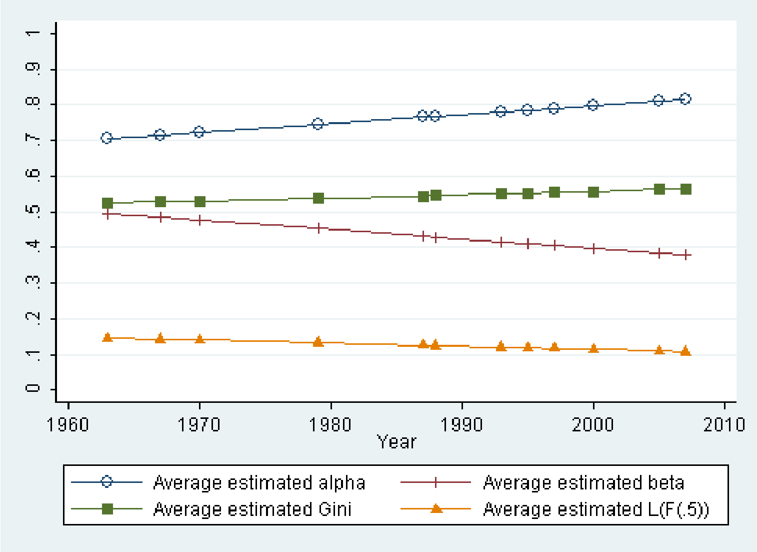
Number of farms n=9
Total area h=90 ha
Average farm size=10 ha
Gini coefficient=0

Number of farms n=6
Total area h=90 ha
Average farm size=15 ha
Gini coefficient=0

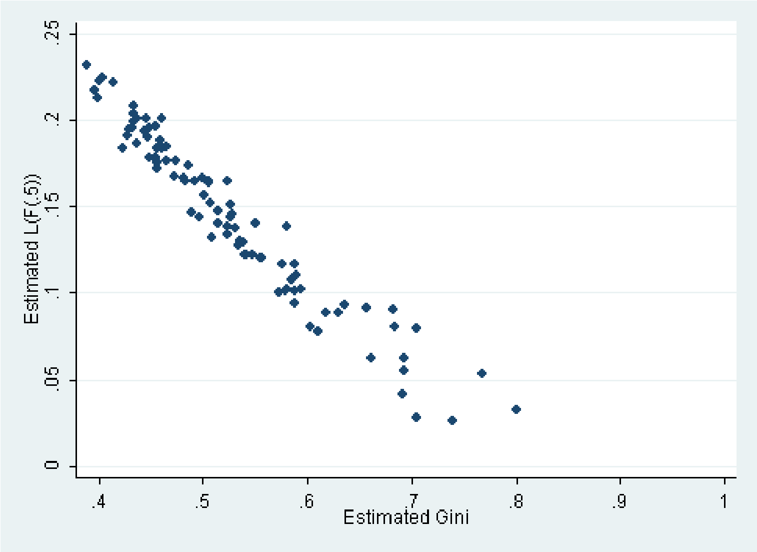
Number of farms n=6
Total area h=90 ha
Average farm size=15 ha
Gini coefficient>0

Figure 3. Evolution of $\hat{\alpha}$, $\hat{\beta}$, $\hat{G}$ and $\hat{L}(F(.5))$ during the whole period and relationship between $\hat{G}$ and $\hat{L}(F(.5))$ in 1967

Panel 3.a. Evolution of average $\hat{\alpha}$, $\hat{\beta}$, $\hat{G}$, $\hat{L}(F(.5))$



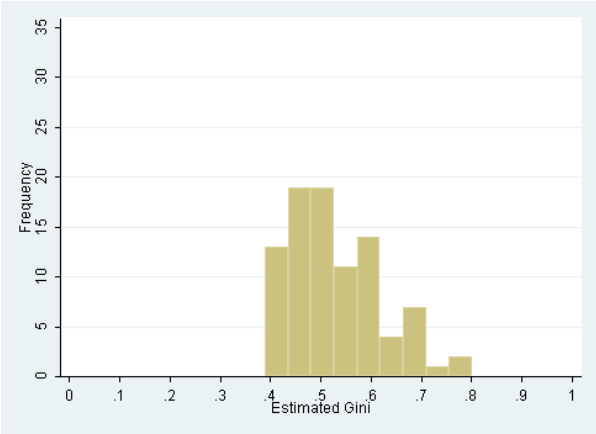
Panel 3.b. $\hat{L}(F(.5))$ against $\hat{G}$ for 1967



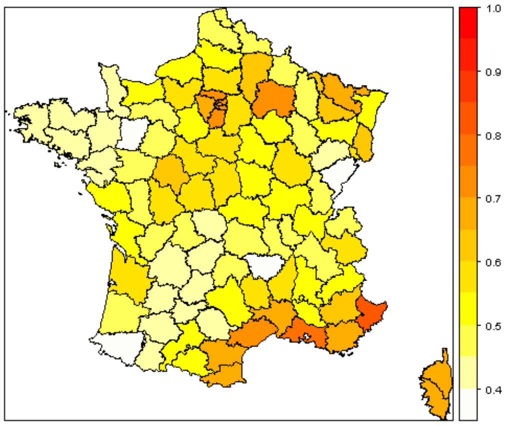
Source: authors' own estimates

Figure 4. Distribution of $\hat{G}$ over all “départements” in 1967, total effect of time on $\hat{G}$ and average farm size in 1967

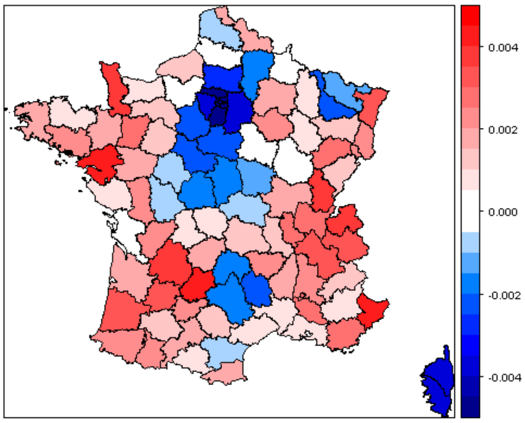
Panel 4.a. Distribution of $\hat{G}$ in 1967



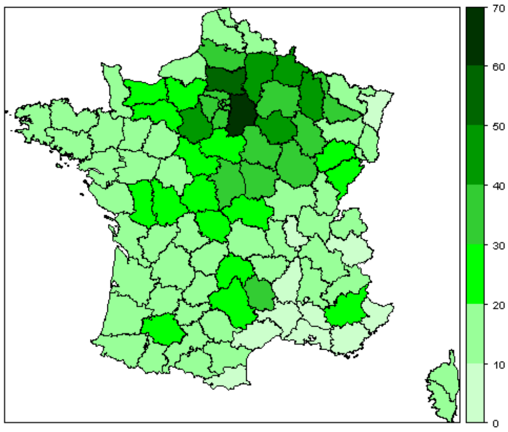
Panel 4.b. Spatial distribution of $\hat{G}$ in 1967



Panel 4.c. Total time effect on $\hat{G}$ [a]



Panel 4.d. Average farm size in 1967 [b]



[a]: The total time effect is given by $\hat{g}_t + \hat{g}_j^t$ for each “département” j (see equation (3’)).

[b]: Units are hectares.

Notes: in panel 4.b., c. and d., the two Corsican “départements” have been attributed the same unique value obtained for our region 20; the same applies for Paris and its surrounding 5 “départements” which have been attributed the value obtained for our region 75

Source: authors’ own estimates

ANNEX

Table A1. Available years and definition of size classes used for each of them

<table>
<tr><th>Years</th><th>1963</th><th>1967</th><th>1970</th><th>1979</th><th>1987</th><th>1988</th><th>1993</th><th>1995</th><th>1997</th><th>2000</th><th>2005</th><th>2007</th></tr>
<tr><td>Number of classes</td><td>8</td><td>8</td><td>11</td><td>11</td><td>13</td><td>11</td><td>11</td><td>11</td><td>11</td><td>11</td><td>11</td><td>11</td></tr>
<tr><td>< 1 ha</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>1 to 1.99 ha</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>2 to 4.99 ha</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>5 to 9.99 ha</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>10 to 19.99 ha</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>20 to 34.99 ha</td><td rowspan="2">x</td><td rowspan="2">x</td><td rowspan="2">x</td><td rowspan="2">x</td><td>x</td><td rowspan="2">x</td><td rowspan="2">x</td><td rowspan="2">x</td><td rowspan="2">x</td><td rowspan="2">x</td><td rowspan="2">x</td><td rowspan="2">x</td></tr>
<tr><td>35 to 49.99 ha</td><td>x</td></tr>
<tr><td>50 to 74.99 ha*</td><td rowspan="2">x</td><td rowspan="2">x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>75** to 99.99 ha</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>100 to 149.99 ha</td><td rowspan="5">x</td><td rowspan="5">x</td><td>x</td><td>x</td><td rowspan="2">x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>150 to 199.99 ha</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>200 to 299.99 ha</td><td rowspan="3">x</td><td rowspan="3">x</td><td>x</td><td rowspan="3">x</td><td rowspan="3">x</td><td rowspan="3">x</td><td rowspan="3">x</td><td rowspan="3">x</td><td rowspan="3">x</td><td rowspan="3">x</td></tr>
<tr><td>300 to 499.99 ha</td><td>x</td></tr>
<tr><td>> 500 ha</td><td>x</td></tr>
</table>

*: for 1987, the upper class limit is 69.99 ha; **: for 1987, the lower class limit is 70 ha.

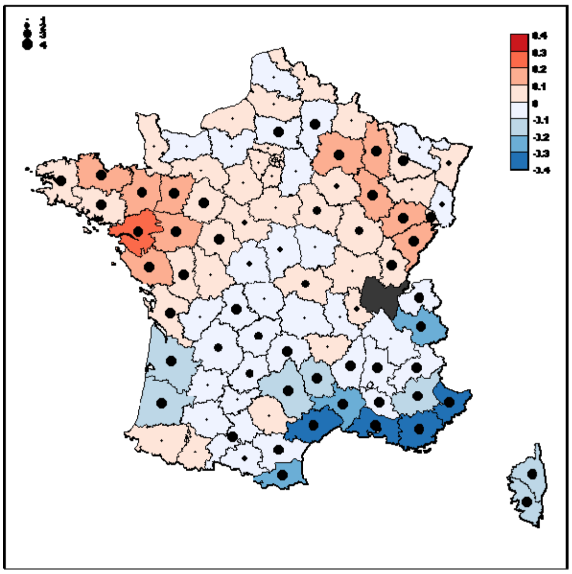
Table A2. Estimation results of model (3')

	Estimate	Robust Std. Err	t stat.	P>|t|
g_0	0.49852	0.00110	454.17	0.000
g_t	0.00282	0.00004	64.27	0.000
g_j		*see panel A2.a. of Figure A2*		
g_j^t		*see panel A2.b. of Figure A2*		
Adjusted R^2	0.9994			
Number of obs.	1080.0			

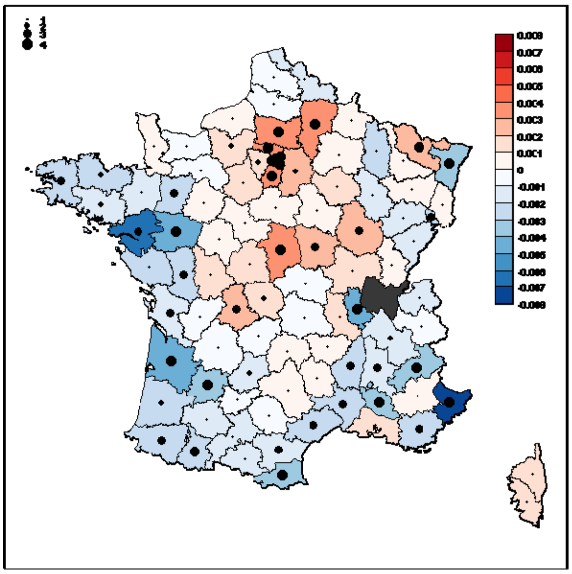
Source: authors' own estimates

Figure A1. Estimation results of model (1)-(3)

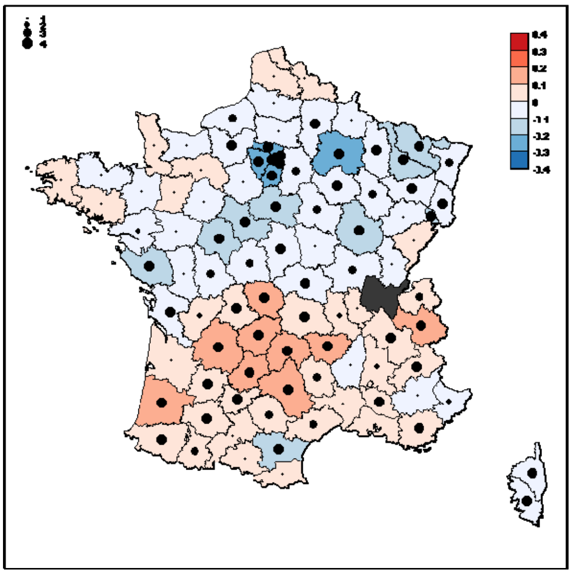
Panel A1.a. Map of $\hat{\alpha}_j$



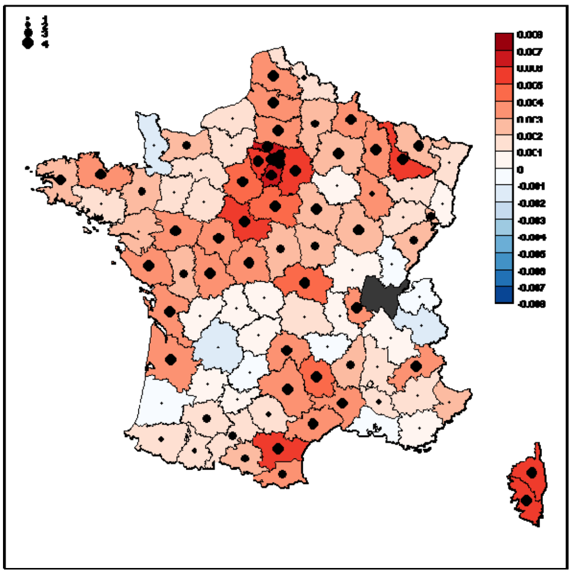
Panel A1.b. Map of $\hat{\alpha}_j^t$



Panel A1.c. Map of $\hat{\beta}_j$



Panel A1.d. Map of $\hat{\beta}_j^t$

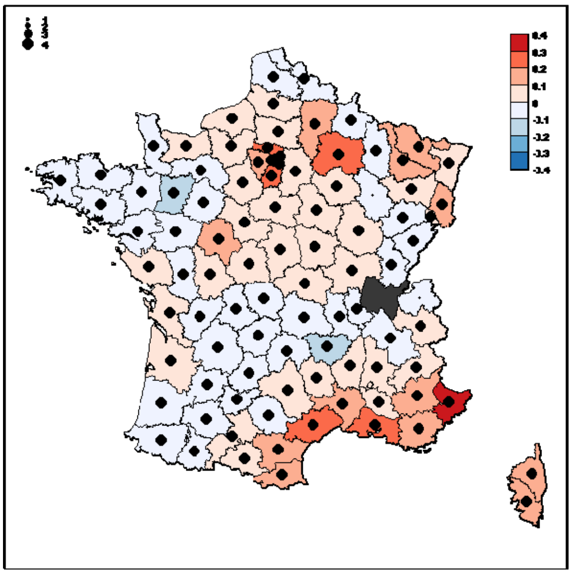


Note: the dark-greyed “département” is the reference (“Ain”), *i.e.* the “département” for which the coefficients are zero; red-blue scales depict the deviation of the parameters characterising “département” j from the reference; dots depict the level of significance of the parameters as follows: 1 = not significant; 2 = significant at 10% ; 3 = significant at 5%; 4 = significant at 1%.

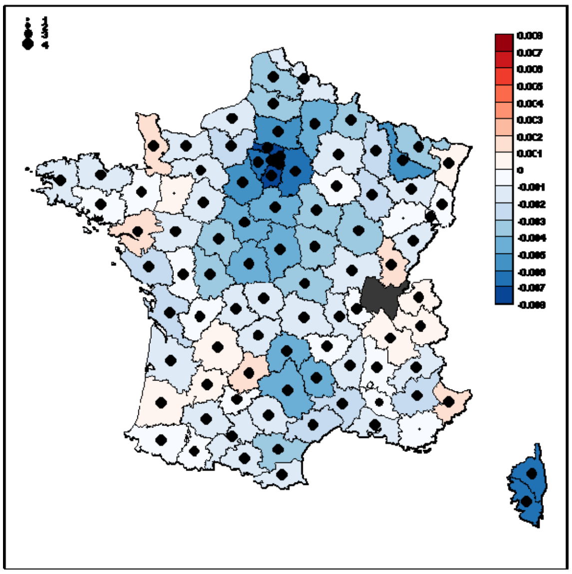
Source: authors’ own estimates

Figure A2. Estimation results of model (3’)

Panel A2.a. Map of $\hat{g}_j$



Panel A2.b. Map of $\hat{g}_j^t$



Note: the dark-greyed “département” is the reference (“Ain”), *i.e.* the “département” for which the coefficients are zero; red-blue scales depict the deviation of the parameters characterising “département” j from the reference; dots depict the level of significance of the parameters as follows: 1 = not significant; 2 = significant at 10% ; 3 = significant at 5%; 4 = significant at 1%.

Source: authors’ own estimates