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Does land fragmentation affect farm performance?
A case study from Brittany

ABSTRACT

Agricultural land fragmentation is widespread and may affect farmers' decisions and impact farm performance, either negatively or positively. We investigated this impact for the western region of Brittany, France, in 2007. To do so, we regressed a set of performance indicators on a set of fragmentation descriptors. The performance indicators (production costs, yields, revenue, profitability, technical and scale efficiency) were calculated at the farm level using Farm Accountancy Data Network (FADN) data, while the fragmentation descriptors were calculated at the municipality level using data from the cartographic field pattern registry (RPG). The various fragmentation descriptors enabled us to account for not only the traditional number and average size of plots, but also their geographical scattering. We found that farms experienced higher costs of production, lower crop yields and lower profitability where land fragmentation (LF) was more pronounced. Total technical efficiency was not found to be significantly related to any of the municipality LF descriptors used, while scale efficiency was lower where the average distance to the nearest neighbouring plot was greater. Pure technical efficiency was found to be negatively related to the average number of plots in the municipality, with the unexpected result that it was also positively related to the average distance to the nearest neighbouring plot. By simulating the impact of hypothetical consolidation programmes on average pre-tax profits and wheat yield, we also showed that the marginal benefits of reducing fragmentation may differ with respect to the improved LF dimension and the performance indicator considered. Our analysis therefore shows that the measures of land fragmentation usually used in the literature do not reveal the full set of significant relationships with farm performance and that, in particular, measures accounting for distance should be considered more systematically.

Keywords: agricultural land fragmentation, farm performance, cartographic field pattern registry, France. **JEL classifications:** Q12, Q15, D24

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1. Introduction

Fragmentation of agricultural land is widespread in the world and is the result of various institutional, political, historical and sociological factors, such as inheritance laws, collectivisation and consolidation processes, transaction costs in land markets, urban development policies, and personal valuation of land ownership (King and Burton, 1982; Blarel et al., 1992). Farm land fragmentation (LF) is a complex concept that encompasses five dimensions covering: i) number of plots farmed; ii) plot size; iii) the shape of plots; iv) distance of the plots from farm buildings; v) distances between plots (or plot scattering).

From the public economics perspective, LF may generate both positive and negative externalities: it may increase biodiversity and society's economic value of landscape but, conversely, it may induce additional trips by farmers that result in extra roadworks, road safety issues, greenhouse gas emissions, etc. First and foremost, however, LF may affect farmers' production decisions and thus impact farm performance. This impact may be negative or positive. The impact may be negative, for several reasons. First, LF may exacerbate conflicts regarding labour allocation on the farm: it takes time to travel from one plot to another while the labour force could be undertaking more productive tasks. Second, production costs may be increased as LF may require additional equipment, secondary farm buildings and/or external service expenses. Third, LF may restrict the choice of production and constrain management practices, especially in terms of herd management. This could be true for regions where dairy production prevails, such as Brittany, a region in the west of France. Fourth, investments for soil quality improvement, such as drainage, may be reduced on remote plots, potentially reducing yields. However, the impact of LF on farm performance may be positive. This is the case if LF leads to an increased diversity in land quality so that the allocation of crops across plots may be optimised, potentially resulting in higher overall yields. In addition, LF may give greater opportunities for risk diversification, thereby reducing production risks at the farm level. For example, a fragmented farm would be less affected by a pest outbreak that spreads on contiguous plots only.

Several authors have tested empirically the effects of LF on the performance of farms. For example, Jabarin and Epplin (1994) investigated the impact of LF on the production cost of wheat in Jordan. In China, Nguyen et al. (1996), Wan and Cheng (2001) and Tan et al. (2010) investigated the effect of LF on the productivity of major crops, crop output of rural households, and the technical efficiency of rice producers in the south-east of the country, respectively. Kawasaki (2010) evaluated both the costs and benefits of LF in the case of rice production in Japan, similarly to Rahman and Rahman (2008) in Bangladesh. Parikh and Shah (1994) investigated the influence of LF on the technical efficiency of farms in the North-West Frontier Province of Pakistan, while Manjunatha et al. (2013) carried out a similar

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investigation in India. In Europe, Di Falco *et al.* (2010) analysed how LF affects farm profitability in Bulgaria and Del Corral et al. (2011) analysed how LF affects the profits of Spanish dairy farms.

In most of this research, LF is represented by the number of plots and/or their average size. These two variables are employed, either directly or indirectly, by the use of more elaborate measures, such as the Simpson index or the Januszewski index (which are defined further in the text). These variables do not account for all dimensions of LF however, and may not reflect all the constraints that LF imposes on production systems. There are a few exceptions to the use of these sole variables. For example, Tan et al. (2010) considered the average distance from the plots to the homestead, while Gonzalez et al. (2007) used more elaborate measures of LF (which accounted for the size, shape and dispersion of plots) to study the productivity gains from land consolidation. However, in this latter case, these measures were not tested on a real sample of farms, but instead were applied to a hypothetical dataset of farms.

The objective of the paper is to analyse the influence of LF on the performance of farms in the case of one French region, the western region of Brittany, or 'Bretagne'. This is a NUTS2 region which is composed of four NUTS3 regions (the 'départements'), namely 'Côtes-d'Armor', 'Finistère', 'Ille-et-Vilaine' and 'Morbihan'.[1] As in many other regions and countries, agricultural land is very fragmented in Brittany. For example in 2007, according to the cartographic field pattern registry ('Registre Parcellaire Graphique' or RPG) introduced in France in 2002 following the European Council Regulation No 1593/2000 (European Commission, 2000), Breton farms were composed of 14 plots on average, with a mean plot size of 4.35 ha. Twenty-five percent of the farms had 18 plots or more, and 25% of these plots had an average area of 2.42 ha or less. Such figures are quite similar to the national averages for France. In this paper, the relationship between LF and farm performance is investigated for the year 2007 using several performance indicators (production costs, yields, financial results and technical efficiency) calculated from farm-level data, and various LF indicators calculated at the municipality level using data from the RPG. The various fragmentation indicators enable us to account for the traditional measures of plot number and mean size of plots, as well as the scattering of plots.

The paper is structured as follows. Section 2 describes the data and explains the methodology used to calculate the various indicators of performance and of LF. Section 3 presents the methodology used to investigate the effect of LF on performance and the results of the empirical analysis. Section 4 concludes.

2. Data and methodology

2.1 Measuring farm performance

As mentioned above, we used farm-level data for the calculation of farm performance indicators, and municipality-level averages for the calculation of LF. More precisely, we investigated the relationship between farm performance for a sample of farms, and LF of the municipality where the sample farms are located. The underlying assumption is that a farm's LF is positively correlated with the LF in the municipality where the farmstead is located. The farms studied were extracted from the French Farm Accountancy Data Network (FADN) 2007 database. The FADN database, managed by the French Ministry of Agriculture, contains structural and bookkeeping information for a five-year rotating panel of professional farms. In 2007, 480 farms of the FADN sample were located in Brittany. Among those 480 farms we excluded ten farms that used no land and one farm with inconsistent

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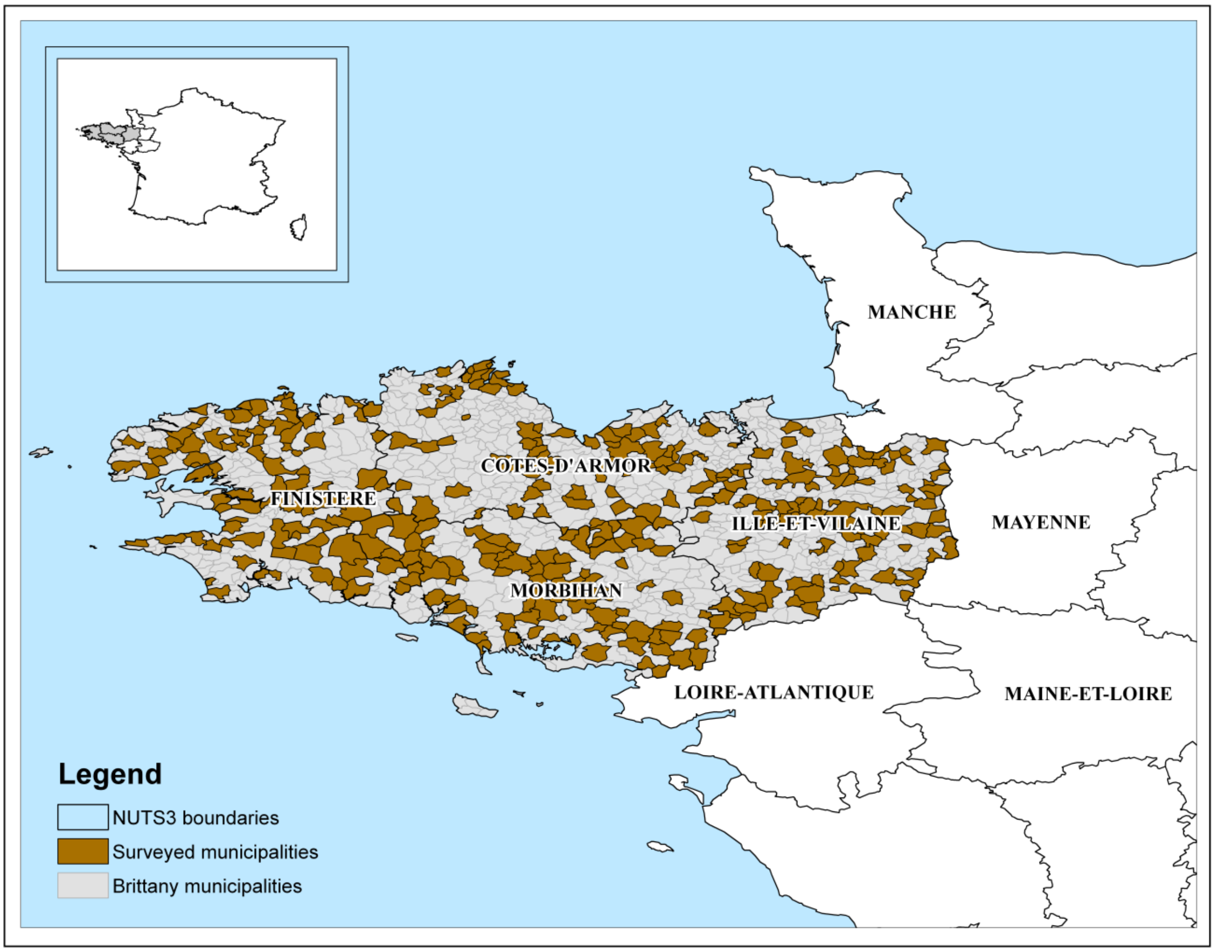
[1] The Nomenclature of Territorial Units for Statistics (NUTS) provides a single uniform breakdown of territorial units for the production of regional statistics for the European Union (EU).

(Source: http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction).

capital data. The final sample thus consisted of 469 farms. Figure 1 shows the location of the municipalities of the 469 FADN Brittany farms.

Table 1 describes the sample of the 469 farms used to analyse the relationship between farm performance and LF. It shows the distribution of these farms according to their main type of production, according to the European definition of type of farming (European Commission, 2010), where the main production is the one that provides at least two-thirds of the farm's gross standard margin. The distribution reflects Brittany's agriculture where dairy, poultry and pig breeding prevail: 29% of the sample specialised in dairy production, and 27% in granivores production. Mixed crop and livestock farming (generally the production of cows' milk and field crops) accounted for 11% of the sample, and the breeding of other grazing livestock (goats and sheep) for 14%. Finally, for 13% of the sample farms the main production was field crops, and for another 6% the main production was crops other than field crops (mainly vegetables).

Figure 1. Brittany NUTS3 regions and studied municipalities



Source: Authors' calculations, based on © IGN 2011, Geofla®.

Table 1. Main characteristics of the farms in the FADN sample used (469 farms)

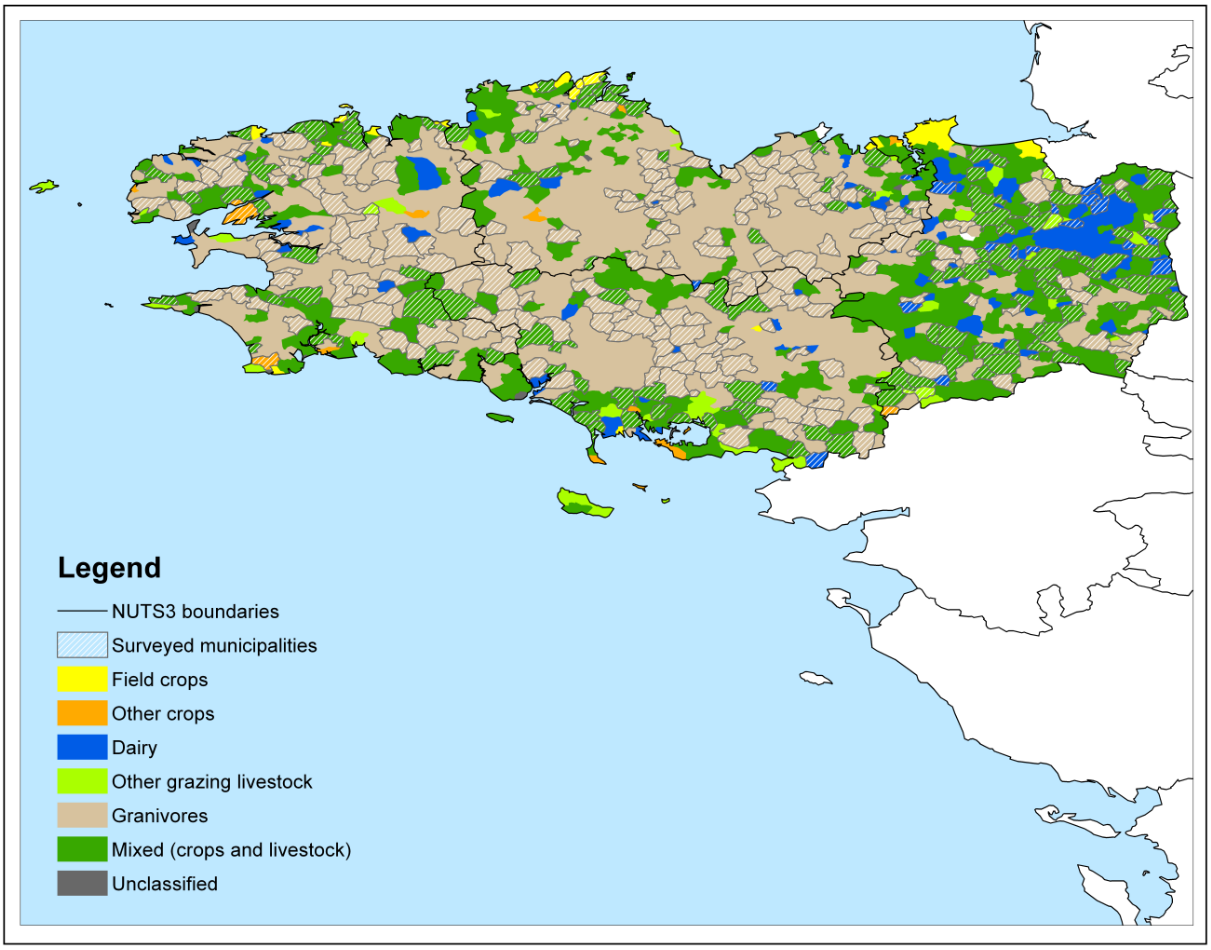
	Share of farms in the sample (%)
According to their main production	
Field crops	13
Dairy	29
Other grazing livestock	14
Granivores	27
Mixed (crops and livestock)	11
Other crops	6
In areas with nitrate pollution zoning restrictions	4

	Mean	**Std. deviation**	**Minimum**	**Maximum**
Utilised agricultural area (ha)	62.36	44.93	0.12	398.96
Number of full time labour equivalents	2.44	2.57	1.00	23.96
Number of livestock units	244.85	359.62	0.00	2,522.11
Share of land rented in (%)	77	33	0	100
Share of hired labour (%)	15	25	0	100

Source: Authors' calculations based on the French FADN 2007 database.

Figure 2 shows the distribution of Brittany municipalities according to the main production of each municipality based on the 2010 Agricultural Census. Granivores farms were located principally in central and eastern Brittany, while crops were mainly produced on the coast, and grazing livestock breeding took place mainly in the western part of the region. Four percent of the farms in the FADN sub-sample used were located in areas subject to nitrate pollution zoning regulations (Table 1). In 2007, the farms studied utilised on average 62.4 ha, a figure greater than the average for the whole farm population in Brittany (47.3 ha) but close to the average of Brittany's commercial farm sub-population (60.0 ha) (2010 Agricultural Census). The farms in our sample used, on average, 2.4 full time equivalents calculated as Annual Working Units (AWU; where 1 AWU corresponds to 1,200 hours of labour per year). This is higher than the region's average (1.7 AWU) and similar to the region's commercial farms' average (2.1 AWU) (2010 Agricultural Census). The average number of livestock units (calculated using the European standard coefficients applied to each livestock type) on the sample farms was 244.9. This relatively high figure is due to the numerous farms in Brittany specialised in livestock and, in particular, to the poultry and pig head numbers. On average, farms rented in 77% of their utilised area and employed 15% of hired labour force.

Figure 2. Main productions in Brittany's municipalities



Source: Authors' calculations based on Agricultural Census, 2010 – © IGN 2011, Geofla®.

Several indicators of farm performance were computed for each farm in the sample. Firstly, various categories of production costs were calculated per farm and per unit of utilised area. These consisted of costs of fertilisers, seeds, pesticides, fuel, intermediate consumption and hired labour. Secondly, two production yields were calculated: wheat yield in tons of wheat produced per hectare of wheat cultivated; and milk yield in litres of milk produced per cow. Thirdly, four revenue or profitability results were calculated per farm and per unit of utilised area: the farm gross product, composed of farm sales and insurance compensations; the farm gross margin, obtained from the farm gross product minus variable costs specific to crop and livestock production; the farm operating surplus, obtained from the farm gross margin minus land, labour and insurance costs; and the farm pre-tax profit, given by the farm operating surplus minus depreciation and interest, and before taxes are deducted. Subsidies were not included in the farm gross product, and therefore not included either in the three profitability indicators. Finally, technical efficiency and scale efficiency were calculated for each farm. Technical efficiency assesses how far farms are located from the maximum production frontier for a given combination of inputs. It is a more complex measure than partial productivity indicators such as yields, since it relates all outputs produced to all inputs used on the farm. Technical efficiency is composed of pure technical efficiency (that is to say, whether farmers operate their farm efficiently) and of scale efficiency (that is to say, whether the farm's production scale is optimal). Technical and scale efficiencies were computed using the non-parametric method Data Envelopment Analysis (DEA) which employs linear programming to construct a frontier that envelops the data used (Charnes et al., 1978). Efficiency scores obtained by DEA are between one – for a fully efficient farm (i.e. a farm located on the efficient frontier) – and zero, with smaller scores indicating lower efficiency.

Since the efficient frontier depends on the sample used, the efficiency scores may be overestimated if the most highly performing farms in the population are not included. For this reason, we constructed the efficient frontier for the whole Brittany sample (469 farms). We merged all types of farming into one sample to overcome the limited sizes of the type of farming sub-samples. The DEA model was output-oriented (so that farms were assumed to maximise their output level, given input levels). The model had one single output, namely the farm output produced in euros, and four inputs: the utilised area in hectares; the labour used in AWU; the intermediate consumption in euros; and the capital value in euros. Under the assumption that farms operated under constant returns to scale, the total technical efficiency score for each farm was obtained. Total technical efficiency was then decomposed into pure technical efficiency and scale efficiency. The calculation of the pure technical efficiency was made under the assumption that farms operated under variable returns to scale, and indicated the efficiency of farmers' practices irrespective of farm size. By contrast, scale efficiency, which was calculated for each farm as the ratio between its total technical efficiency and its pure technical efficiency, revealed whether the farm operated at the optimal scale of production.

Table 2 presents the descriptive statistics of the performance indicators for the 469 sample farms. Among these, 342 farms (73% of the sample) produced wheat with an average yield of 5.3 tons per hectare, and 269 farms (57% of the sample) produced milk with an average yield of 7,043 litres per cow. The 469 farms generated on average almost 1,800 euros per hectare of pre-tax profit without subsidies. Their total technical efficiency score was 0.595 on average, indicating that they could increase their output by 40.5% without increasing their input use.

Table 2. Performance of the farms in the FADN sub-sample used

Farm performance indicator	**Average value**		**Number of observations**
	per farm	**per hectare**	
Production costs (euros)			
Fertiliser cost	7,083.73	341.87	469
Seed cost	7,724.19	1,143.79	469
Pesticide cost	6,010.70	225.95	469
Fuel cost	4,768.39	156.43	469
Intermediate consumption cost	194,364.50	13,542.45	469
Hired labour cost	13,622.62	3,360.09	469
Yields			
Wheat yield (tons / hectare)	5.3		342
Milk yield (litres / cow)	7,043		269
Revenue and profitability without farm subsidies (euros)			
Gross product	297,385.60	23,901.72	469
Gross margin	103,021.10	10,359.27	469
Operating surplus	63,214.24	5,258.55	469
Pre-tax profit	13,697.48	1,756.50	469
Efficiency scores			
Total technical efficiency	0.595		469
Pure technical efficiency	0.680		469
Scale efficiency	0.883		469

Source: Authors' calculations based on the French FADN 2007 database.

2.2 Measuring land fragmentation

LF was measured using the RPG put in place in France in 2002 following the European Council Regulation No. 1593/2000 (European Commission, 2000). This is a Geographic Information System (GIS) database which is maintained by the 'Agence de Service et de Paiement' (ASP); a public body that gathers the field patterns declared by farmers who apply for support under the framework of the Common Agricultural Policy (CAP)[2] and which delivers subsidies to farmers based on these declarations. In fact, farmers are not requested to delineate each of their individual fields but rather each of their 'plots', which we define for this paper as follows: a plot is a set of contiguous fields (which may or may not all bear the same crop) which is both delimited by easily identifiable landmarks (such as agricultural byways, roads, rivers, another plot, etc.) and is stable from year to year.

We used the 2007 registry ('RPG anonyme ASP 2007') which identifies 450,787 plots used by 31,921 farms for the four NUTS3 regions of Brittany. Each farm could be categorised as one of the following: i) a farm that was registered in one of the four Brittany NUTS3 regions and whose plots were all located inside this one region; ii) a farm that was registered in one of the four Brittany NUTS3 regions, but whose plots were partly located outside that region; and iii) a farm that was registered outside Brittany but whose plots were located totally or partly inside one of the four Brittany NUTS3 regions. We retained all farms and plots corresponding to case i). As regards case ii), we only retained those farms whose plots were located in one of the four NUTS3 regions directly neighbouring Brittany (namely 'Loire-Atlantique', 'Maine-et-Loire', 'Manche' and 'Mayenne', see Figure 1) and we considered both their plots located in Brittany and their plots located in these four directly neighbouring regions. Similarly, as regards case iii), we retained those farms registered in one of the four above-mentioned NUTS3 regions directly neighbouring Brittany and we considered both their plots located in Brittany and their plots located in one of these four directly neighbouring regions. Finally, in order to ensure that we included 'entire' farms only, we excluded those farms whose total area declared by the farmer in the RPG was 0.02 ha or more different from the area obtained from summing the areas of each individual plot of the farm. In the end, the database used consisted of 29,433 farms and 418,480 plots.

For each farm i among these 29,433 farms, ten fragmentation descriptors were computed, which relate to one of the five dimensions of LF as described in the introduction (the formal definitions of the descriptors are given in the Appendix).

1. LF descriptors relating to the number of plots. One descriptor was used, namely the number of plots on the farm ($nplot_i$).
2. LF descriptors relating to the shape of plots. Two descriptors were used: the weighted average of the shape index of the plots ($wshsq_i$) (Akkaya Aslan et al., 2007); and the average of the areal form factor ($aform_i$) (Gonzalez et al., 2004).
3. LF descriptors relating to the size of plots. Three descriptors were used: the average plot size ($avpls_i$); and two more elaborate indexes, namely the Simpson index ($simps_i$) (Blarel et al., 1992; Hung et al., 2007; Kawasaki, 2010) and the Januszewski index ($janus_i$) (King and Burton, 1982).
4. LF descriptors relating to the distance of plots from the farm. Three descriptors were used: the average distance of a hectare from the farm ($avdha_i$); and two more elaborate indexes, namely the grouping index ($grpgi_i$) (Marie, 2009) and the structural index ($strui_i$) (Marie, 2009).
5. LF descriptors relating to the scattering of plots (*i.e.*, to the distance between plots). One descriptor was used, namely the normalised average nearest neighbour distance ($nannd_i$).

[2] For more information on the RPG, see the dedicated pages on the website of the ASP (http://www.asp-public.fr/?q=node/856).

Since there was no information in the registry concerning the location of the farmsteads, we first computed the centroid of each plot (that is, its geometric centre) and inferred from this the barycentre of each farm (that is, its 'centre of mass', with the 'mass' associated with each plot of the farm being the plot's area); we then replaced the distance from the farmstead by the distance from the barycentre of the farm in those LF indicators which use distance in their definition (namely $avdha_i$, $grpgi_i$, $strui_i$ and $nannd_i$).

It should be stressed that the relationship between a descriptor and LF may be positive (i.e. a higher value of the descriptor indicates higher fragmentation) or negative (i.e. a higher value of the descriptor indicates lower fragmentation). As can be seen in Table 3, descriptors positively related to LF are the number of plots, the weighted average shape index, the Simpson index, descriptors relating to the distance from the barycentre of the farm and the normalised average nearest neighbour distance, while descriptors negatively related to LF are the average areal form factor, the Januszewski index and average plot size.

Table 3. Relationship between the studied descriptors and LF

Descriptors positively related to LF	**Descriptors negatively related to LF**
Number of plots ($nplot_i$)	Average plot areal form factor ($aform_i$)
Weighted average plot shape index ($wshsq_i$)	Average plots size ($avpls_i$)
Simpson index ($simps_i$)	Januszewski index ($janus_i$)
Average distance of a hectare ($avdha_i$)	
Grouping index ($grpgi_i$)	
Structural index ($strui_i$)	
Normalised average nearest neighbour distance ($nannd_i$)	

Table 4 reports descriptive statistics for the 29,433 farms in our database. On average, the farms registered outside Brittany were the largest (their average area was 75.51 ha) and the farms registered within Brittany were relatively similar across Brittany's NUTS3 regions in terms of average area (around 50 ha with a standard deviation of about 40 ha). Among the four Brittany NUTS3 regions, 'Côtes-d'Armor' appears to be the most fragmented one for most LF descriptors, followed by 'Finistère', 'Ille-et-Vilaine' and finally 'Morbihan'. The fragmentation of farms registered outside Brittany showed greater variation: they were relatively fragmented when considering most descriptors but, in contrast, they presented a lower fragmentation level in terms of mean size of plots, which was higher than that of farms registered inside Brittany. There are two explanations for this contrasting picture. Firstly, the sample of farms registered outside Brittany was smaller. Secondly, when considered together they constituted a heterogeneous category (the structure and main production of farms in the northern neighbour 'Manche' were quite different from those of the southern neighbour 'Loire-Atlantique').

As explained in Section 2.1, we analysed the influence of average LF in the municipality where a farm was located on the farm's performance. To do this, we calculated the aggregated fragmentation descriptors at the level of each municipality r of the 29,433 farms in the field pattern database. We computed the weighted average of each descriptor considering all farms with at least one plot in r, each of these farms being weighted by its share in the total operated area of r, or, formally:

$$x_r = \frac{1}{A_r} \sum_{i \in r} A_{ir} x_i \qquad (1)$$

where x represents one of the ten fragmentation descriptors, A_{ir} represents farm i's operated area located within municipality r and $A_r = \sum_{i \in r} A_{ir}$ is the total operated area in municipality r. Note that, because the RPG only includes farms which apply for CAP payments and because we excluded almost 8% of the farms (2,488 out of 31,921) from the initial database during the sample selection process (see above), the descriptors calculated at the municipality level should be viewed only as proxies for the true farmland fragmentation of municipalities.

Table 4. Descriptive statistics of the fragmentation descriptors at the farm level [a]

Land fragmentation descriptor	NUTS3 'Côtes-d'Armor'	NUTS3 'Finistère'	NUTS3 'Ille-et-Vilaine'	NUTS3 'Morbihan'	Neighbouring NUTS3 regions [b]	**All**
Number of farms	7,942	6,149	8,653	6,298	391	**29,433**
Average farm area (ha)	49.13	54.85	47.49	52.92	75.51	**51.00**
	(34.98)	*(41.64)*	*(38.72)*	*(39.60)*	*(40.96)*	***(38.82)***
Number of plots ($nplot_i$)	15.11	14.55	12.24	12.32	14.93	**13.55**
	(11.10)	*(11.10)*	*(10.09)*	*(9.62)*	*(9.24)*	***(10.56)***
Weighted average plot shape	1.34	1.32	1.31	1.33	1.37	**1.33**
index ($wshsq_i$)	*(0.19)*	*(0.17)*	*(0.18)*	*(0.19)*	*(0.18)*	***(0.19)***
Average plot areal form	0.044	0.044	0.044	0.044	0.042	**0.044**
factor ($aform_i$)	*(0.006)*	*(0.006)*	*(0.006)*	*(0.006)*	*(0.005)*	***(0.006)***
Average plot size ($avpls_i$)	3.67	4.41	4.53	4.90	5.74	**4.37**
	(2.45)	*(3.53)*	*(14.58)*	*(3.65)*	*(3.32)*	***(8.36)***
Simpson index ($simps_i$)	0.77	0.77	0.72	0.73	0.80	**0.75**
	(0.22)	*(0.21)*	*(0.25)*	*(0.24)*	*(0.15)*	***(0.23)***
Januszewski index ($janus_i$)	0.37	0.37	0.42	0.41	0.34	**0.39**
	(0.19)	*(0.18)*	*(0.21)*	*(0.20)*	*(0.13)*	***(0.20)***
Average distance of an	1,221	1,373	1,246	1,084	3,115	**1,256**
hectare ($avdha_i$)	*(1,823)*	*(1,917)*	*(1,844)*	*(1,392)*	*(3,452)*	***(1,814)***
Grouping index ($grpgi_i$)	8.93	8.92	8.74	6.84	18.01	**8.55**
	(12.68)	*(11.86)*	*(13.35)*	*(10.33)*	*(17.45)*	***(12.41)***
Structural index ($strui_i$)	3.93	3.42	3.15	2.19	4.13	**3.23**
	(11.52)	*(7.67)*	*(7.83)*	*(5.21)*	*(5.56)*	***(8.53)***
Normalised average nearest	1.47	1.32	1.66	1.40	2.18	**1.49**
neighbour distance ($nannd_i$)	*(3.90)*	*(3.76)*	*(4.89)*	*(3.53)*	*(5.23)*	***(4.14)***

[a] Except for the number of farms, averages are presented and standard deviations are shown in brackets and italic font.

[b] Farms registered in NUTS3 regions directly neighbouring Brittany ('Loire-Atlantique', 'Maine-et-Loire', 'Manche' and 'Mayenne', see Figure 1) and whose plots are at least partly located in one of Brittany's NUTS3 regions ('Côtes-d'Armor', 'Finistère','Ille-et-Vilaine' and 'Morbihan').

Source: Authors' calculations based on the field pattern registry 'RPG anonyme ASP 2007' database.

In total, 349 municipalities were related to the 469 farms of the FADN, out of the 1,255 Brittany municipalities for which we had data in the RPG. Table 5 reports descriptive statistics for the 349 municipalities, as well as for all the 1,255 Brittany municipalities. It appears from this table and from a further examination of the distributions for all LF descriptors that our sample of 349 municipalities is skewed towards higher values of LF compared to the full sample of 1,255 municipalities, but that the discrepancy is very slight. We are confident, therefore, that our sample can be regarded as representative of Brittany.

Table 5. Descriptive statistics of the fragmentation descriptors at the municipality level

Land fragmentation descriptor	Mean	Std. deviation	Min	Max
Studied municipalities (349 observations)				
Number of farms	60.56	29.73	3	200
Farmed area (ha)	3,588.31	1,844.17	53.32	11,811.04
Number of plots ($nplot_r$)	19.29	7.04	8.84	62.09
Weighted average plot shape index ($wshsq_r$)	1.344	0.065	1.172	1.542
Average plot areal form factor ($aform_r$)	0.043	0.002	0.038	0.049
Average plots' size ($avpls_r$)	4.77	2.10	0.31	30.24
Simpson index ($simps_r$)	0.841	0.043	0.727	0.954
Januszewski index ($janus_r$)	0.302	0.047	0.158	0.422
Average distance of a hectare ($avdha_r$)	1,675	443	897	4,339
Grouping index ($grpgi_r$)	9.555	2.843	4.332	26.063
Structural index ($strui_r$)	3.179	3.751	0.780	47.152
Normalised average nearest neighbour distance ($nannd_r$)	0.986	0.281	0.415	2.444
All municipalities in Brittany (1,255 observations)				
Number of farms	45.67	28.72	1	200
Farmed area (ha)	2,781.25	1,704.15	9.01	11,811.04
Number of plots ($nplot_r$)	20.97	8.34	3.00	85.18
Weighted average plot shape index ($wshsq_r$)	1.347	0.075	1.084	1.848
Average plot areal form factor ($aform_r$)	0.043	0.002	0.026	0.056
Average plots' size ($avpls_r$)	4.87	15.23	0.31	540.57
Simpson index ($simps_r$)	0.850	0.049	0.404	0.973
Januszewski index ($janus_r$)	0.290	0.052	0.124	0.668
Average distance of a hectare ($avdha_r$)	1,670	562	217	6,854
Grouping index ($grpgi_r$)	9.358	3.207	1.976	43.073
Structural index ($strui_r$)	3.075	2.620	0.582	47.152
Normalised average nearest neighbour distance ($nannd_r$)	0.937	0.350	0.289	5.344

Source: Authors' calculations based on the field pattern registry 'RPG anonyme ASP 2007' database.

3. The role of LF on farm performance

3.1 Methodology

The influence of LF on farm performance was investigated using Ordinary Least Squares (OLS) regressions, where the dependent variables were, in turn, each of the 15 per-farm performance indicators described above. All LF indicators were introduced in turn in the regressions as explanatory variables. Therefore, there were $15 \times 10 = 150$ regressions, which differed according to the dependent variable (each performance indicator) and the LF indicator used as the explanatory variable.

Various explanatory variables, available in the FADN data, were used in all 150 regressions in addition to LF descriptors: farmer's age; farm size in terms of utilised area in hectares; a farm size dummy based on classes of economic size (the dummy is equal to one if the farm is greater than 100 Economic Size Units (ESU), with 1 ESU equivalent to 2,200 euros of standard gross margin, and zero if it is less than 100 ESU); a farm legal status dummy (equal to one for an individual farm, and zero for a partnership or company); the share of rented land in the farm utilised area; the share of hired labour in total labour used on the farm; the farm capital to labour ratio; the operational subsidies received by the farm, related to hectares of utilised area; a farm location dummy (equal to one if the farm is located in an area subject to nitrate pollution zoning restrictions, and zero if not); and farm production specialisation dummies (based on the categories in Table 1 with 'other crops' being the reference).

For each regression, we computed the confidence interval of the estimated parameters from the White or 'sandwich' estimator of the variance-covariance matrix, which is robust to misspecification problems such as heteroskedasticity and small sample size.

3.2 Results

Table 6 summarises the accuracy with which the 150 models fit the data, as measured by the R-squared statistics. This accuracy ranges from an average of 0.167 for the regressions with the milk yield as the dependent variable, to an average of 0.659 for the regressions with the hired labour cost as the dependent variable; 94 out of the 150 regressions exhibited an R-squared statistic above 0.30, which is fairly satisfactory for such cross-sectional micro data models based on a limited sample. It is also worth noting that the standard deviations of the R-squared statistics are low, indicating that, for a given farm performance indicator, the fit of the model is quite similar whatever the LF descriptor used as a regressor.

Table 6. R-squared statistics for the 150 OLS regressions

Farm performance indicator (dependent variable)	Obs.	Mean	Std. deviation	Min	Max
Production costs					
Fertiliser cost per farm	469	0.358	0.001	0.357	0.360
Seed cost per farm	469	0.439	0.001	0.438	0.441
Pesticide cost per farm	469	0.581	0.001	0.581	0.583
Fuel cost per farm	469	0.459	0.003	0.457	0.463
Intermediate consumption cost per farm	469	0.543	0.000	0.542	0.543
Hired labour cost per farm	469	0.659	0.001	0.657	0.661
Yields					
Wheat yield	342	0.260	0.014	0.246	0.288
Milk yield	269	0.167	0.006	0.161	0.180
Revenue and profitability without farm subsidies					
Gross product per farm	469	0.577	0.001	0.577	0.579
Gross margin per farm	469	0.460	0.003	0.458	0.467
Operating surplus per farm	469	0.251	0.003	0.248	0.259
Pre-tax profit per farm	469	0.184	0.003	0.181	0.189
Efficiency scores					
Total technical efficiency	469	0.386	0.001	0.386	0.388
Pure technical efficiency	469	0.301	0.003	0.299	0.308
Scale efficiency	469	0.202	0.002	0.201	0.207

Source: Authors' calculations.

Due to space constraints, we do not present the detailed results for each of the 150 regressions. Instead, we report in Table 7 the signs and significance levels of the regression coefficients obtained for each LF descriptor. Our results show that, from a methodological point of view, each LF descriptor relates to one or more performance indicators but not to all of them and that, reciprocally, each performance indicator is explained by one or more LF descriptors, but not by all of them. This gives weight to our strategy of using a wide set of variables for both dimensions. LF descriptors which are most related to farm performance appear to be, first, the grouping index ($grpgi_r$) and the average areal form factor ($aform_r$), and then the structural index ($strui_r$) and the number of plots ($nplot_r$). The number of plots proves to be the only LF descriptor that is significantly related to at least one indicator in the four categories of farm performance that we considered, but the significance levels are somewhat limited (never less than 5%). By contrast, the average size of plots, although a traditionally used LF descriptor, seems to have a limited impact on the various dimensions of farm performance, be it directly considered ($avpls_r$) or indirectly through the more elaborate indexes ($simps_r$ and $janus_r$).

Table 7. Fragmentation and FADN farms' performance: sign and significance of regression coefficients for LF indicators [a]

Farm performance indicator	**Indicators of the number of plots**	**Indicators of plot shape**		**Indicators of plot size**		
	number of plots ($nplot_r$)	**weighted average plot shape index ($wshsq_r$)**	***average plot areal form factor ($aform_r$)***	***average plot size (ha) ($avpls_r$)***	**Simpson index ($simps_r$)**	***Januszewski index ($janus_r$)***
Production costs						
Fertiliser cost per farm	– ns	– ns	+ ns	+ ns	– ns	+ ns
Seed cost per farm	+ ns	– ns	+ °	+ ns	+ ns	– ns
Pesticide cost per farm	– ns	– *	+ ns	– ns	+ ns	+ ns
Fuel cost per farm	– ns	– ns	+ ns	– *	+ ns	– ns
Intermediate consumption cost per farm	– ns	+ ns	+ ns	+ ns	– ns	+ ns
Hired labour cost per farm	+ *	– ns	+ *	– ns	+ *	– *
Yields						
Wheat yield	– *	– ns	– ns	+ ns	– *	+ *
Milk yield	– ns	– ns	+ ns	– ns	– ns	+ ns
Revenue and profitability without farm subsidies						
Gross product per farm	– ns	– ns	+ °	– ns	– ns	+ ns
Gross margin per farm	+ ns	– *	+ **	– ns	+ ns	– ns
Operating surplus per farm	– ns	– °	+ *	– ns	– ns	+ ns
Pre-tax profit per farm	– °	– ns	+ ns	+ ns	– ns	+ ns
Efficiency scores						
Total technical efficiency	– ns	– ns	+ ns	+ ns	– ns	+ ns
Pure technical efficiency	– *	– ns	+ ns	+ ns	– ns	+ ns
Scale efficiency	+ ns	– ns	– ns	– ns	+ ns	– ns

[a] The fragmentation descriptors (columns) are calculated at the municipality level and the descriptors in italic are negatively related to land fragmentation (see text).
***, **, *, °: significance at the 0.1%, 1%, 5% and 10% level respectively; ns: not significant at the 10% level.

Source: Authors' calculations.

Table 7 (continued). Fragmentation descriptors and FADN farms' performance: sign and significance of regression coefficients for LF indicators [a]

Farm performance indicator	Indicators of plots' distance from the farm			Indicators of plots' scattering
	average distance of a hectare ($avdha_r$)	grouping index ($grpgi_r$)	structural index ($strui_r$)	Normalised av. nearest neighbour distance ($nannd_r$)
Production costs				
Fertiliser cost per farm	– ns	– ns	+ ns	– ns
Seed cost per farm	+ ns	– ns	– ns	– ns
Pesticide cost per farm	– ns	– ns	+ ns	+ ns
Fuel cost per farm	– ns	+ **	+ *	+ ns
Intermediate consumption cost per farm	+ ns	+ ns	– ns	+ ns
Hired labour cost per farm	+ °	+ ns	+ ns	– ns
Yields				
Wheat yield	– °	– *	– *	+ ns
Milk yield	– ns	– **	– *	+ ns
Revenue and profitability without farm subsidies				
Gross product per farm	+ ns	+ ns	– ns	+ ns
Gross margin per farm	– ns	+ ns	+ ns	+ °
Operating surplus per farm	– ns	+ ns	+ °	+ ns
Pre-tax profit per farm	– *	– °	+ ns	+ ns
Efficiency scores				
Total technical efficiency	– ns	– ns	+ ns	+ ns
Pure technical efficiency	– ns	– ns	– ns	+ **
Scale efficiency	– ns	– ns	+ ns	– °

[a] The fragmentation descriptors (columns) are calculated at the municipality level and the descriptors in italic are negatively related to land fragmentation (see text).
***, **, *, °: significance at the 0.1%, 1%, 5% and 10% level respectively; ns: not significant at the 10% level.

Source: Authors' calculations.

Most results regarding the detailed links between LF descriptors and performance indicators conform to agronomic and economic understanding. Firstly, production costs are positively related to the number of plots and to their distance from the farm, but decrease with plot size. The results regarding the shape of plots are more surprising since they first suggest that seed cost, pesticide cost and hired labour cost should decrease when plots are more irregularly shaped. The result regarding seed cost is difficult to interpret but it is significant at the 10% level only. However, the other two results, which are more significant, may be explained as follows: on the one hand, irregularly shaped plots may impede the spread of pest attacks and hence reduce the use and therefore cost of pesticides; on the other hand, irregularly shaped plots may be more difficult to entrust to the care of hired, often less qualified, people so that the operator will farm them himself or herself, hence reducing the cost of hired labour. Secondly, LF appears to have a negative impact on yields, especially that of wheat, mostly through size and distance. Thirdly, revenue and profitability are found to decrease with the number of plots, the irregularity of their shape and their distance from the farm, but the average size of plots does not seem to have a significant impact. Then again, counter-intuitive results (the positive impact of $strui_r$ on the operating surplus and of $nannd_r$ on the gross margin) are significant at the 10% level only. Finally, total technical efficiency proves to be significantly related to none of the considered LF descriptors. By contrast, conforming to intuition, the number of plots seems to play a role in reducing pure technical efficiency, while the scattering of plots affects scale efficiency. However, the positive and significant impact of the scattering of plots on pure technical efficiency is more difficult to interpret.

In order to present the regression results in a more practical and accessible way, we simulated the impact of a reduction in LF at the municipality level on two key performance indicators; wheat yield, as a main physical component of farm performance, and pre-tax profit, as a main financial component of farm performance. This reduction in LF could hypothetically be reached by, for example, a consolidation programme. To this end, we computed for each LF descriptor what improvements in pre-tax profit and wheat yield could be obtained by the average farm when moving, at the municipality level, from one LF quartile to the next in the direction of reducing fragmentation. With this, fragmentation improvements are immediately readable in terms of euros per farm for the pre-tax profit and tons per hectare for the wheat yield. Therefore, this can illustrate the relative importance of LF descriptors whose estimated regression coefficients are not directly comparable with each other.

Table 8 illustrates that the highest benefits in terms of pre-tax profit would be reached by reducing LF in terms of distance of plots from the barycentre of the farm: on average, decreasing the average distance of a hectare ($avdha_r$) at the municipality level by around 500 m would raise the pre-tax profit by 5,862 euros per farm – a 43% increase. By comparison, reducing the average number of plots ($nplot_r$) per farm at the municipality level from 22.5 to 14.5 would lead to a pre-tax profit increase of 4,987 euros per farm (or 37%). Concerning the yield of wheat, the highest benefits (almost 0.5 ton per hectare, or a 9% increase) would be obtained from a reduction in the grouping index ($grpgi_r$), *i.e.*, by reducing the maximum distance of plots from their barycentre, rather than their average distance. In the case of the wheat yield, the second best option would consist of improving the size of plots at the municipality level as measured by the Januszewski ($janus_r$) and the Simpson ($simps_r$) indexes, rather than the number of plots by farms, with expected gains estimated at approximately 0.4 ton per hectare (or an 8% increase).

Table 8. Pre-tax profit and wheat yield regression results and potential improvements for each land fragmentation descriptor [a]

Land fragmentation descriptor	**Regression estimate (*std. dev.*)**		**Descriptor quartiles**		**Improvement**	
	Pre-tax profit	**Wheat yield**	**Q1**	**Q3**	**Pre-tax profit (Euros per farm)**	**Wheat yield (tons per hectare)**
Number of plots ($nplot_r$)	-629.51 (*360.50*)°	-0.041 (*0.019*)*	14.56	22.49	4,986.75 (*2,855,75*)°	0.323 (*0.154*)*
Weighted average plot shape index ($wshsq_r$)	-36,276.57 (*35,861.91*)	-0.893 (*1.446*)	1.301	1.378	2,767.93 (*2,736.29*)	0.068 (*0.110*)
Average plot areal form factor ($aform_r$)	1,529,747 (*1,123,538*)	-28.749 (*46.887*)	0.042	0.045	3,816.72 (*2,803.23*)	-0.072 (*0.117*)
Average plots' size ($avpls_r$)	77.29 (*1,043.45*)	0.060 (*0.064*)	3.63	5.84	171.37 (*2,313.60*)	0.132 (*0.142*)
Simpson index ($simps_r$)	-56,885.52 (*52,879.09*)	-6.851 (*2.886*)*	0.815	0.871	3,176.96 (*2,953.21*)	0.384 (*0.161*)*
Januszewski index ($janus_r$)	73,543.39 (*47,487.62*)	6.692 (*2.666*)*	0.271	0.333	4,548.27 (*2,936.86*)	0.414 (*0.165*)*
Average distance of a hectare ($avdha_r$)	-11.54 (*5.83*)*	-0.00058 (*0.00030*)°	1,369	1,877	5,861.69 (*2,960.35*)*	0.297 (*0.153*)°
Grouping index ($grpgi_r$)	-1,615.90 (*929.33*)°	-0.145 (*0.065*)*	7.686	11.009	5,369.48 (*3,088.08*)°	0.481 (*0.215*)*
Structural index ($strui_r$)	337.84 (*880.19*)	-0.277 (*0.117*)*	1.803	3.384	-534.08 (*1,391.44*)	0.439 (*0.185*)*
Normalised average nearest neighbour distance ($nannd_r$)	5,506.71 (*8,334.41*)	0.082 (*0.369*)	0.803	1.121	-1,753.17 (*2,653.42*)	-0.026 (*0.118*)

[a] For each LF descriptor, the 'improvement' (two last columns) represents what, for the average farm, would be the impact on the pre-tax profit and the wheat yield of a reduction in the fragmentation of the municipality, obtained by moving from one quartile to the other (columns four and five) given the estimated regression coefficients (second and third columns); as it is reported as an 'improvement', the impact corresponds to moving from Q3 to Q1 for descriptors positively related to land fragmentation and from Q1 to Q3 for those negatively related (see text for further details).

***, **, *, °: significance at the 0.1%, 1%, 5% and 10% level, respectively.

Source: Authors' calculations.

Such figures may look quite substantial for both performance indicators. However, they are mainly intended to illustrate our results and especially to compare the marginal benefit (or, reciprocally, the relative burden) of each LF dimension on the various aspects of performance. They should not be viewed as accurate predictions, for at least three reasons. Firstly, the simulated LF improvements may actually be very substantial themselves, hence very costly to implement in reality. These implementation costs should thus be compared, in addition to comparing the benefits from improving one LF descriptor with respect to the others. Secondly, it is hardly plausible that a particular consolidation programme would enhance one LF descriptor only, leaving the others unchanged. In general, a consolidation programme would seek to improve several LF dimensions at the same time, e.g. by reducing the number and distance of plots, improving their shapes and increasing their average size. However, these dimensions may be competing among themselves to some extent, so that a compromise would have to be reached, leading to a limited improvement in each dimension – if not to a deterioration for some descriptors in some cases. It is our view that the way in which these multi-dimensional benefits and costs aggregate together remains an empirical question, which may be addressed only thanks to hypothetical simulations such as that of Gonzalez et al. (2007) or for specific case studies. Thirdly, the above average pre-tax profit and wheat yield improvements may also reveal that such heavy consolidation programmes are likely to induce additional changes in farming practices and in farm production, so that they should not be simply compared to the average pre-consolidation figures as if they were *ceteris paribus*.

4. Conclusion

We have investigated the relationship between agricultural land fragmentation (LF) and farm performance in 2007 in the French NUTS2 region of Brittany. Various farm performance indicators (in terms of costs, yields, revenue, profitability, technical and scale efficiency) calculated for a sub-sample of FADN farms were regressed on several explanatory variables, including average LF descriptors computed for the municipalities where those farms were located. Among the LF descriptors used, we considered not only the number of plots and the mean size of plots that are traditionally used in the economic literature investigating the impact of LF on farm performance, but also more complex indexes. This was done to account for: the shape of plots; (a proxy thereof) the distance between plots and farmsteads; and the distance between plots themselves (or scattering of plots).

In our view, our analysis highlights that, from a methodological perspective, the measures of LF traditionally used in the literature, namely the number of plots and the average plot size, may not reveal the full set of significant relationships with farm performance because they do not capture all the dimensions of land fragmentation. In particular, they exclude distance considerations. In this respect, the grouping index used here seems to be powerful. However, circumventing the absence of information regarding the location of the farmsteads by computing distances relative to the farm barycentre, as we have done in this paper, may introduce some bias that would be worth investigating.

Considering only the significant relationships, the analysis of farm performance and LF gives three main findings. Firstly, whatever the LF descriptor considered, in general similar conclusions are reached regarding the impact of LF on the various components of farm performance. There are three main conclusions: i) LF tends to increase production costs; ii) LF has a negative impact on crop yields; iii) LF tends to reduce the revenue and profitability of the farm. Such findings that LF is overall harmful to farm performance are consistent with those found in the previous literature on the subject. Secondly, these very general conclusions should not hide the fact that in some cases, even if very few, the impact of LF on farm performance was the opposite to that expected, and that it was not always possible to find an economic rationale for such results. This is another argument in favour of using several LF indicators to investigate the link between fragmentation and performance. Thirdly, we have shown that the benefits from reducing fragmentation may differ with respect to the improved

LF dimension and the performance indicator considered. The overall impact of a real-life consolidation programme, which may modify several LF dimensions at the same time, remains an empirical open question that should be investigated carefully in each specific case.

We should also stress that, while the general finding of our analysis is a negative impact of LF on farm performance, we do not advocate a 'blind' reduction of farm fragmentation through large-scale and systematic consolidation programmes. One reason is the necessity of balancing the private and societal gains of LF reduction. In the Brittany case, fragmented agricultural land is usually associated with hedges and natural corridors that have been shown to be beneficial to, e.g. biodiversity, water fluxes and the environment in general (Thenail and Baudry, 2004; Thenail et al., 2009). This indicates that the private costs of LF at the farm level should be carefully balanced with potential public benefits at society level. In this respect, programmes that aim to enhance the structure of field patterns under the constraint of preserving and/or replanting hedges, such as the 'amicable plot exchange' programme set up in Brittany by the agricultural extension services and the local authorities, may represent an efficient compromise (CA Bretagne, 2011).

Even though these results sound reasonable and generally conform to common understanding, our analysis suffers two major limitations that should be considered with great care if such research is to be aimed at proposing a consolidation programme. Firstly, endogeneity issues would have to be investigated carefully: although we can be relatively confident that the relationship between variables is mainly in one direction from a static point of view, namely that municipalities' LF influences the performance of specific farms, it might be that, in a dynamic perspective, efficient farms are more likely to be in a position to decrease their fragmentation at the expense of neighbouring farms. Secondly, drawing any causal conclusions would mean assuming a direct link between the LF of the municipality where the considered farm is located, and the LF within the farm itself. Although the approach adopted here – due to data limitations – indeed relies on the hypothesis that the higher the LF of the municipality, the higher the probability for the farm to be fragmented, it may happen that farms that are not very fragmented may be located in a highly fragmented municipality, and vice versa. Finding a way to gain access to a measure of fragmentation at the individual level for the farms in our sample constitutes a major challenge for future work. Although our analysis has shed some light on the relationship between the performance of a farm and the LF in the municipality where it is located, further investigation is therefore needed, especially before any policy recommendations can be made.

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Appendix. Formal definitions of the LF descriptors used

Considering:

- i a subscript denoting the farms
- $k, l = 1, \dots, K_i$ subscripts denoting the plots of farm i
- (x_k, y_k) the plane coordinates of the centroid of plot k
- a_k the area of plot k and $A_i = \sum_{k=1}^{K_i} a_k$ the total area of farm i
- p_k the perimeter of plot k
- $(\bar{x}_i, \bar{y}_i) = \left(\frac{1}{A_i}\sum_{k=1}^{K_i} a_k x_k, \frac{1}{A_i}\sum_{k=1}^{K_i} a_k y_k\right)$ the plane coordinates of the barycentre of farm i;

The LF descriptors are defined as follows:

1. LF descriptors relating to the number of plots

- number of plots: $nplot_i = K_i$

2. LF descriptors relating to the shape of plots

- weighted average plot shape index: $wshsq_i = \frac{1}{A_i}\sum_{k=1}^{K_i} a_k \frac{p_k}{4\sqrt{a_k}}$
- average plot areal form factor: $aform_i = \frac{1}{K_i}\sum_{k=1}^{K_i} \frac{a_k}{p_k^2}$

3. LF descriptors relating to the size of plots

- average plots' size: $avpls_i = \frac{A_i}{K_i}$
- Simpson index: $simps_i = 1 - \frac{\sum_{k=1}^{K_i} a_k^2}{A_i^2}$
- Januszewski index: $janus_i = \frac{\sqrt{A_i}}{\sum_{k=1}^{K_i}\sqrt{a_k}}$

4. LF descriptors relating to the distance of plots from the farm

- average distance of a hectare:

$$avdha_i = \frac{1}{A_i}\sum_{k=1}^{K_i} a_k\sqrt{(x_k - \bar{x}_i)^2 + (y_k - \bar{y}_i)^2}$$

- grouping index:

$$grpgi_i = \frac{argmax_{k=1}^{K_i}\left(\sqrt{(x_k - \bar{x}_i)^2 + (y_k - \bar{y}_i)^2}\right)}{\sqrt{A_i/\pi}}$$

- structural index:

$$strui_i \equiv \frac{grpgi_i}{avpls_i} = \frac{K_i.\, argmax_{k=1}^{K_i}\left(\sqrt{(x_k - \bar{x}_i)^2 + (y_k - \bar{y}_i)^2}\right)}{A_i\sqrt{A_i/\pi}}$$

5. LF descriptors relating to the scattering of plots

- normalised average nearest neighbour distance:

$$nannd_i = \frac{\sum_{k=1}^{K_i} argmin_{l=1}^{K_i}\left(\sqrt{(x_k - x_l)^2 + (y_k - y_l)^2}\right)}{K_i\sqrt{A_i/\pi}}$$

Comparative Analysis of Factor Markets for Agriculture across the Member States

245123-FP7-KBBE-2009-3

The Factor Markets project in a nutshell

Title	Comparative Analysis of Factor Markets for Agriculture across the Member States
Funding scheme	Collaborative Project (CP) / Small or medium scale focused research project
Coordinator	CEPS, Prof. Johan F.M. Swinnen
Duration	01/09/2010 – 31/08/2013 (36 months)
Short description	Well functioning factor markets are a crucial condition for the competitiveness and growth of agriculture and for rural development. At the same time, the functioning of the factor markets themselves are influenced by changes in agriculture and the rural economy, and in EU policies. Member state regulations and institutions affecting land, labour, and capital markets may cause important heterogeneity in the factor markets, which may have important effects on the functioning of the factor markets and on the interactions between factor markets and EU policies. The general objective of the FACTOR MARKETS project is to analyse the functioning of factor markets for agriculture in the EU-27, including the Candidate Countries. The FACTOR MARKETS project will compare the different markets, their institutional framework and their impact on agricultural development and structural change, as well as their impact on rural economies, for the Member States, Candidate Countries and the EU as a whole. The FACTOR MARKETS project will focus on capital, labour and land markets. The results of this study will contribute to a better understanding of the fundamental economic factors affecting EU agriculture, thus allowing better targeting of policies to improve the competitiveness of the sector.
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Partners	17 (13 countries)
EU funding	1,979,023 €
EC Scientific officer	Dr. Hans-Jörg Lutzeyer