Recent trends in the distribution of farm sizes in the EU

Laurent PIET
SMART-LERECO, INRA, Agrocampus Ouest, F-35000 Rennes

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Abstract: Over the last decades, the number of farms has been decreasing and the average operated area has been increasing all over the European Union. This paper aims at studying the distribution of farm sizes across the 27 EU Member states both at the national and regional levels, and how it evolved from 2005 to 2013. Using two indicators of farm size, namely the median size of farms and the hectare-weighted median size of farms, along with two indicators of farm-size inequality, the Gini coefficient and the Herfindahl-Hirschman index, it shows that a variety of situations exists across Europe but that the overall tendency is that of a general increase in farm sizes which most often results in an increase in farm-size inequality and concentration.

Keywords: Farm size distribution, inequality, parametric Lorenz curve, Gini coefficient, Herfindahl-Hirschman index, European Union.

JEL classification: Q12, Q24, D33, L11

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1. Introduction

Agricultural statistics for the European Union (EU) show that, over the last decades, the number of farms has been decreasing and the average operated area has been increasing (Eurostat, 2016). This double trend has had repercussions on the distribution of agricultural land across farms, with the main result being a concentration of land into the hands of fewer operators (Martins and Tosstorff, 2011). For example, Levesque (2016b) reports that, in Romania, three agricultural holdings operate more than 50,000 hectares each. This raises concerns about the distribution of land across holdings, a standing issue for agricultural researchers, stakeholders and policy makers.

Recently, Piet *et al.* (2012) investigated the issue for France, analysing the role of several drivers in the relative stability of farm-size inequality over the period 1970-2007. Even more recently, Loughrey *et al.* (2016) studied the distribution of agricultural land in Western Europe, focusing on identifying spatial clusters of homogeneous farm-size inequality for the year 2010. In the mean time, the OECD tackled the subject for a set of 14 countries observed at several dates, two in Asia (Korea, Japan), two in America (Canada, the USA), and ten EU Member states (Bokusheva and Kimura, 2016).

This paper adds to this literature by describing the distribution of farm sizes for the EU-27 as a whole, thus extending Loughrey *et al.* (2016)'s study to Central and Eastern European countries. It focuses on cross-country and cross-region comparisons as well as inter-temporal evolutions from 2005 to 2013. Basically, the method employed has been widely used in the economic literature investigating distributional issues. It is based on the analysis of 'grouped' data on the number of holdings and operated hectares by farm-size categories from which a number of farm size and farm-size inequality indicators may be derived. 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 and Rocchi, 2008; Vollrath, 2006; Mishra *et al.*, 2009; Sinabell *et al.*, 2013).[1]

[1]Note that farm-size inequality measures such as the Gini coefficient have also been used as ex-

The present study is original with respect to this strand of agricultural economics in two respects. First, it introduces the use of the Herfindahl-Hirschman index (HHI) to study the issue of land concentration, an index which has been so far mainly used in the industrial organisation literature (Herfindahl, 1959; Hirschman, 1964; Rhoades, 1993, 1995). In the former agricultural economics studies cited above, the Gini coefficient has been mainly used to characterise farm-size inequality. But, as a relative measure, the Gini coefficient fails to completely capture concentration effects. Because it incorporates the absolute number of firms in the sector, the HHI overcomes this limitation. Second, this paper argues that no farm size or farm-size inequality indicator is alone sufficient to fully describe the trends at stake. It therefore jointly studies four of such indicators. This allows to group the EU-27 regions into a limited number of clusters exhibiting similar developments in farm size and farm-size inequality.

The rest of the paper is structured as follows. Section 2 details the implemented method. Section 3 then describes the data used while section 4 reports the results obtained for EU-27, both at the national and regional scale. Finally, Section 5 concludes.

2. Method

Consider we want to study the size distribution of a population of N holdings which operate a total of H hectares of utilised agricultural area (UAA), but whose individual sizes are not known. Only 'grouped' data are available, that is, the N farms are arranged into K mutually exclusive and exhaustive size categories (Abounoori and McCloughan, 2003). For each size category k ($k = 1, .., K$) we only observe the number of holdings, n_k, and the total area they operate, h_k. The central component of our method consists in building the so-called Lorenz curves from these data, from which a number of inequality measures can be derived (Kleiber and Kotz, 2003; Cowell and Van Kerm, 2015).

The grouped data are transformed into a set of K points which map the cumulative shares of holdings, $\sum_{k=1}^{i} n_k/N$ for $i = 1, .., K$, to the cumulative shares of hectares, $\sum_{k=1}^{i} h_k/H$ for $i = 1, .., K$. From these points we can estimate the corresponding Lorenz curve by fitting a parametric function to the observed data, using the functional specification proposed by Rasche *et al.* (1980):

$$L(F; q) = \Big(1 - \big(1 - F(q)\big)^{\alpha}\Big)^{1/\beta} \quad (1)$$

where $L(F; q)$ is the cumulative distribution of the operated hectares, $F(q)$ is the cumulative distribution of the number of holdings, 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), α and β are estimated through non-linear least squares, parametrising α as $\dfrac{\exp(a)}{1 + \exp(a)}$ and β as $\dfrac{\exp(b)}{1 + \exp(b)}$, where a and b are the parameters actually estimated, so as to enforce the constraints on α and β.

Once the Lorenz curve parameters have been estimated, a number of farm size and farm-size inequality measures may be derived. Among the possible indicators, we chose

planatory variables to other components of agricultural structural change (see for example Huettel and Margarian, 2009).

to compute the four following ones:[2]

- the *median farm size* (*med*) which is the second quartile of the distribution of farm sizes defined as:
$$\text{med} = \frac{H}{N} L'(F; 0.5) \tag{2}$$
where H/N is the average farm size over the whole population, and $L'(F; 0.5)$ is the value of the first derivative of $L(F; q)$ evaluated at $q = 0.5$;

- the *hectare-weighted median* of farm sizes (*hwm*) which is the threshold size under which smaller farms operate 50% of the total area and above which larger farms operate the other 50% of the total area (Lund and Price, 1998; Bokusheva and Kimura, 2016); with our notations, it is defined as:
$$\text{hwm} = \frac{H}{N} L'(F; q | L(F; q) = 0.5). \tag{3}$$
where $L'(F; q|L(F; q) = 0.5)$ is the value of the first derivative of $L(F; q)$ evaluated at the centile q for which $L(F; q) = 0.5$;

- the *relative Gini coefficient* (*gin*) defined as (Cowell and Van Kerm, 2015; Rasche *et al.*, 1980):
$$\text{gin} = 1 - 2 \int L(F; q) \mathrm{d}q = 1 - \frac{2}{\alpha} B(1/\alpha, \frac{1}{\beta} + 1) \tag{4}$$
where B is the Beta distribution.

- and the *Herfindahl-Hirschman index* (*hhi*) which is the sum over all holdings of individual area shares raised at the power two (Herfindahl, 1959; Hirschman, 1964; Rhoades, 1993, 1995):
$$\text{hhi} = \sum_{n=1}^{N} \Big(\frac{h(n)}{H} \Big)^2 \tag{5}$$
where $h(n)$ is the area operated by holding n, *i.e.*, its size in hectares.

One advantage of Rasche *et al.* (1980)'s parametric specification of the Lorenz curve is that the first derivative of L, needed to compute *med* and *hwm*, has a simple analytical expression:
$$L'(F; q) = \frac{\alpha}{\beta} \big(1 - F(q)\big)^{\alpha - 1} \Big(1 - \big(1 - F(q)\big)^{\alpha}\Big)^{\frac{1}{\beta} - 1}. \tag{6}$$

An indirect approach is however needed to compute the *hhi* indicator because it is a discrete measure defined at the individual firm level. Usually, it is used in industrial organisation economics where only a limited number of firms is considered and, often, some firms concentrate high market shares. In the farming context, where production is generally atomised over a large number of holdings, the size of each and every farm is not directly available and no farm operates more than a few percent of the total area. The adopted approach to compute equation (5) is as follows.

[2] Other farm size indicators include the average farm size, any decile of farm sizes, etc.; other farm-size inequality indicators include the standard deviation of farm sizes, the inter-quartile or inter-centile ranges, the coefficient of variation, the relative mean deviation, etc. See for example Cowell and Van Kerm (2015).

Once the α and β parameters have been estimated, we first generate a set of N observations indexed by $n = 1, \ldots, N$. From this set and the estimated parameters, we can compute $F(n) = n/N$ and derive $L(F, n)$ from equation (1) and $L'(F, n)$ from equation (6). The size of each simulated farm n is then given by:

$$h(n) = \frac{H}{N} L'(F, n) \tag{7}$$

The computation of *hhi* is now straightforward. Here, the approximation consists in assuming that farms exhibit a continuum of sizes with every farm having a unique size. This tends to overestimate the *hhi* but, in our case, N and H will be in general sufficiently large, hence the individual shares $h(n)/H$ sufficiently small, for the bias to remain limited.

Each of the above indicators has different merits in synthetically describing the distribution of farm sizes. As the names imply, the *med* and *hwm* indicators draw an overall picture of how large farms in a region/country are. They are expressed in hectares and the larger their value, the larger the farms tend to be. By definition of the Lorenz curve, *med* will be smaller than *hwm*.[3] As is well known, the two median-based indicators are more robust to outliers, small or large, than the simple average farm size, H/N. But Bokusheva and Kimura (2016) note that *hwm* has the additional advantage of being less sensitive to the choice of the minimum threshold size which defines a 'farm' in statistical surveys. However, none of these two indicators give a real clue on how unequal the distribution of farm sizes is. At reverse, the *gin* and *hhi* indicators are more informative in this respect. They are dimensionless indicators and both take on values ranging from 0 to 1, with higher values denoting greater inequality.[4] But because the *gin* indicators is a relative measure, it only depicts the overall inequality in farm sizes without giving any clue on how concentrated farming structures are: as long as the relative distributions of farms and hectares are the same, two regions/countries may exhibit the same value for *gin* while having different numbers of farms and/or overall farm sizes. For instance, a hypothetical 1,000ha-region/country 'A' with 2 farms, one sized 200 hectares and the other sized 800 hectares, will exhibit the same *gin* indicator as another hypothetical 1,000ha-region/country 'B' with 100 farms, 50 of which operating 4 hectares each and the other 50 operating 16 hectares each. Generally 'A' would nonetheless be qualified as more *concentrated* a situation than 'B'. In such a case, the *hhi* indicator makes a difference: *hhi* would be 0.64 for 'A' but would only be 0.0136 for 'B', given credit to the common sense. But none of these two indicators would enable discriminating situation 'B' from a third, larger, hypothetical region/country 'C' with 100 farms, 50 of which operating 200 hectares each and the other 50 operating 800 hectares each. Here, only an overall-size indicator such as *med* or *hwm* would complement the information.

In sum, it is clear that none of the four considered indicators is alone sufficient to synthetically describe the distribution of farm sizes, in particular when cross-country or diachronic comparisons are to be made. To get the whole picture, it is therefore necessary to consider more than just one of such indicators, and especially to combine –at least– one farm size indicator with –at least– one farm-size inequality measure.

[3] At most, *med* will be equal to *hwm* under perfect equality in the distribution of farm sizes.

[4] Actually, it is common practice in the related literature to express in percent the shares used to compute the *hhi* indicator, so that *hhi* takes on values ranging from 0 to $10,000$. We adopt this convention in our tables and figures.

3. Data

We used the publicly available Eurostat statistics on the number of holdings and operated area by size of farms as measured in hectares of UAA. Such data are available since 1990 in two different forms: based on agricultural censuses every ten years and; based on farm structure surveys (FSS) every two or three interim years. Ten non consecutive observation years were therefore originally available, namely 1990, 1993, 1995, 1997, 2000, 2003, 2005, 2007, 2010 and 2013.[5]

We used both the data available at the Member state national level and the NUTS2, hereafter regional, level.[6] Not all years were available for every Member state, both at the national and regional levels. Table 1 summarises which data were available where and when. Based on this table, we chose to exclude Croatia from the analysis since data for this country were available starting on 2007 only. We also restricted the analysis to the 2005-2013 period in order to implement the method for the EU-27 and not for a subset of Member states only.

[*insert Table 1 around here*]

The number of holdings and operated area was originally available for nine size categories. Since we studied the unequal distribution of land across farms, we excluded the first category, namely 'exactly zero hectare', from the analysis, ending-up with the following eight size categories:

- more than zero but less than 2 hectares;
- 2 hectares or more but less than 5 hectares;
- 5 hectares or more but less than 10 hectares;
- 10 hectares or more but less than 20 hectares;
- 20 hectares or more but less than 30 hectares;
- 30 hectares or more but less than 50 hectares;
- 50 hectares or more but less than 100 hectares;
- 100 hectares or more.

Table 2 provides an overview of the corresponding data for 2005 and 2013. To spare space, the eight original size categories have been aggregated into three, namely: more than zero but less than 10 hectares; 10 hectares or more but less than 50 hectares and; 50 hectares or above. In his table, farm and UAA numbers by category are not reported as such, rather as category shares along with the total number of holdings and operated hectares. This allows a more direct cross-country comparison of the distribution of farm sizes.

From these figures, it appears that: Romania, with over 3.5 million farms in 2013, exhibits the highest number of holdings in the EU-27, before Poland (around 2.5 million farms) and Italy and Spain (both around 1 million farms); France, with over 27.7

[5]Note that, at the time we collected the data, Eurostat included a warning statement indicating that 2013 data were still provisional (see `http://ec.europa.eu/eurostat/documents/749240/6743790/FSS-EB-2013-EN.PDF`).

[6]The Nomenclature of Territorial Units for Statistics (NUTS) is a hierarchical breakdown system for the European Union territory (see `http://epp.eurostat.ec.europa.eu/statistics/_explained/index.php/Glossary:NUTS`).

million hectares, has the largest total UAA, before Spain (23.3 million hectares), Germany (16.7 million hectares) and Poland (over 14.4 million hectares). At the other end of the distribution, Luxembourg and Malta, with less than ten thousand farms in 2013, not surprisingly exhibit the smallest numbers of holdings, before a group of five Member states (Estonia, Slovakia, Czech Republik, Cyprus and Denmark) which all report less than 50 thousand farms. With only 11 thousand hectares, Malta cumulates the lowest total UAA, before Cyprus (less than 110 thousand hectares), Luxembourg (just over 130 thousand hectares), Slovenia (almost 500 thousand hectares) and Estonia (almost 960 thousand hectares). All other Member states operate more than one million hectares of agricultural land. It should be noted that, albeit the total number of holdings decreased almost everywhere and the total number of hectares moved up or down, the ranking of countries remained fairly stable between 2005 and 2013 from both perspectives.

[*insert Table 2 around here*]

As far as the distribution of farm numbers is concerned, contrasted situations appear in the EU-27. In some Member states, the share of farms smaller than 10 hectares is very high, ranging from above 75% (Italy, Poland), 80% (Greece, Hungary, Slovenia), 90% (Bulgaria, Cyprus) to even more than 95% (Malta, Romania). Conversely, this share is below 30% in seven Member states, namely Belgium, Denmark, Finland, Germany, Ireland, Luxembourg and the United-Kingdom (UK). In these countries but Belgium and more notably Ireland, it is the share of farms larger than 50 hectares which is high, around or above 30%, and sometimes well above, such as in the UK (40%) and Luxembourg (51%). In these two latter countries, farms with 50 hectares or more are more numerous than those between 10 and 50 hectares and, in Luxembourg, even more numerous than the sum of the other two categories. Farms of the intermediate category, from 10 to 50 hectares, are the absolute majority in Ireland (almost 64%) and Finland (55.5%) only. In other Member states, holdings are more scattered across farm sizes, sometimes in a quite uniform manner such as in the Czech Republic, France, Germany or Sweden.

Broadly speaking, the shares of utilised agricultural land reflect the distribution of holdings. There are a limited number of noticeable cases though. For instance, while in Bulgaria and Cyprus holdings below 10 hectares represent more than 90% of the overall farm population, they operate only 5.5% of the total area in the former but 42.1% in the latter. In Bulgaria, 88% of the hectares are operated by less than 4% of the farms, those with 50 hectares or more per farm which, in this specific case, exceed 400 hectares each on average. The analogous comparison apply to Greece and Hungary, with farms below 10 hectares being 89% of the population in both cases, but operating almost 30% of the area in Greece while only around 9% in Hungary. Finally, two other 'extreme' situations may be pointed. Firstly, that of Malta where holdings appear to be quite uniformly distributed in the below-10ha category since 94% of the land are operated by such farms which, in turn, represent almost 95% of the population. Secondly, that of the Czech Republic and Slovakia where the least numerous farms, those above 50 hectares, operate almost the entire available area, with their share representing 90% of the land. And thirdly, in Ireland, while farms with 50 hectares or more are a minority, they operate more than one half of the total area.

Even this short description of Table 2, a simplified version of the original data, shows that farm-size distributions are quite diverse across the EU and that rough data are not well-suited for conducting cross-country or diachronic comparisons. In particular, it shows that 'small', 'medium' or 'large' are not satisfying terms to describe, and especially compare, farm populations since such a terminology is inevitably contingent to the context: 20 hectares will be 'large' in, *e.g.*, Romania, while 'small' in, *e.g.*, neighbouring Bulgaria, and 'medium' in many Western EU countries. The next section therefore reports the result of the above-presented method which provides with more synthetic and informative indicators, allowing for cross-country and inter-temporal analysis.

4. Results

4.1. Parametric Lorenz curve estimation

We start by reporting in Table 3 the results for the estimation of equation (1) both for 2005 and 2013 at the national level. The parametric Lorenz curve fits the data to a highly satisfactory extent everywhere and at both dates since every R^2 are well above 0.90, many of them peaking at 0.99 or above. The lowest R^2 value, 0.977, is obtained for Romania in 2005. The estimated parameters are also accurately identified, with standard deviations being moderate in most cases. At worst, the standard deviation is 0.048 for α –or 21% of the point estimate– for Slovakia in 2005, and 0.104 for β –or 11% of the point estimate– for Romania in 2013.

[*insert Table 3 around here*]

The α and β values are difficult to interpret *per se*. The derived farm size and farm-size inequality indicators will be more informative. Note nonetheless that both parameters take on values which spread over almost their entire support, with α ranging from 0.127 for Bulgaria in 2005 to 0.956 for Luxembourg in 2013, and β ranging from 0.253 for Hungary in 2013 to 1.000 for Romania in 2005. Also, there is no univocal relation between α and β, confirming the intuition drawn from Table 2 that distributions of farm sizes are diversely shaped across the EU-27.

4.2. Farm size and farm-size inequality in 2013

Following the method described in Section 2, we then derive the two indicators for farm size, *med* and *hwm*, as well as the two indicators for farm-size diversity, *gin* and *hhi*, from the estimated α and β parameters, . Table 4 reports the results obtained at the national level while Figure 1 displays that of the regional level in a cartographic manner, both for 2013.

[*insert Table 4 and Figure 1 around here*]

The highest median farm sizes, *med*, are found in Luxembourg (45 hectares), the UK (almost 34 hectares), France (30 hectares) and a group composed of Finland, Denmark, Germany, Belgium and Ireland (all with *med* lying between 20 and 30 hectares). Panel a) of Figure 1 confirms this result that farming structures are globally larger in the North-Western part of the EU, with half of the farm population sizing above the aforementioned figures. At the opposite, a group of Eastern Member states composed of Bulgaria, Hungary and Romania (to which Cyprus and Malta may be added), exhibits a huge amount of small farming structures, with a median size of farms, *med*, not exceeding one hectare. This means that, in these countries, half of the farm population lies below this limit.

Conversely, some Eastern countries also host very few yet extremely large holdings: Table 4, confirmed by panel b) of Figure 1, indeed reveals that the hectare-weighted median size of farms, *hwm*, sometimes reaches 1,000 hectares and above, meaning that half of the agricultural area is operated by holdings larger than this size. This is so for Slovakia ($hwm >$ 4,400 ha), Bulgaria ($hwm >$ 2,100 ha) and the Czech Republic ($hwm \approx$ 1,800 ha). Countries with a hectare-weighted median size of farms above 200 hectares are also found in the East in majority (Estonia, Hungary), the UK being an exception. In addition, the panel b) of Figure 1 also reveals some intra-country disparities in Western European countries, especially in Portugal (where *hwm* is much higher in the Southern region Alentejo), Germany (where *hwm* is much higher in the former East) and Greece (where *hwm* is much higher in the Epirus region).

Farm-size inequality measures, *gin* and *hhi*, synthesize the above information about farm sizes. Both indicators are especially high in Slovakia, Bulgaria and the Czech Republic, with *gin* at almost 0.900 or above, and *hhi* exceeding 200, all being countries where *hwm* is particularly high and *med* is low or very low. Symmetrically, the lowest *gin* values are obtained for Finland (0.489) and Ireland (0.496), the two countries for which the ratio of *hwm* to *med* is lowest. The *hhi* is usually consistent with the *gin* indicator. For instance, highest *hhi* values are obtained for those countries which have also top *gin* values. However, there a number of situations where both inequality indicators diverge. Firstly, France exhibits the lowest *hhi* indicator at 0.05 for a *gin* value of 0.606 which is surely among lower values yet not the lowest. Secondly, in Greece, the *gin* indicator is 0.753 while the *hhi* indicator reaches 41.39, a value well above that of most other countries with higher *gin* values. Finally, Spain and Portugal are worth comparing: while both have quite comparable *gin* values (0.801 for Spain, 0.851 for Portugal), Portugal's *hhi* (51.01) is a hundred times larger than that of Spain (0.56). At the regional level, the comparison of panels c) and d) of Figure 1 also reveals some interesting cases. For instance, while *gin* emphasizes the Champagne-Ardennes region inside France, *hhi* brings a much more homogeneous picture of the country as a whole. At reverse, *hhi* leads to more heterogeneous descriptions of Italy and Spain, especially highlighting Trentino-Alto Adige and Abruzzo in Italy, and Asturias, Cantabria and La Rioja in Spain.

All in all, the four selected indicators do give a consistent picture of the distribution of farm sizes across countries. However, as the detailed analysis of Table 4 shows, they are not perfectly correlated with each other so that each of them brings a complementary information or highlights specific cases which the others fail to identify. This point is confirmed by Table 5 and Figure 2: linear correlations reported in Table 5, though almost all significant, do not exceed two thirds in absolute value and; scatterplot graphs for each possible pair of indicators presented in Figure 2 confirm that any value of a specific indicator may correspond to many values of the other indicators.

[*insert Table 5 and Figure 2 around here*]

4.3. Recent trends in farm size and farm-size inequality

In this section, the evolution of farm size and farm-size inequality between 2005 and 2013 is investigated, examining again the four considered indicators.

Figure 3 presents maps of the annual change rates, in percentage change per year, at the regional level. A comparison of panels a), reporting the evolution in the *med* indicator, and b), reporting the evolution in the *hwm* indicator, reveals that, in some regions, the gap between both sizes tended to shrink because the median farm size increased and the hectare-weighted median farm size decreased (see for example the cases of Slovakia and the Czech Republic). Conversely, in other regions, both indicators diverged, with a decrease in the median farm size and an increase in the hectare-weighted median farm size (see for example the cases of Finland, Sweden, Romania, Lithuania, Latvia, Greece and Denmark). Finally, elsewhere, both indicators moved in the same direction, either up (see for example Estonia, most parts of Italy and England, Western regions of Germany) or down (see for example Ireland and most regions of Spain).

Resulting from the interplay of these tendencies, the inequality measures either increased or decreased (see panels c) and d) of Figure 3). Both indicators are consistent in some cases, either increasing simultaneously (in Ireland, Scotland, Denmark, Sweden, Latvia, Lithuania, Greece and some regions of Romania, France and Germany) or decreasing simultaneously (in the Czech Republic, Slovakia, most regions of Italy and some regions of Poland and France). But there again it is worth noticing that *gin* and *hhi* did not change consistently everywhere. For example, in Spain, Portugal, Hungary, Estonia, the North and East region of Finland, most regions of Bulgaria and some regions of Romania, the *gin* indicator went up when the *hhi* indicator went down. Conversely, *gin* decreased but *hhi* increased in most parts of England and most Western regions of Germany or Poland.

Combining these four trends, it was possible to group regions according to a few types (see Figure 4). Since each indicator could either go up or down, there was *a priori* $2^4 = 16$ possible combinations or groups. Eventually, only 11 groups were actually observed:[7]

- group labelled '0000': all indicators decreased between 2005 and 2013;
- group labelled '1000': only *med* increased, the other three decreased;
- group labelled '0010': only *gin* increased, the other three decreased;
- group labelled '1100': *med* and *hwm* both increased, *gin* and *hhi* both decreased;
- group labelled '0011': *med* and *hwm* both decreased, *gin* and *hhi* both increased;
- group labelled '1001': *med* and *hhi* increased, *hwm* and *gin* decreased;
- group labelled '0110': *hwm* and *gin* increased, *med* and *hhi* decreased;
- group labelled '1110': only *hhi* decreased, the other three increased;
- group labelled '1101': only *gin* decreased, the other three increased;
- group labelled '0111': only *med* decreased, the other three increased;
- group labelled '1111': all indicators increased.

The distribution of the 279 NUTS2 regions and 27 countries across these groups is as follows, from the most represented group to the least:[8]

- '1101': 122 regions and 6 countries (Belgium, Germany, Luxembourg, Malta, Poland and the UK);
- '1111': 51 regions and 5 countries (Finland, France, Latvia, Lithuania and The Netherlands);

[7] The five groups which were ***not*** observed are: '0100' (only *hwm* increased, the other three decreased); '0001' (only *hhi* increased, the other three decreased); '1010' (*med* and *gin* both increased and *hwm* and *hhi* both decreased); '0101' (*med* and *gin* both decreased and *hwm* and *hhi* both increased) and; '1011' (only *hwm* decreased, the other three increased).

[8] Note that three of the groups observed at the regional level have no counterpart at the national level.

- '0111': 32 regions and 7 countries (Cyprus, Denmark, Greece, Ireland, Romania, Slovenia and Sweden);
- '1000': 26 regions and 3 countries (Austria, Slovakia and Spain);
- '1100': 21 regions and 2 countries (Italy and Hungary);
- '1001': 9 regions and 1 country (the Czech Republic);
- '1110': 8 regions and 2 countries (Estonia and Portugal);
- '0110': 4 regions;
- '0010': 3 regions and 1 country (Bulgaria);
- '0000': 2 regions;
- '0011': 1 region.

From these figures it can be first deduced that an increase in both farm size measures (groups labelled '11xx', 202 regional occurrences) results at 90% in an increase in farm-size inequality, be it measured by the *gin* or the *hhi* indicators (181 regional occurrences when summing groups '1101', '1110' and '1111', out of 202); however, *hhi* captures this inequality increase more often than *gin* (173 times out of 181 for *hhi* against 59 times out of 181 for *gin*). But even if both farm sizes decrease (groups labelled '00xx', 6 regional occurrences), inequality is also likely to increase (4 occurrences out of 6). Finally, when only the median size of farms increases (groups labelled '10xx', 35 regional occurrences), inequality is likely to decrease (26 occurrences out of 35) while when only the hectare-weighted size of farms increases (groups labelled '01xx', 36 regional occurrences), inequality inevitably increases too, *gin* capturing the fact every time.

5. Conclusion

This paper describes the recent trends in farm size and farm-size inequality over the EU-27 for the 2005-2013 period, both at the national and regional level. Using two indicators of farm size, namely the median size of farms and the hectare-weighted median size of farms, along with two indicators of farm-size inequality, the Gini coefficient and the Herfindahl-Hirschman index, it shows that a variety of situations exists across Europe: in some cases all four indicators increased or decreased simultaneously; in other regions one or both farm size indicators increased while one or both decreased; etc. Out of the 16 possible trends, only 11 are actually observed for EU regions during the studied period. Nonetheless, the overall tendency is that of a general increase in farm sizes at all scales (*i.e.*, at smaller sizes as measured by the median farm size, as well as at larger sizes, as measured by the hectare-weighted median), generally resulting in an increase in farm-size inequality (as measured by the Gini coefficient) and/or concentration (as measured by the HHI).

As noted by some authors, this becomes a topical political issue with questions arising about the decline of family farms and the surge in land grabbing strategies (van der Ploeg *et al.*, 2015). This becomes all the more problematic as the development of incorporated forms of agricultural production sometimes allows to escape national policies aimed at regulating either the land market or the 'excessive' enlargement of holdings. For instance, Levesque (2016a) reports that a Chinese group recently took over the control of more than 1,750 hectares in the French Berry region by acquiring the absolute majority in the society shares of several pre-existing farms. Because such purchases did not concern land but society shares, Levesque (2016a) argues that they escaped the French '*contrôle des structures*' policy and especially the pre-emption rights of the SAFER and the process of operating authorizations (see Latruffe and Le Mouël, 2006 and Latruffe *et al.*, 2008 for a detailed description of land market regulations in France). According to several authors and reports, such a case is no longer isolated all over the EU (Kay *et al.*, 2015; van der Ploeg *et al.*, 2015; Levesque, 2016a).

While the present paper contributes to the issue, it may be extended in two directions. First, the statistics used here cover the entire population of European farms. This means that, in particular, holdings which operate a limited amount of land, such as horticulture, fruit production or off-land hog and poultry producers, are put together with holdings which have an extensive use of land, such as grain crop producers or dairy and livestock producers. Even if Loughrey *et al.* (2016) indicate that this does not seem to be too big a deal, splitting the analysis by homogeneous types of farming would certainly constitute an improvement. Alternatively, using another definition of farm size, *e.g.*, based on an economic measure such as the gross product or the standard output would help in overcoming the issue. Yee and Ahearn (2005) did so for the USA using five different measures of farm size. In the European case, this raises the question of the availability of relevant statistics through-out the EU and for a sufficiently long observation period.

Second, the present work should be extended by studying the potential drivers of the measured inequality and concentration levels and trends, with a particular emphasis on the potential role of land market regulations and agricultural policies. Such an analysis would contribute to the political debate on the relevance and efficiency of a public intervention in the agricultural sector to impede the so-called 'financialisation' of farming, and/or to promote a specific model, or a diversity of models, of production structures.

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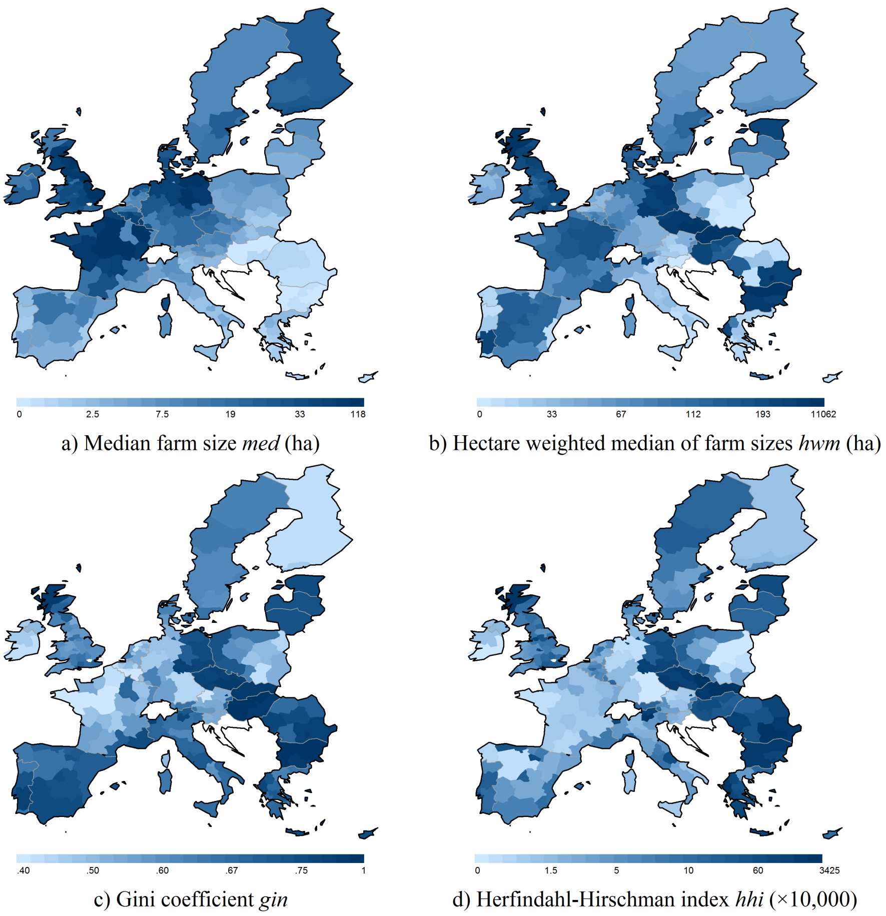
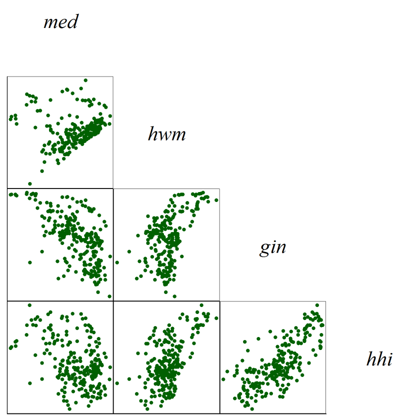
Figure 1. Farm-size distribution indicators at the regional level in 2013



Source: Censuses and FSS 2005-2013, Eurostat - authors' calculation

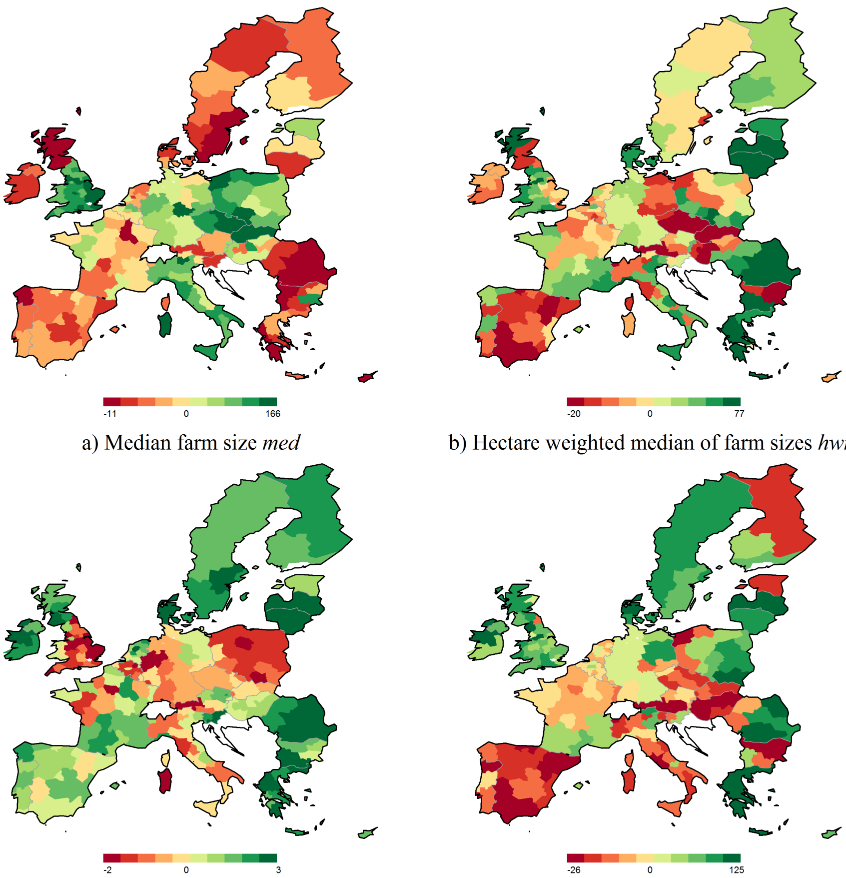
Figure 2. Scatterplot matrix of farm size and farm-size inequality indicators at the regional level in 2013[a]



[a]Scales in log for all indicators.

Source: Censuses and FSS 2005-2013, Eurostat - authors' calculation

Figure 3. Change in farm-size distribution indicators at the regional level between 2005 and 2013 (% per year)



a) Median farm size *med*

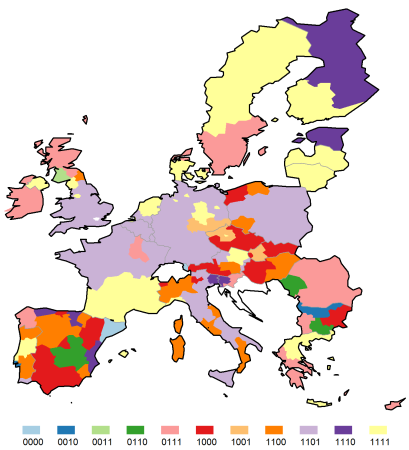
b) Hectare weighted median of farm sizes *hwm*

c) Gini coefficient *gin*

d) Herfindahl-Hirschman index *hhi*

Source: Censuses and FSS 2005-2013, Eurostat - authors' calculation

Figure 4. Groups of homogeneous trends at the regional level[a]



[a]See text for an explanation of the group labels.

Source: Censuses and FSS 2005-2013, Eurostat - authors' calculation

Table 1. Available observation years for each Member state and level of disaggregation, national or regional[a]

Member state (MS)	1990		1993		1995		1997		2000		2003		2005		2007		2010		2013	
	N0	N2	N0	N2	N0	N2	N0	N2	N0	N2	N0	N2	N0	N2	N0	N2	N0	N2	N0	N2
Austria (AT)					x		x		x		x		x	x	x	x	x	x	x	x
Belgium (BE)	x		x		x		x		x		x		x	x	x	x	x	x	x	x
Bulgaria (BG)											x	x	x	x	x	x	x	x	x	x
Cyprus (CY)											x	x	x	x	x	x	x	x	x	x
Czech Republic (CZ)											x	x	x	x	x	x	x	x	x	x
Croatia (HR)															x	x	x	x	x	x
Denmark (DK)	x		x		x		x		x		x		x	x	x	x	x	x	x	x
Estonia (EE)											x	x	x	x	x	x	x	x	x	x
Finland (FI)					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
France (FR)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Germany (DE)									x	x	x	x	x	x	x	x	x	x	x	x
Greece (EL)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Hungary (HU)									x	x	x	x	x	x	x	x	x	x	x	x
Ireland (IE)	x		x		x		x		x	x	x	x	x	x	x	x	x	x	x	x
Italy (IT)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Latvia (LV)									x	x	x	x	x	x	x	x	x	x	x	x
Lithuania (LT)											x	x	x	x	x	x	x	x	x	x
Luxembourg (LU)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Malta (MT)											x	x	x	x	x	x	x	x	x	x
The Netherlands (NL)	x		x		x		x		x		x		x	x	x	x	x	x	x	x
Poland (PL)											x	x	x	x	x	x	x	x	x	x
Portugal (PT)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Romania (RO)											x	x	x	x	x	x	x	x	x	x
Slovakia (SK)									x	x	x	x	x	x	x	x	x	x	x	x
Slovenia (SI)									x		x	x	x	x	x	x	x	x	x	x
Spain (ES)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sweden (SE)					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
United Kingdom (UK)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Number of MS	11	7	11	7	14	9	14	9	19	14	27	23	27	27	28	28	28	28	28	28

[a] In the column headings, 'N0' stands for the national (NUTS0) level and 'N2' stands for the regional (NUTS2) level.

Source: Censuses and FSS 1990-2013, Eurostat - authors' calculation

Table 2. Distribution of holding numbers and UAA at the national level by size category (in hectares of UAA)[a]

Member state	Total holdings (×1000)		Share within the total (%)						Total UAA (×1000)		Share within the total (%)					
			0+ to < 10		10 to < 50		50 or more				0+ to < 10		10 to < 50		50 or more	
	2005	2013	2005	2013	2005	2013	2005	2013	2005	2013	2005	2013	2005	2013	2005	2013
Austria (AT)	170	140	50.8	47.8	42.9	44.1	6.4	8.1	3,266	2,727	11.5	10.5	49.1	51.6	39.4	37.9
Belgium (BE)	51	37	38.5	26.9	44.7	49.8	16.8	23.4	1,386	1,308	5.5	3.9	42.5	37.3	52.1	58.6
Bulgaria (BG)	521	245	97.5	90.8	1.5	5.5	1.0	3.7	2,729	4,651	15.6	5.5	5.3	6.4	79.1	88.0
Cyprus (CY)	45	35	94.1	94.8	5.1	4.3	0.8	0.9	152	109	45.3	42.1	29.5	27.8	25.1	30.1
Czech Republic (CZ)	41	26	63.2	36.7	21.2	36.0	15.6	27.3	3,558	3,492	1.9	1.2	5.6	6.1	92.6	92.7
Denmark (DK)	51	37	20.8	23.9	46.9	40.6	32.3	35.5	2,708	2,619	2.6	2.3	21.7	13.9	75.7	83.8
Estonia (EE)	28	19	65.3	52.7	26.5	31.6	8.2	15.7	829	958	8.6	4.7	18.2	13.4	73.2	82.0
Finland (FI)	70	54	21.2	16.5	59.9	55.5	18.6	28.0	2,264	2,282	3.7	2.4	47.7	34.7	48.6	62.9
France (FR)	562	464	34.6	32.1	29.8	26.7	35.6	41.2	27,591	27,739	2.4	1.9	16.5	11.9	81.1	86.2
Germany (DE)	389	282	36.8	23.5	41.4	46.2	21.8	30.3	17,035	16,700	3.7	2.2	23.6	19.6	72.7	78.2
Greece (EL)	828	704	89.4	88.8	9.8	10.2	0.8	1.0	3,984	4,857	45.1	29.5	39.0	28.5	15.9	42.0
Hungary (HU)	662	453	93.3	88.9	5.0	7.9	1.8	3.1	4,267	4,657	13.0	9.2	15.9	16.5	71.0	74.3
Ireland (IE)	133	140	20.9	18.2	61.3	63.8	17.8	18.0	4,219	4,960	4.0	3.0	50.4	46.3	45.6	50.7
Italy (IT)	1,726	1,009	85.5	75.8	12.3	19.8	2.2	4.5	12,708	12,099	27.3	21.4	33.8	34.7	38.9	44.0
Latvia (LV)	128	81	70.8	61.8	25.8	31.3	3.4	6.9	1,702	1,878	20.3	9.9	36.8	27.1	42.9	63.0
Lithuania (LT)	253	172	77.4	75.6	20.3	18.7	2.3	5.7	2,792	2,861	29.7	18.2	33.5	22.8	36.8	59.0
Luxembourg (LU)	2	2	29.5	24.8	25.0	24.3	45.5	51.0	129	131	2.0	1.5	13.6	10.5	84.4	88.0
Malta (MT)	11	9	99.7	99.4	0.3	0.6	0.0	0.0	10	11	96.2	94.1	3.8	5.9	0.0	0.0
The Netherlands (NL)	80	66	42.2	39.8	44.5	42.5	13.3	17.7	1,958	1,848	6.9	5.9	48.3	40.5	44.8	53.6
Poland (PL)	2,466	1,422	85.6	78.9	13.6	21.9	0.8	2.2	14,755	14,410	35.4	28.2	41.0	41.0	23.5	30.8
Portugal (PT)	323	264	86.2	84.1	10.6	11.9	3.2	4.1	3,680	3,642	18.3	15.3	18.5	17.9	63.3	66.7
Romania (RO)	4,121	3,564	97.7	97.5	2.0	1.9	0.3	0.6	13,907	13,056	50.5	38.5	9.5	9.4	40.0	52.1
Slovakia (SK)	66	22	92.6	69.1	3.5	16.9	3.9	14.1	1,880	1,902	3.0	2.5	2.7	4.2	94.2	93.3
Slovenia (SI)	77	72	85.0	83.6	14.6	15.6	0.4	0.7	485	486	52.1	45.8	38.1	41.4	9.8	12.8
Spain (ES)	1,063	944	68.3	66.4	22.4	22.9	9.4	10.8	24,855	23,300	9.4	8.7	21.0	20.8	69.6	70.6
Sweden (SE)	75	66	31.8	34.4	43.1	41.3	25.1	24.3	3,193	3,036	4.2	4.6	24.4	21.1	71.4	74.4
United Kingdom (UK)	248	182	38.9	21.2	31.1	38.4	30.0	40.3	15,957	17,327	2.2	1.3	12.5	10.2	85.4	88.5

[a]Shares may not sum to 1 on each row due to rounding.

Source: Censuses and FSS 2005-2013, Eurostat - authors' calculation

Table 3. Equation (1) estimation results at the national level[a]

Member state	R^2		α		β	
	2005	2013	2005	2013	2005	2013
Austria (AT)	0.9998	1.0000	0.497(0.017)	0.621(0.003)	0.579(0.022)	0.492(0.003)
Belgium (BE)	1.0000	1.0000	0.749(0.006)	0.731(0.004)	0.413(0.004)	0.478(0.003)
Bulgaria (BG)	0.9987	0.9954	0.127(0.026)	0.239(0.027)	0.535(0.096)	0.289(0.034)
Cyprus (CY)	0.9995	0.9983	0.431(0.019)	0.419(0.034)	0.452(0.030)	0.412(0.054)
Czech Republic (CZ)	0.9994	0.9995	0.282(0.009)	0.262(0.010)	0.347(0.009)	0.479(0.012)
Denmark (DK)	0.9993	0.9999	0.614(0.018)	0.549(0.023)	0.500(0.017)	0.468(0.020)
Estonia (EE)	0.9999	0.9999	0.249(0.008)	0.301(0.018)	0.589(0.016)	0.504(0.026)
Finland (FI)	1.0000	0.9999	0.708(0.006)	0.681(0.008)	0.555(0.005)	0.555(0.007)
France (FR)	0.9999	0.9999	0.832(0.007)	0.860(0.006)	0.327(0.005)	0.315(0.004)
Germany (DE)	0.9999	1.0000	0.481(0.005)	0.482(0.003)	0.498(0.006)	0.541(0.004)
Greece (EL)	0.9999	0.9982	0.521(0.011)	0.226(0.028)	0.478(0.016)	0.767(0.088)
Hungary (HU)	0.9996	1.0000	0.293(0.009)	0.358(0.005)	0.297(0.011)	0.253(0.005)
Ireland (IE)	1.0000	0.9996	0.701(0.003)	0.550(0.021)	0.581(0.003)	0.674(0.023)
Italy (IT)	0.9997	0.9991	0.419(0.011)	0.454(0.021)	0.460(0.017)	0.483(0.029)
Latvia (LV)	0.9997	0.9999	0.358(0.008)	0.309(0.005)	0.643(0.019)	0.584(0.010)
Lithuania (LT)	0.9999	0.9986	0.315(0.006)	0.311(0.025)	0.802(0.019)	0.601(0.048)
Luxembourg (LU)	0.9995	0.9998	0.943(0.018)	0.956(0.014)	0.338(0.013)	0.345(0.009)
Malta (MT)	1.0000	0.9999	0.686(0.019)	0.691(0.023)	0.412(0.021)	0.429(0.022)
The Netherlands (NL)	0.9997	0.9999	0.736(0.024)	0.742(0.016)	0.420(0.016)	0.413(0.010)
Poland (PL)	0.9988	0.9999	0.429(0.024)	0.406(0.007)	0.536(0.041)	0.653(0.014)
Portugal (PT)	0.9991	0.9987	0.252(0.015)	0.271(0.018)	0.551(0.033)	0.500(0.034)
Romania (RO)	0.9770	0.9988	0.169(0.005)	0.141(0.016)	1.000(0.000)	0.910(0.104)
Slovakia (SK)	0.9877	0.9951	0.224(0.048)	0.227(0.032)	0.466(0.050)	0.474(0.041)
Slovenia (SI)	0.9995	0.9999	0.513(0.021)	0.510(0.011)	0.703(0.037)	0.643(0.017)
Spain (ES)	0.9997	0.9987	0.407(0.018)	0.456(0.022)	0.410(0.020)	0.373(0.021)
Sweden (SE)	0.9994	0.9987	0.598(0.016)	0.538(0.024)	0.466(0.015)	0.474(0.024)
United Kingdom (UK)	1.0000	0.9998	0.557(0.003)	0.474(0.007)	0.372(0.003)	0.488(0.007)

[a]Standard errors in parenthesis.

Source: Censuses and FSS 2005-2013, Eurostat - authors' calculation

Table 4. Farm size and farm-size inequality at the national level in 2013

Member state	*med* (ha)	*hwm* (ha)	*gin*	*hhi*[a]
Austria (AT)	10.7	37.0	0.584	0.27
Belgium (BE)	23.1	59.6	0.523	0.60
Bulgaria (BG)	0.2	2,159.2	0.964	293.10
Cyprus (CY)	0.7	14.5	0.795	14.84
Czech Republic (CZ)	17.0	1,774.4	0.869	209.97
Denmark (DK)	28.0	163.9	0.666	1.78
Estonia (EE)	9.1	366.9	0.827	112.93
Finland (FI)	29.2	64.9	0.489	0.43
France (FR)	30.0	133.0	0.606	0.05
Germany (DE)	25.4	134.1	0.653	0.53
Greece (EL)	1.9	36.1	0.753	41.39
Hungary (HU)	0.2	228.6	0.936	17.28
Ireland (IE)	22.7	51.8	0.496	0.31
Italy (IT)	4.1	35.6	0.715	0.35
Latvia (LV)	6.0	108.0	0.772	31.72
Lithuania (LT)	4.7	71.0	0.757	18.51
Luxembourg (LU)	45.0	120.4	0.515	9.00
Malta (MT)	0.6	2.4	0.602	3.33
The Netherlands (NL)	15.6	54.7	0.580	0.39
Poland (PL)	4.5	21.8	0.637	0.41
Portugal (PT)	2.1	144.4	0.851	51.01
Romania (RO)	0.8	53.9	0.794	167.59
Slovakia (SK)	3.2	4,409.8	0.938	601.31
Slovenia (SI)	3.8	11.1	0.552	0.96
Spain (ES)	4.6	113.8	0.801	0.56
Sweden (SE)	19.1	107.6	0.662	1.24
United Kingdom (UK)	33.8	258.6	0.700	1.02

[a]Shares have been multiplied by 100 before computation so that values of the *hhi* indicator may range from 0 to $10,000$.

Source: Censuses and FSS 2005-2013, Eurostat - authors' calculation

Table 5. Correlations between farm size and farm-size inequality indicators at the regional level in 2013[a]

	med	*hwm*	*gin*
hwm	-0.053(0.417)		
gin	-0.500(0.000)	0.467(0.000)	
hhi	-0.227(0.000)	0.615(0.000)	0.525(0.000)

[a]Standard errors in parenthesis.

Source: Censuses and FSS 2005-2013, Eurostat - authors' calculation