Inequality and Concentration in Farmland Production and Size: A Regional Analysis for the European Union from 2010 to 2020

Simone Boccaletti [1], Paolo Maranzano [2]*, Miguel Viegas [3]

[1] Department of Economics, Management and Statistics, University of Milano-Bicocca, Milano, Italy & Osservatorio O-Fire, University of Milano-Bicocca, Milano, Italy; ORCID: https://orcid.org/0000-0002-6972-5005

[2] Department of Economics, Management and Statistics, University of Milano-Bicocca, Milano, Italy & Fondazione Eni Enrico Mattei, Milano, Italy; ORCID: https://orcid.org/0000-0002-9228-2759

[3] Research Unit on Governance, Competitiveness and Public Policies (GOVCOPP), University of Aveiro, Portugal, ORCID: https://orcid.org/0000-0003-1390-4992

* Corresponding author at paolo.maranzano@unimib.it

Corresponding author: a.adenuga@qub.ac.uk

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record.

Please cite this article as:

Boccaletti S., Maranzano P., Viegas M. (2025). Inequality and Concentration in Farmland Production and Size: A Regional Analysis for the European Union from 2010 to 2020, *Just Accepted*. DOI: 10.36253/bae-17797

Abstract

This article investigates the phenomenon of market concentration in the European agricultural sector from 2010 to 2020 at the regional level. To this end, we exploit the spatiotemporal dynamics of the Gini concentration index for farmland and production. First, we examine the variability within and between countries to assess whether the industry has suffered from increasing concentration during the study period. The next objective is to identify the empirical relationship between the two indicators and determine whether spatial spill-overs occur in terms of market concentration across regions. Our findings confirm the fragmented picture of the European agricultural sector, which is characterized by a high degree of heterogeneity within and across countries as concerns both land concentration and production concentration. In addition, we confirm the existence of a positive association between the two concentration measures. Lastly, the remarkable spatial autocorrelation we observe supports the hypothesis that adjacent regions tend to register similar levels of concentration, generating clusters of regions with either high or low values.

1. Introduction

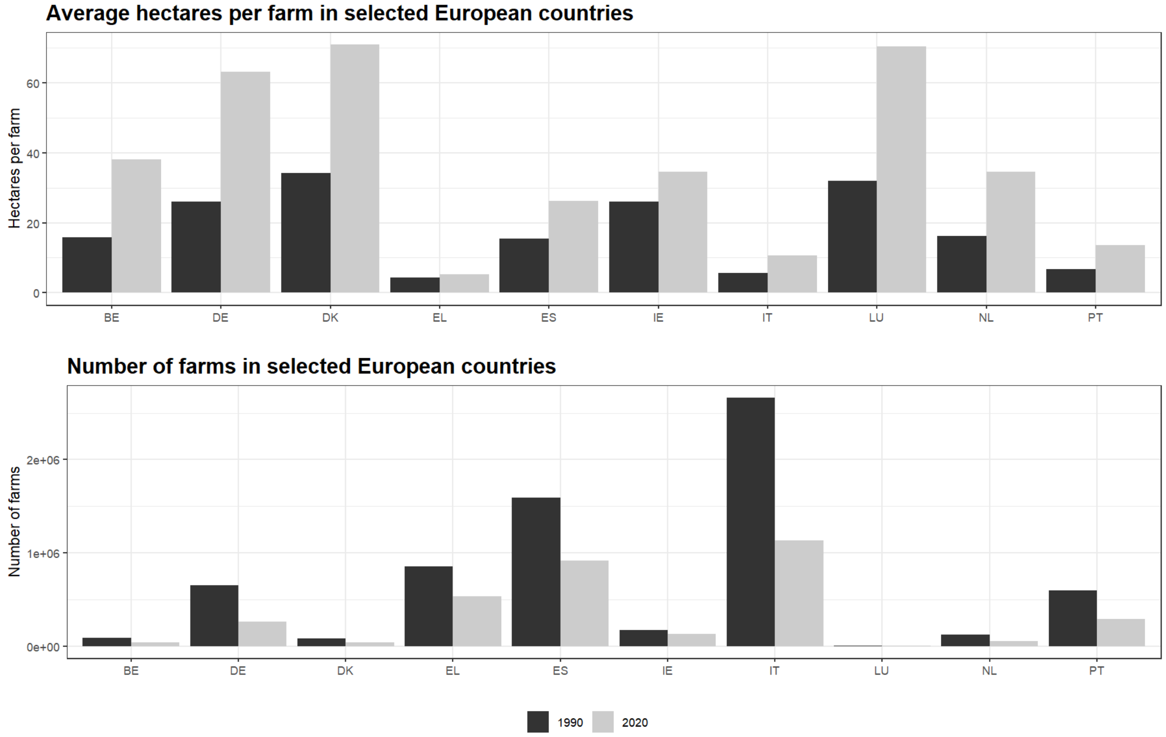
Understanding the dynamics of industry concentration in the agricultural sector is crucial for policymakers to determine where and how policies aimed at supporting small-scale farms might be most effective. As a matter of fact, the agricultural sector is a key sector that may help withstand and recover from the impact of economic downturns, especially in rural areas (e.g., see Giannakis & Bruggeman, 2018).

At worldwide level, the picture is very fragmented and, consequently, still opaque. Lowder et al. (2021) provide an overview of the number of farms by size at global scale, pointing out that small farms (less than 5 hectares) represent the vast majority of firms, but have less than 20% of the overall farmland. Giller et al. (2021) provide a similar picture, although they recognize that, since production costs and selling prices are determined by large-scale markets, the danger in the next decades is the increase in the marginalization of smallholder farmers, and additional and excessive dependence on very large farms. As of today, the picture of the market is the same as at the beginning of the millennium: the distance described in Von Braun (2005) between the “marginal” farm (small, with low level of sustainability and disconnected to science) and the “dominant” farm (large, more sustainable and users of advanced science) has not closed.

In the European agricultural sector, two large bodies of evidence have emerged. First, research has shown that farm and company structures vary considerably across and within regions and countries (Guarín et al., 2020). A comprehensive review of the scholarship reveals that numerous historical, cultural, geographical, economic, and political factors influence these disparities (Zimmermann et al., 2009). Second, the European Union’s (EU) agricultural sector has undergone a significant transformation over the last decades, marked by a steady concentration of agricultural holdings. Because larger farms have the potential to achieve economies of scale, which can reduce production costs and, thus, increase overall production, this concentration may, in theory, increase efficiency. Nonetheless, the intensive agricultural practices associated with larger farms can give rise to issues of soil degradation, water pollution, and biodiversity loss (Fassò et al., 2023). Moreover, the decline of small farms can have adverse effects on rural communities through job losses and the deterioration of social cohesion.

Between 2010 and 2020, the number of EU farms fell from 12 to 9 million, while output rose from €304 to €360 billion (Eurostat, 2024a), indicating growing concentration and structural change.

Figure 1: Land concentration of farms within the European Union



Note. Figure 1 shows values referring only to countries for which data is available for both 1990 and 2020.

Figure 1 visually represents the concentration of agricultural sectors within the EU. From 1990 to 2020, the aggregate number of farms fell substantially in most EU countries. Importantly, the average area per farm expanded significantly.

Several factors contribute to this trend. Global competition and volatile market prices push smaller farms towards consolidation or closure. Meanwhile, larger farms can often afford advanced machinery and automation, leading to increased efficiency and productivity. In parallel, younger generations are less likely to pursue careers in agriculture, leading to a decline in the available workforce for smaller farms. Lastly, EU policies, while not directly aimed at concentration, affect land distribution and might inadvertently favor larger farms or smaller ones. This raises questions about how the structure (e.g., the type of farming and average size) of farms has changed and whether this change has been uniform or heterogeneous in Europe.

In this paper, we investigate the phenomenon of market concentration in the EU agricultural and livestock farming industry between 2010 and 2020. To this end, we use regional (Nomenclature of territorial units for statistics classification [NUTS-2]) and national (NUTS-0) level data from Eurostat (Eurostat, 2024a) to examine the spatiotemporal dynamics of concentration measures for agricultural standard output (as a proxy for economic size) and farmland (as a proxy for physical size) of European farms. Our research focuses on the evolution of the Gini index (Giorgi & Gigliarano, 2017) within and between countries to assess whether the European agricultural market has seen increased concentration of power in fewer but larger farm holdings during the past decade. The overarching aim of the study can be declined into two research questions:

1) What temporal and spatial patterns characterize the levels of concentration of farmland and agricultural production? Specifically, is there a common trajectory between (i.e., at the national level) and within (i.e., at the regional level) European countries in terms of concentration measures between 2010 and 2020?
2) What empirical relationship exists between the concentration of agricultural farmland and the concentration of standard output? Specifically, are the two concentration measures positively correlated, such that an increase in the physical concentration of agricultural businesses is associated with an increase in their economic concentration, and vice versa?

To the best of our knowledge, the literature on territorial disparity in the European Agricultural sector is still developing. One early notable paper relevant to our analysis was authored by Vollrath (2007) and showed that land inequality is inversely related to productivity. In other words, a decrease in the Gini index of land distribution substantially increases land productivity. This is because farms that operate with family labor benefit from productivity advantages, and more equal land distribution equalizes the marginal product of labor across farms. In this regard, the existence of a sizeable effect of land inequality on output is a symptom of economic inefficiencies in the agricultural sector.

The present paper contributes to the literature in several important ways. First, whereas prior studies have examined land and output concentration at the national or coarse regional levels, our analysis exploits regional data for the EU27 countries over a decade (2010–2020) to offer a finer-grained and more spatially detailed picture of market concentration trends. Second, unlike most of the existing research, we examine both farmland and output (production) concentration jointly, which allows us to explore the relationship between physical and economic size concentration. Third, we incorporate exploratory spatial data analysis techniques to assess the presence of spatial dependence and clustering in concentration patterns, an approach largely overlooked in the current literature. Finally, we provide a temporal and spatial mapping of concentration trends, enabling a dynamic assessment of how concentration evolved over the post–financial crisis decade and in the context of ongoing Common Agricultural Policy (CAP) reforms.

The remainder of this paper is organized as follows. In Section 2, we briefly synthesize relevant issues raised in the agricultural economics literature and directly related to market concentration. In particular, we focus on territorial heterogeneities and the unequal distribution of production, profits, and resources among farms, as well as their economic consequences. In Section 3, we discuss the role of the Gini index in quantifying market concentration and the statistical tools we used to analyze spatial patterns of concentration. We also describe the regionalized Eurostat database on agricultural indicators we drew from to compute the Gini index for production (as a proxy for the economic size) and farmland (as a proxy for physical size) of EU farm holdings. In Section 4, we discuss the empirical findings derived from the data analysis of available data on European regions from 2010 to 2020. Concluding remarks are provided in Section 5.

2. Background on distributional issues in the European agricultural sector

Disparities in the agricultural sector, particularly in land ownership and productivity, have long been recognized as a major factor shaping economic and social outcomes in rural areas. Unequal access to productive land contributes to broader divisions in income, opportunity, and regional development (Wegerif & Guereña, 2020). In recent decades, the growing consolidation of farmland has renewed concerns about equity, efficiency, and sustainability in European agriculture (van der Ploeg et al., 2015).

The structure of agricultural holdings in the EU reflects a complex mix of historical, geographical, economic, and institutional factors. Post-war land reforms in Eastern Europe (e.g., Poland, East Germany, and Czechoslovakia) broke up large estates, while countries like Italy implemented milder redistributive measures in their southern regions (Bonanno, 1988; Mathijs, 2018; van der Ploeg et al., 2009). These legacies continue to shape farm size and ownership patterns today. In many Western European countries, family-owned farms dominate, while parts of Eastern and Southern Europe show more dualistic or fragmented structures. Natural conditions also contribute to heterogeneous land concentration. Soil quality, terrain, and climatic suitability influence not only the types of crops or livestock but also the potential for economies of scale (Lobley & Winter, 2009). Demographic pressures, such as rural depopulation and aging farmer populations, further affect the viability of smaller holdings (Eurostat, 2022).

Economic and institutional drivers also play a key role. Technological change, globalization, and EU policies, though not directly aimed at consolidation, may have disproportionately benefited larger farms. Notably, investments in capital-intensive machinery and access to financial markets tend to favor actors with greater scale and bargaining power, and policy instruments such as area-based subsidies may inadvertently accelerate concentration processes (Nolte & Ostermeier, 2017).

Several studies have linked land inequality to productivity gaps. Vollrath (2007) found that more equal land distribution tends to increase land productivity, particularly in systems that rely on family labor. In his cross-country analysis, a 0.16 reduction in the farmland Gini coefficient was associated with an 8.5% increase in productivity. This relationship reflects the inefficiency of highly unequal land distribution, which often fails to allocate resources to their most productive use.

Other research has explored spatial patterns of productivity. Ezcurra et al. (2008) documented significant spatial dependence in agricultural performance across European NUTS-2 regions, finding that neighboring regions tend to exhibit similar productivity levels. Giannakis and Bruggeman (2018) added a classification of agricultural systems (e.g., field crops, permanent crops, livestock) and revealed considerable heterogeneity within and between these systems, providing evidence that specialization and geography play intertwined roles.

Recently, Tóth (2023) insisted on the importance of territorial capital in shaping land use outcomes, while Guarín et al. (2020) proposed new typologies of small farms to better understand the diversity and challenges facing this segment of the sector. These works converge on the idea that agricultural disparity is a multi-scalar issue, visible both between countries and within regions, and requires nuanced measurement and analysis. In this context, our study adds to the literature by jointly analyzing the spatiotemporal dynamics of land and output concentration, using disaggregated NUTS-2 level data from across the EU. While much of the existing research focuses either on productivity or land-use patterns, we emphasize distributional concentration and its spatial interdependence, which have been underexplored in empirical assessments of European agriculture.

3. Exploring agricultural market concentration patterns in European regions using the Gini index and exploratory spatial data analysis

We considered regionalized data about the agricultural market in Europe provided by Eurostat (2024b) according to the 2010 NUTS. In particular, we examined the regional (NUTS-2) and national (NUTS-0) level information on EU farms contained in the "Main farm indicators by NUTS 2 regions" open database (Eurostat, 2024a). The database features indicators on the agricultural industry in Europe for 2010, 2013, 2016, and 2020.[1] Among the full set of available data, we extracted a subsample concerning the following regional quantities:

- Overall number of agricultural holdings or farms (measured as headcount)
- Utilized agricultural land (in hectares)
- Standard output of agricultural production (in euros)

Given the exploratory nature of this paper, we did not consider subclassifications of farms based on their productive specialization, such as organic producers or livestock farms. Nevertheless, subsequent research must incorporate this information to expand the findings and provide a more comprehensive characterization of the market concentration dynamics in the agricultural sector. Because our objective was to consider the largest possible spatiotemporal sample, we included European regions with complete (non-missing) information for the entire period under study. Although more recent classifications were available, we selected the NUTS 2010 nomenclature due to its comprehensive coverage of the 27 EU member states during the 2010–2020 period. The selected dataset contains comprehensive data from 236 regions.

[1] As of August 2025, the "Main farm indicators by NUTS 2 regions" open database also contains information for 2010, 2013, 2016, 2020, and 2023. For 2023, a dedicated analysis of the effects of the major geopolitical events that occurred in previous years on the European agricultural market would be required. Such events constitute insightful research opportunities that should be seized.

We computed concentration indices for both farmland (i.e., utilized agricultural area) and production (i.e., standard output of farming), considering the stratification of agricultural farms into $K = 11$ classes[2] of economic size based on increasing standard output values. Taking advantage of the number of farms and the cumulated standard output for each stratum in a region, we calculated the Gini indices for production and farmland following Cerqueti et al. (2024), which rely on the Gini index specification for grouped data described in Brown (1994). Specifically, let d be the index for production ($d = P$) and farmland ($d = L$), and let $j = 1, \dots, K$ be the index for the economic strata. We then computed the Gini index for each region $s = 1, \dots, 236$ as follows:

$$\boldsymbol{Gini_{ds}} = \frac{\boldsymbol{N_s}}{\boldsymbol{N_s - 1}}\left[\mathbf{1} - \sum_{j=1}^{K}\left[\left(\boldsymbol{Q_{dj}} + \boldsymbol{Q_{dj-1}}\right) \times \left(\boldsymbol{F_{dj}} - \boldsymbol{F_{dj-1}}\right)\right]\right]$$

where $d = \{P, L\}$ represents the production (P) or farmland (L) values, N_s is the total number of farms in region s, $Q_{dj} = \sum_{i=1}^{j} q_{di}$ is the cumulative proportion of production or farmland up to the j-th ordered class (with q_{di} being the regional share of production or farmland associated with the i-th ordered class over the total), and $F_{dj} = \sum_{i=1}^{j} f_{di}$ is the cumulative proportion of farm holding up to the j-th ordered class (with $f_{di} = \frac{N_{si}}{N_s}$ being the regional share of farms associated with the i-th ordered class over the total number of farms in the region under the constraint $\sum_{i=1}^{K} N_{si} = N_s$). In short, $Gini_{Ps}$ corresponds to the Gini index for the production (standard output) in region s, while $Gini_{Ls}$ is the Gini index for farmland in region s. Given that we utilized yearly data for 2010, 2013, 2016, and 2020, we computed a Gini index for each year and region.

[2] The Eurostat database used to build the area-level concentration measures refers to a large set of farm indicators by organic farming, utilized agricultural area, economic size (i.e., standard output), and type of agricultural holding aggregated at the regional (NUTS-2) level. Eurostat classifies farms by standard output as follows: 0 euros; over 0 euros to less than 2,000 euros; from 2,000 to 3,999 euros; from 4,000 to 7,999 euros; from 8,000 to 14,999 euros; from 15,000 to 24,999 euros; from 25,000 to 49,999 euros; from 50,000 to 99,999 euros; from 100,000 to 249,999 euros; from 250,000 to 499,999 euros; 500,000 euros or over.

From a statistical perspective, the Gini index can be interpreted as a measure of either statistical dispersion (i.e., variability) or statistical concentration (Giorgi & Gigliarano, 2017). Whereas the latter measures the agricultural market's concentration in terms of the economic capacity of farms, the latter gauges it in terms of land owned by farm holding (i.e., physical size). By definition, the Gini index is a normalized metric lying between 0 and 1, or, equivalently, between 0 and 100 if rescaled as a percentage (Giorgi & Gigliarano, 2017). A Gini index value equal to 0 is expected when all farms have the same standard output or the same hectares of land (i.e., the perfect equal distribution scenario). Conversely, a value close to 1 (or 100) represents a situation of high concentration in which almost all the land or standard output is owned by a very restricted number of farm holdings, leaving only a very small amount to the remaining companies. In the extreme case of a Gini index value of exactly 1 (or 100), the entire agricultural land (standard output) of a region would be owned (produced) by a single farm holding (i.e., the full concentration scenario).

In this paper, we describe the spatial and temporal evolution of agrobusiness concentration by comparing the two Gini indices to establish an empirical relationship between the concentration of production (as a proxy for the farms' economic size) and the concentration of farmland (as a proxy for the farms' physical size). To do so, we employed a sample covering a time frame subsequent to that of Ezcurra et al. (2008), namely, 2010 to 2020, and all regions of the EU27 countries.

We performed an exploratory analysis by studying the evolution through space and time of the linear correlation between the concentration of agricultural land and the concentration of agricultural production. We also investigated the temporal dynamics of spatial autocorrelation measures that can describe the influence of the Gini index recorded in neighboring regions on that observed in each European region to assess the presence of spatial spillovers in market concentration across regions. Although our study does not directly imply any causal relationship between physical concentration and economic concentration, the next paragraphs will thoroughly examine how these two measures may evolve simultaneously in the EU agricultural market, without assuming any causal relationships.

When examining the correlation between concentration measures, a direct and positive relationship is generally expected; however, careful consideration is still required. Clearly, if the Gini index value of farmland is equal to 1 (i.e., one firm owns all the land in a region), a production Gini index value of 1 is directly implied. On the contrary, a Gini index of farmland close to 0 does not directly imply a low Gini index value of production. Two points support this view. First, even if the land is homogeneously distributed, some of it could be "inactive," leading to an uneven distribution of standard output. Second, even if most of the land is productive, two regions with the same land Gini index value could have higher or lower levels of production concentration for different reasons: for instance, farms in one region could have higher productivity levels due to differences in land-use productivity (e.g., organic vs. non-organic production, crops vs. livestock, etc.) but also due to the cost structure and market characteristics of the farms. Finally, the link between the two levels of inequality depends primarily on the possible presence of economies of scale, scope, and capacity in the agricultural sector. Table 1 displays the conceptual framework, highlighting how different structural configurations of this sector may arise.

Table 1: Conceptual framework

	High concentration/disparity in the standard output	**Low concentration/disparity in the standard output**
High concentration/ disparity in land distribution	There is substantial variation in both farm size and standard output. Higher output levels are associated with greater production capacity. There may be economies of scale and scope, with larger farms driving total sector output.	Disparity in standard output is not driven by unequal land size. This may be due to capacity constraints unrelated to the total size of the farm, or to industry and regional specialization, or to economies of scope favoring smaller farms (while economies of scale may be neither relevant nor present).
Low concentration/ disparity in land distribution	Although the size of the land is homogeneous, productivity and standard output vary substantially. This may reflect differentiation within the sector and thus farm specialization. Although farms have the same land size, they produce and focus on different products, resulting in different standards of output. Scale and farm capacity do not drive the disparity in the standard output.	The region has farms of similar size that produce a similar standard output. This may indicate productivity homogeneity within the region.

As shown in Table 1, we anticipated that, at the NUTS-2 regional level, most regions would fall into either the north–west configuration (i.e., high disparities in both land concentration and standard output) or the south–east configuration (i.e., low disparities in both indicators). The geographical configuration we considered distinguishes between 236 regions in the EU, and each region may cover a substantial amount of land. By contrast, the north–east configuration (i.e., low disparity in standard output combined with high disparity in land concentration) and the south configuration (i.e., high disparity in standard output but low disparity in land concentration) are likely to occur in smaller regions, where specialization may play a more significant role. Therefore, we expected a positive association between the two disparity indicators given that our analysis concerns large regions (defined at the regional level). This is in line with the possible dynamics of both Gini indices. A decline in the Gini index value for farmland could mean either that some micro farms are acquiring other small plots of land and becoming larger or that a large area of land has been sold to a number of other farms. The possible change in the Gini index for standard output could be driven by potential economies of scale following this reduction in land concentration. If economies of scale are relevant, a decrease in land concentration could lead to a decrease in the heterogeneity of standard output as farms become more similar in terms of physical size.

The spatial dependence analysis revealed local patterns in the spatial distribution of the agricultural market, which result in the coexistence of sub-areas with nonhomogeneous characteristics (see, for instance, Ezcurra et al., 2008). Ezcurra et al.'s (2008) findings regarding agricultural productivity suggest at least two sub-areas: north-central Europe, oriented toward animal farming, with a relatively large share of cereal and forage crops, and southern Europe, specializing in the production of vegetables and permanent crops. This confirms the hypothesis of dualism in the European agricultural market discussed by Kearney (1991) and Gutierrez (2000), which also provide evidence of spatial dependence among regions between 1980 and 2001; that is, neighboring regions tended to register similar levels of gross value added per worker in the agricultural sector.

To make our findings comparable with the existing literature, we employed exploratory spatial data analysis techniques (Elhorst, 2010; LeSage, 2008) designed to measure the degree of spatial dependence of agricultural concentration and its temporal evolution. In particular, we estimated the dependence between regions using Moran's statistic for both global and local spatial autocorrelation (Anselin, 1995).

4. Empirical results

4.1 National and regional patterns of farmland and production concentration

We begin the empirical analysis by presenting a combination of country-level and regional-level evidence regarding the spatiotemporal dynamics of the Gini indices for production and farmland. The primary findings are outlined in Table 2, which synthesizes the evolution of the phenomenon between 2010 and 2020, emphasizing country-specific characteristics with respect to temporal and territorial (i.e., intra-country) dynamics. A close examination of the available data revealed significant variations among European countries. Specifically, farmland exhibited lower concentrations than standard output. This suggests that overall land productivity was characterized by significant heterogeneity both between and within countries.

Table 2: Summary of the main empirical results on the Gini index for farmland and production

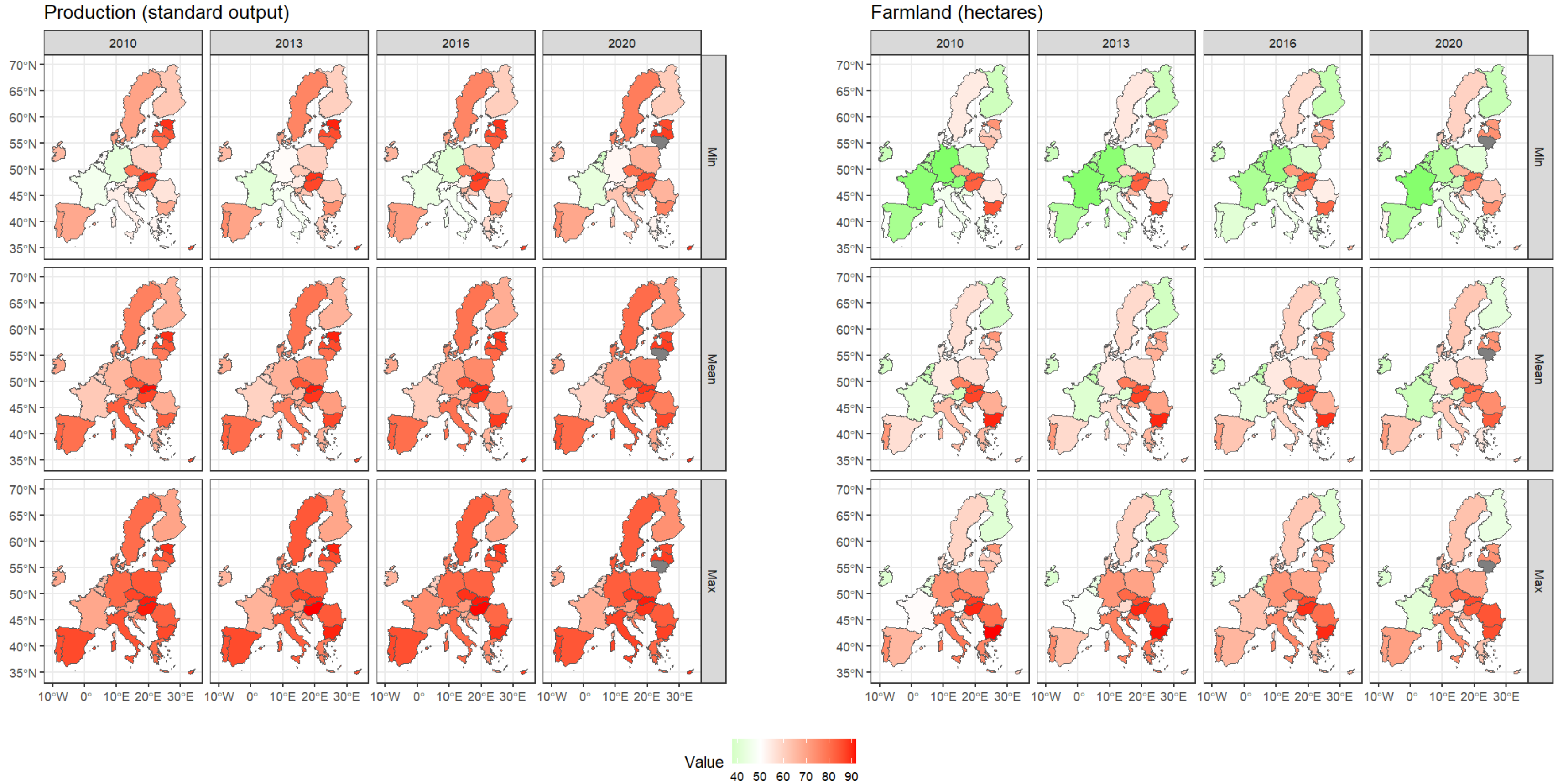
	Farmland Gini Index		Production Gini Index	
Country	**Time variation**	**Intra-country differences**	**Time variation**	**Intra-country differences**
Austria (AT)	Constant after 2013	Some differences detected, but province heterogeneity decreases over time	Constant after 2013	Minor differences detected
Belgium (BE)	Negligible	Minor differences detected	Negligible	Minor differences detected
Bulgaria (BG)	Decreasing in the time horizon considered	Minor differences detected	Increasing until 2016, then slightly decreasing between 2016 and 2020	Minor difference detected, but province heterogeneity decreases over time

Cyprus (CY)	Increasing until 2016, then slightly decreasing between 2016 and 2020	/	Slight increase over time	/
Czech Republic (CZ)	Constant over time	Minor differences detected	Slight increase over time	Minor differences detected
Germany (DE)	Slight increase over time	Some differences detected, especially between East and West Germany	Increase over time	Some differences detected, especially between East and West Germany
Denmark (DK)	Increasing over time	/	Increase over time	/
Estonia (EE)	Considerable time variations	/	Constant until 2016, then slightly decreasing	/
Greece (EL)	Considerable decrease between 2013 and 2016	Some differences detected	Small time variations detected; Jump in 2020	Minor differences detected
Spain (ES)	Slight increase until 2016	Considerable differences, especially between Northern regions and Southern regions	Constant over time	Minor/negligible differences
Finland (FI)	Increase over time (jump in 2020)	Minor/negligible differences	Slight increase over time	Minor/negligible differences
France (FR)	Slightly increasing until 2016, then sharply decreasing; large volatility	Minor differences detected, but province heterogeneity seems to decrease over time	Slightly decrease over time	Minor differences detected
Croatia (HR)	Considerable time variations	Considerable differences, but province heterogeneity seems to decrease over time	Increasing over time	Considerable differences detected
Hungary (HU)	Constant until 2016, then sharply decreasing	Minor/negligible differences	Small time variations detected, but very similar 2010 and 2020	Minor/negligible differences
Ireland (IE)	Small time variations detected	Minor/negligible differences	Small time variations detected, but very similar 2010 and 2020	Minor/negligible differences
Italy (IT)	Sharp decrease between 2010 and 2013	Regional differences detected, but not differentiated between northern and southern Italy	Time variations detected, but very similar 2010 and 2020 levels	Regional differences detected, but not differentiated between northern and southern Italy
Lithuania (LT)	Slightly increasing over time	/	Slightly increasing over time	/
Luxembourg (LU)	Constant over time	/	Slightly increasing over time	/
Latvia (LV)	Strongly increasing over time	/	Slightly increasing over time	/
Malta (MT)	Strongly decreasing over time; Large drop in 2020	/	Decreasing until 2016, then increasing	/

Netherlands (NL)	Small time variations detected; Noticeable drop between 2013 and 2016	Minor/negligible differences	Decreasing until 2016, then constant	Minor/negligible differences
Poland (PL)	Constant over time	Considerable differences detected	Slightly increasing over time	Minor differences detected
Portugal (PT)	Constant over time	Considerable differences detected	Slightly increasing over time	Minor differences detected
Romania (RO)	Large and positive time variations	Considerable differences detected	Increasing over time	Considerable differences detected
Sweden (SE)	Increasing over time	Negligible differences	Increasing over time	Negligible differences
Slovenia (SI)	Small time variations detected	Negligible differences	Constant until 2016, then slightly increasing	Negligible differences
Slovakia (SK)	Slightly decreasing over time	Negligible differences	Slightly decreasing over time	Negligible differences

Figure 2 shows the minimum, average, and maximum Gini index at the country level for both standard output (left panel) and agricultural farmland (right panel). We computed the yearly average Gini index by country according to the following two-step procedure. First, we summed the annual number of farm holdings, hectares, and standard output of all regions (NUTS-2) in a given country (NUTS-0) along the available dimensions, excluding economic size (i.e., organic farming, utilized agricultural area, and farm type of agricultural holding). Then, we calculated the national Gini index by aggregating the economic size classes as described in Section 3. The minimum and maximum values represent the lowest and highest concentration values recorded among the regions in a given country. For a more detailed view, Table A1 of the Appendix displays the numerical value of the average Gini index by country and year for both standard output and hectares, and Table A2 reports country- and year-specific intra-country variability. The latter was computed as the root mean squared error of the available regional concentration measures from the national average in Table A1, which acted as the barycenter.

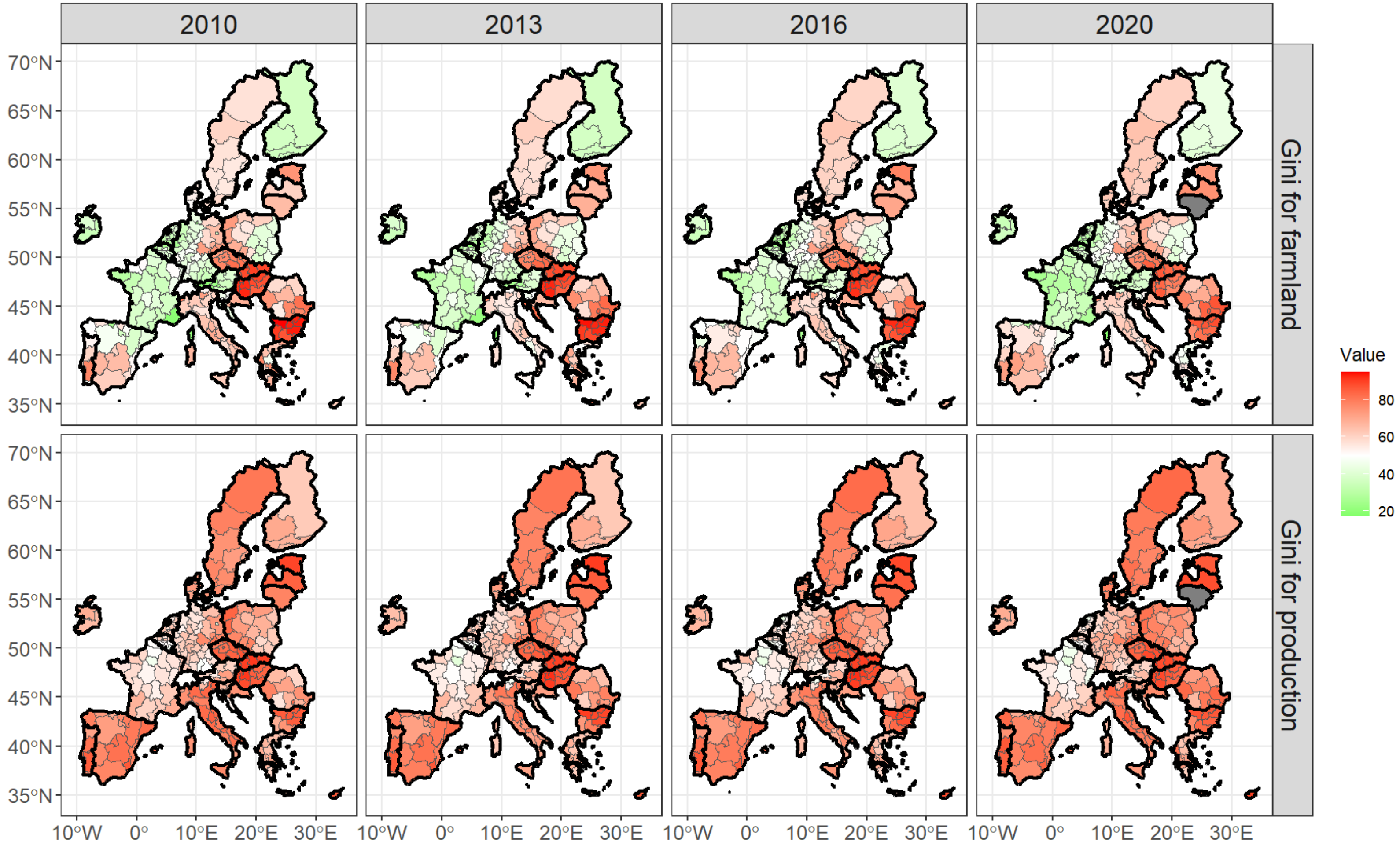
Figure 2: Maps of descriptive stats for Gini index from 2010 to 2020 in Europe



Note: Gini index is reported in a 0-100 scale. By rows are reported the minimum (Min), the average (Mean), and the maximum (Max) Gini index by country and year computed aggregating the available regional values. The yearly average Gini index by country is computed as follows. First, the annual number of farm holdings, the hectares (HA), and the standard output (SO) of all the regions (NUTS-2) belonging to a given country (NUTS-0) are summed across the available dimensions excluding the economic size (i.e., organic farming, utilized agricultural area, and farm type of agricultural holding). Then, the national Gini Index is computed by aggregating the economic size classes as described in Section 3. The minimum and maximum values represent the lowest and highest concentration values recorded among the regions belonging to a given country. Regarding Lithuania (LT), the last available information from Eurostat regards 2016. Thus, Gini index and the corresponding descriptive statistics for 2020 are not available (grey region).

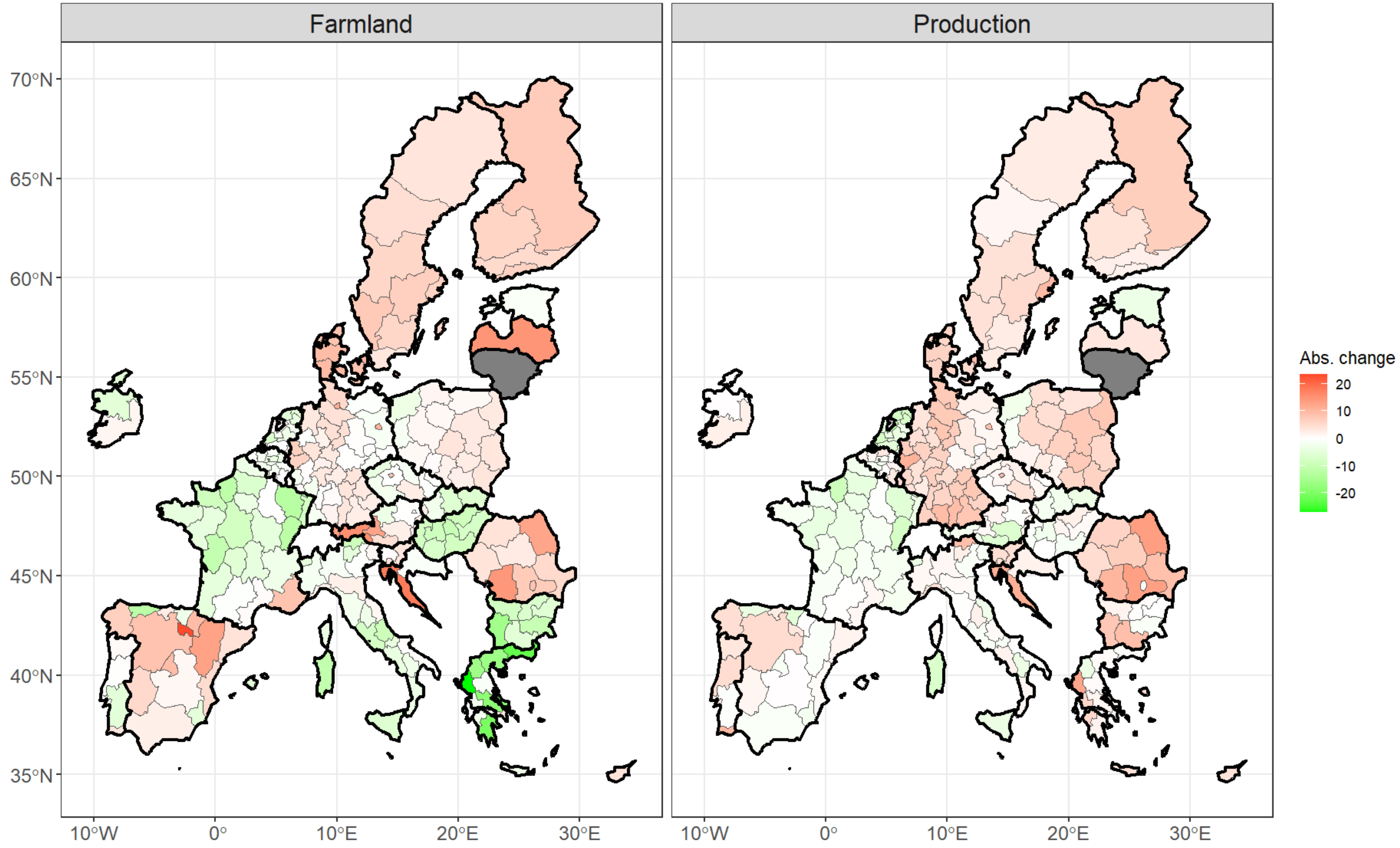
Although the average values remained broadly stable over time, some country-specific patterns emerged. The two Gini indices had similar values only for Bulgaria, Croatia, Hungary, Romania, and Slovakia. We also identified a group of countries with relatively low levels of the Gini index in Central Europe. Specifically, France, Finland, the Netherlands, Belgium, and Austria exhibited an average farmland Gini index value below 40%, with a production Gini index ranging between 50% and 65%. Germany and Slovenia displayed relatively homogeneous market concentration as well. Figure 3 shows the Gini index at the regional NUTS-2 level for both farmland size (first row) and production (second row) in the four years considered.

Figure 3: Maps of Gini index for production and farmland from 2010 to 2020 in Europe



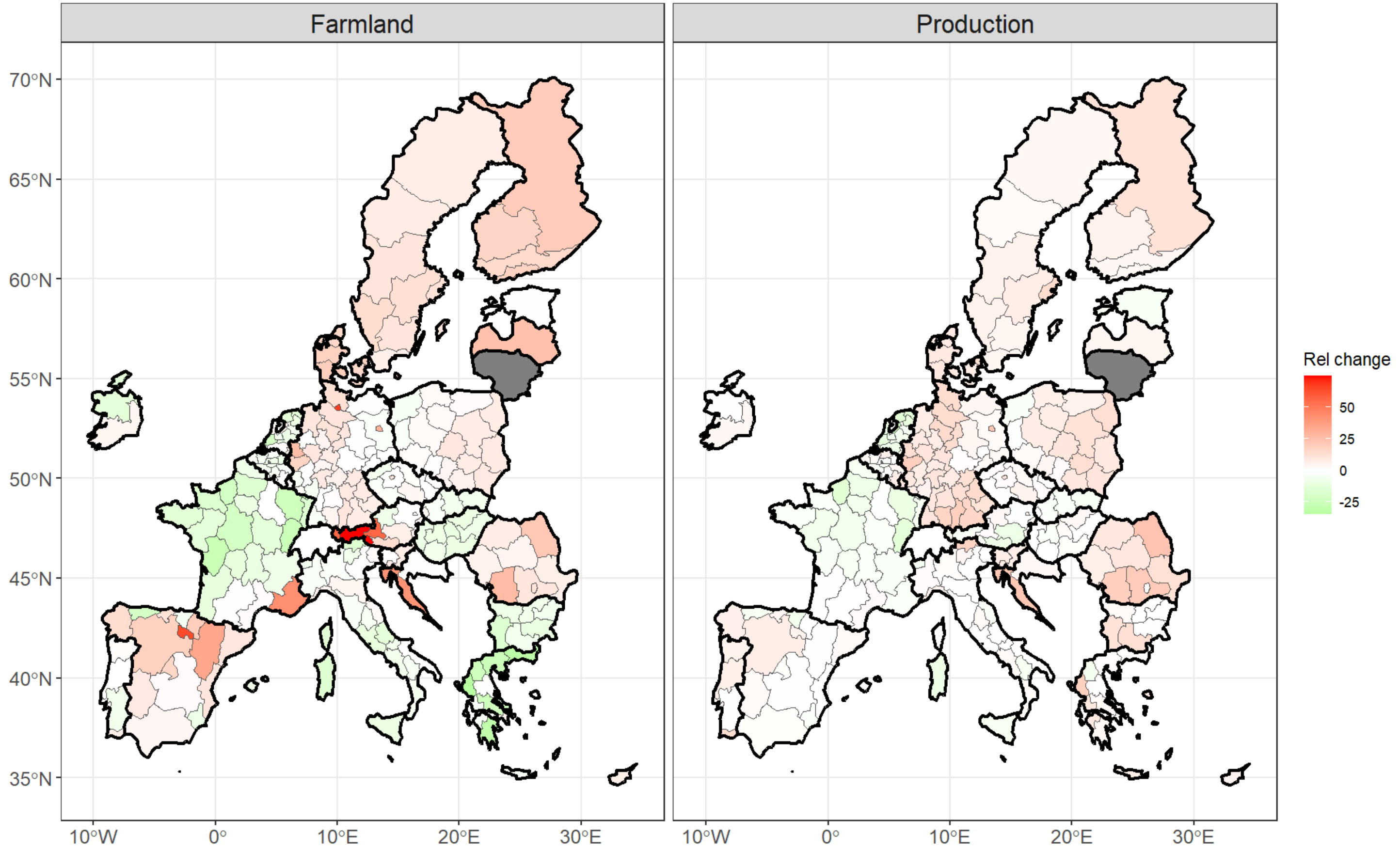
Note: Gini index is reported in a 0-100 scale. Regarding Lithuania (LT), the last available information from Eurostat regards 2016. Thus, Gini index for 2020 is not available (grey region).

Figure 4: Maps of raw change in Gini index for production and farmland from 2010 to 2020 in Europe



Note: Variations of the Gini index is computed as the difference between the regional (NUTS-2) Gini index for 2020 and the Gini index for 2010. As the Gini index are computed on a 0-100 scale, also the variations are in the same scale. Regarding Lithuania (LT), the last available information from Eurostat regards 2016. Thus, Gini index and the corresponding variation is not available (grey region).

Figure 5: Maps of relative change in Gini index for production and farmland from 2010 to 2020 in Europe



Note: Relative variations of the Gini index are computed as the ratio of the difference between the regional (NUTS-2) Gini index for 2020 and the Gini index for 2010 and the regional Gini index for 2010. Thus, it does coincide with the ratio of the raw (absolute) variation and the Gini in 2010. Relative variations are reported in a percentage scale. Regarding Lithuania (LT), the last available information from Eurostat regards 2016. Thus, Gini index and the corresponding relative variation is not available (grey region).

Figure 4 and Figure 5 show the raw change (i.e., the net difference) and the relative change in the indices between 2010 and 2020, respectively. The analysis provides a more granular and informative picture of the European agricultural sector, capturing dynamics that are lost at the aggregate level. Notably, the Gini index for standard output invariably exceeded that of farmland in all NUTS-2 regions. Despite the inherent physical limitations imposed by land size, this outcome was not entirely unexpected. A more homogeneous distribution of land does not guarantee a more homogeneous standard output (Table 1); however, a higher Gini index of standard output suggests a considerable concentration of land ownership compared to the actual distribution of land. This phenomenon may be attributed to several factors, primarily related to the efficiency of the production process. First, economies of scale can generate a higher standard output at a growing rate: even a moderate increase in the available land surface may result in a more than proportional increase in standard output due to improved land-use efficiency. Second, smaller farms may have access only to comparatively cheap machinery and equipment, which may be outdated, potentially reducing overall productivity; in contrast, larger farms may be able to use more advanced and efficient machinery to maximize the use of available land. Lastly, capital investment tends to be more efficient for larger farms.

We identified France and the Netherlands as the countries with the lowest Gini index values observed, both for standard output and farmland. Between 2010 and 2020, France experienced a visible decline in the Gini index, with the southern region constituting a notable exception as it saw either no change or a modest increase. The decline is predominantly attributable to the jump occurred between 2016 and 2020, as illustrated in Table 2. Furthermore, the Gini index appears to have decreased slightly over time, with a more pronounced decline observed in farmland concentration. However, the region of Provence-Alpes-Côte d’Azur in the south saw its hectare index value rise—an exception to the overall trend. Overall, the evidence suggests a decline in regional heterogeneity, defined by variations in land size, over time.

Germany and Spain exhibit highly distinctive patterns. We observed a discrepancy in the levels of the Gini index in German regions, with lower indices in western and southern regions than in eastern ones. This discrepancy was consistently confirmed over the period considered and reflects historical dualism in the national development process, which was only partially resolved by the reunification of the country in the 1990s. There is also some evidence—albeit modest—of this difference for standard output. Meanwhile, the situation in Spain was somewhat different. In 2010, northern regions had a lower degree of concentration than southern regions as concerns size. However, in the period under consideration, the northern regions saw a substantial increase in the hectare Gini index, indicating an increase in concentration, on average, while southern regions demonstrated negligible or minimal change. The latter pattern was not observed for standard output. In Spanish regions, the Gini index value of standard output was relatively high, with minimal variation between areas. Moreover, the pattern in the southern Spanish regions was similar to that of Portuguese regions, in terms of both hectares and standard output.

We observed relevant differences between western and eastern areas in Poland as well. The western region had larger Gini indices than eastern ones, especially areas bordering Germany and the Czech Republic. Between 2010 and 2020, this gap reduced thanks to increased concentration in eastern regions, although the average production Gini index at the country level slightly rose during this period.

The two Scandinavian countries included in the sample (Finland and Sweden) had markedly divergent Gini index values, with Finland receiving lower values than Sweden for both standard output and hectares. Furthermore, we observed an increase in the Gini index in both countries between 2010 and 2020. However, no substantial disparities emerged for either country at the NUTS-2 level.

Next, we thoroughly examined Gini index patterns for Austria and Italy. Austria had both a relatively low farmland Gini index and a low production Gini index, comparable to the averages of western Germany. Interestingly, between 2010 and 2020, the farmland Gini index increased in western Austria (i.e., Vorarlberg, Tirol, and Salzburg regions), with no relevant change in standard output concentration; instead, standard output concentration decreased in Kärnten and Steiermark, regions in which the farmland Gini index slightly increased in the same period. In Italy, the time patterns of the two Gini indices appeared to be regionally specific. We observed a substantial decline in the farmland Gini index in most regions, with notable values recorded in Sardinia, Lazio, and Abruzzo. Conversely, slight increases were evident in Emilia-Romagna and Marche. The production Gini index seemed relatively stable over time, with slight decreases in certain regions and negligible increases in others. Consequently, the size and output concentration of these two countries were still marked by significant heterogeneity and regional specificity. In contrast to the east–west dualism characteristic of Germany and Poland, Italy showed a classical but less pronounced north–south differential. In addition, the country's homogeneous values in both land and production suggested a lack of divergence in these domains.

The time patterns in Greece's Gini index values are of particular interest. In 2010, Greece's average Gini index was similar to that of Western Germany. The largest absolute decrease in our sample was observed in most Greek regions over the 10 years under study. However, during the same period, we observed different variations in the production Gini index: while land size became more homogeneous, the standard output became much more concentrated. This phenomenon was particularly salient in the Ipeiros region, where the production Gini index saw the most substantial increase, alongside a pronounced decline in the farmland Gini index.

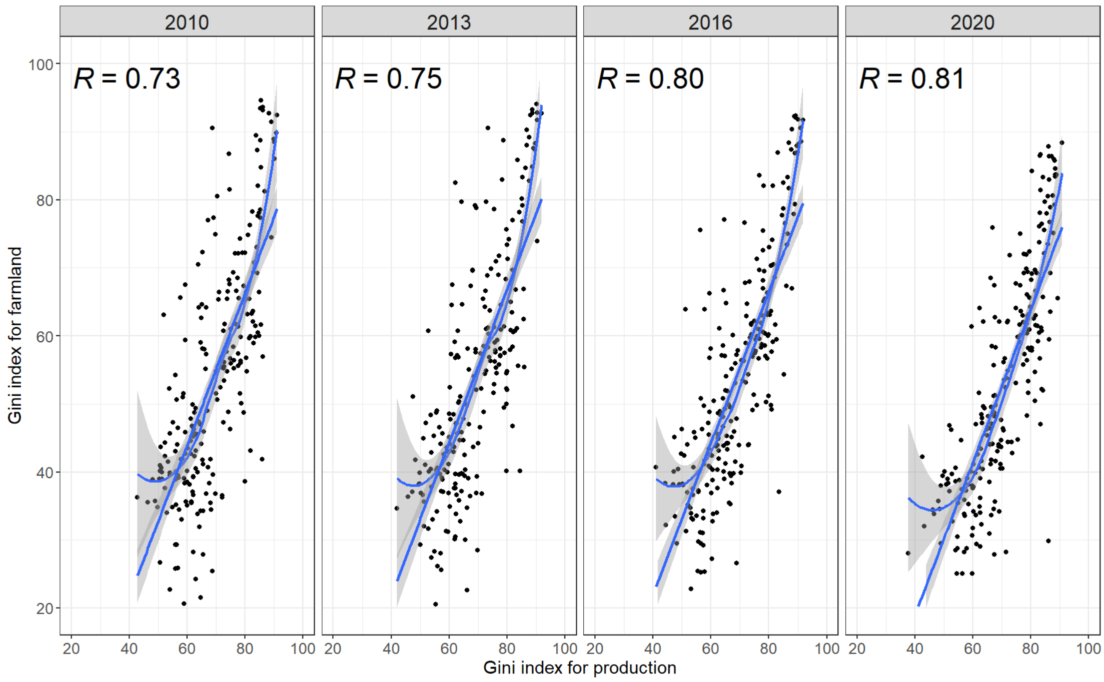
Some countries in central and eastern Europe had remarkably high Gini index values, although the patterns were heterogeneous. In 2010, Bulgaria exhibited one of the highest farmland Gini indices on record. This index declined throughout the nation's territory over the subsequent decade. Concurrently, the production Gini index rose modestly, particularly in the southwestern, south central, and northwestern regions. A similar pattern was noted in Hungary and Slovakia, which differed only in the minimal or negligible increase in standard output concentration. Meanwhile, Ireland, the Netherlands, and Belgium had similarly low Gini indices with little variation over the decade.

Eventually, some important differences in border areas should be highlighted due to their similar physical characteristics (e.g., mountainous areas between Italy and Austria and between France and Spain) and weather conditions, especially in terms of rain, wind, and solar irradiance. Accordingly, we observed similarities in agricultural land concentration in some cross-border areas: the Portugal–Spain border, a large part of central Europe comprised of France, the Netherlands, Belgium, Austria, and western Germany, a smaller part of central Europe including eastern Germany, western Poland, and the Czech Republic, and, lastly, Hungary and Slovakia. For other cross-border areas, the picture remained fragmented, and common patterns cannot be easily defined.

4.2 Common and index-specific dependence patterns in farmland and output concentration

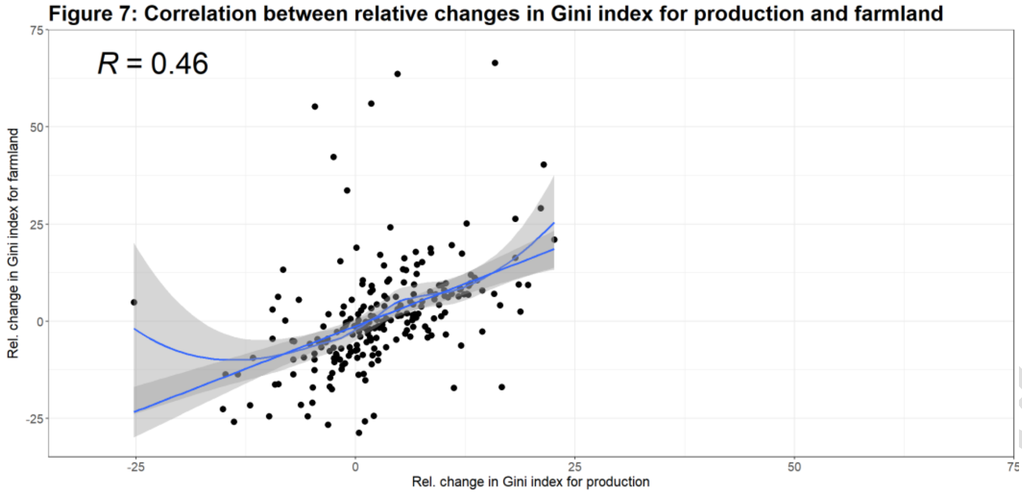
As illustrated in Figures 6 and 7, a moderately strong linear correlation (i.e., the R value indicates the Pearson's correlation coefficient) existed between the two indices at the year level, as well as between the change in the two indices between 2010 and 2020. The graphs reveal a direct and unambiguous relationship between the farmland Gini index and the production Gini index.

Figure 6: Correlation between Gini index for production and farmland



Note: the R value reported on top of each figure represents the Pearson's linear correlation coefficient.

Figure 7: Correlation between relative changes in Gini index for production and farmland

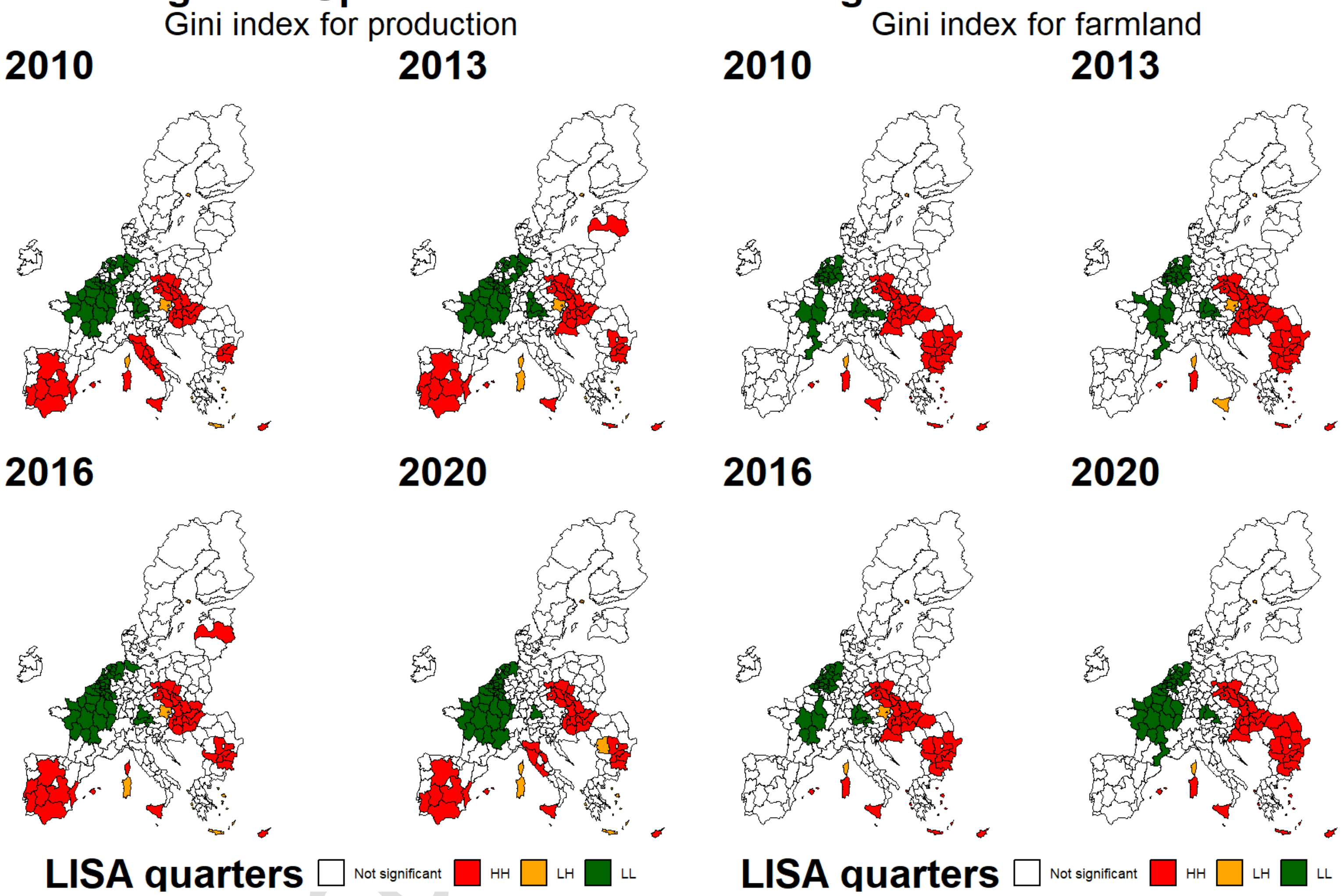


Note: the R value reported on top of the figure represents the Pearson's linear correlation coefficient.

Figure 6 indicates an increasing positive linear correlation between the concentration index for hectares and standard output during the decade. This is corroborated by the growth rates documented in Figure 7, which demonstrate a positive correlation between the increments in the Gini index for production and for farmland concentration, proving that the two concentration measures consistently varied simultaneously over time for most regions. Furthermore, Figure 6 reveals that although the range of the Gini index for standard output (horizontal axis) remained constant, the range of the farmland Gini index (vertical axis) narrowed slightly due to a decline in the maximum Gini index values and a concurrent rise in the minimum levels.

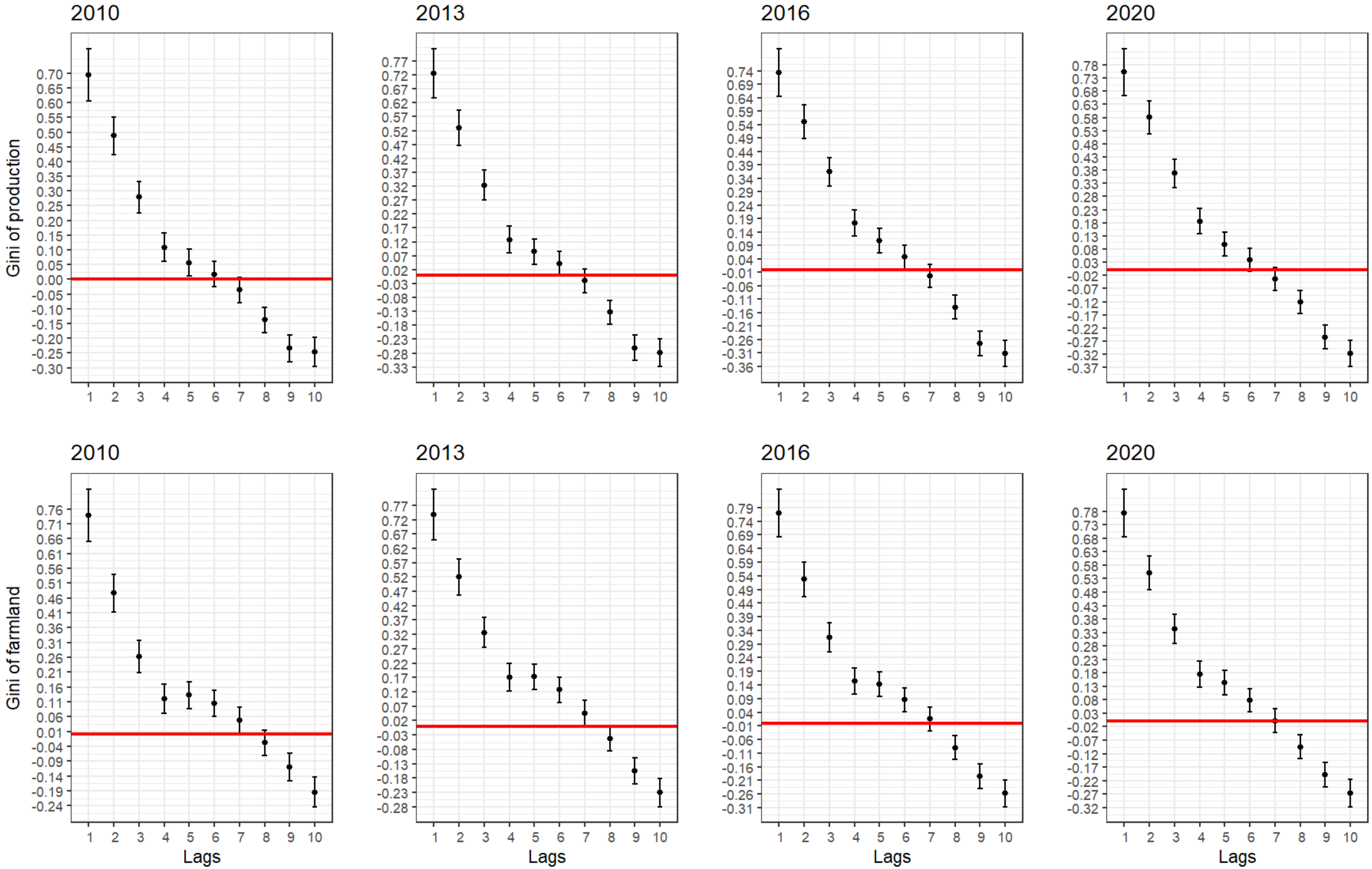
Further, the spatial dependence analysis (see Appendix, Table A3) demonstrated the presence of a strong positive autocorrelation between EU regions for both production and farmland concentration. This finding supports the hypothesis that adjacent regions tend to register similar levels of statistical concentration, generating clusters of regions with either similarly high or similarly low values. In this regard, spatial clusters transcend national borders, forming contiguous clusters of regions that can be traced back to historical-political events and processes. Once again, the evidence supports the hypothesis of a dichotomy between north-central and southeastern Europe. The results presented in Figure 8 are consistent with those of Ezcurra et al. (2008), which highlight the European dualism characterized by the presence of distinct geographical regions on the continent: regions in southern Europe, such as Spain and Italy, and eastern Europe, including Romania and Hungary, exhibit notably high production and farmland concentrations, while regions in the Netherlands, Belgium, and France have significantly lower levels. A very similar clustering structure was also confirmed by Cerqueti et al. (2024). Extending the notion of spatial autocorrelation within a cluster-based framework, the authors ascertained that European regions can be categorized into three macro-regions (e.g., Germany, Benelux, and the northeastern French regions form a homogeneous cluster) with group-specific determinants of agricultural production concentration. Figure 9 shows the robustness of these results, where spatial autocorrelation remained positive for a considerable number of spatial lags and values increased from 2010 to 2020

Figure 8: Spatial autocorrelation using local Moran's index



Note: LISA stands for Local Indicator of Spatial Autocorrelation (Anselin, 1995). Regions are grouped into five non-overlapping clusters or quarters, that is, high-high (HH) group (i.e., regions with high concentrations are surrounded by highly-concentrated neighbors); low-low (LL) group (i.e., regions with low concentrations are surrounded by lowly-concentrated neighbors); high-low (HL) group (i.e., regions with high concentrations are surrounded by lowly-concentrated neighbors); low-high (LH) group (i.e., regions with low concentrations are surrounded by highly-concentrated neighbors); non-significant area in which local autocorrelation index is not statistically significant.

Figure 9: Global Moran's spatial autocorrelogram



4.3 Discussion and further considerations

The present study offers novel evidence of the fragmentation of the European agricultural sector, a phenomenon characterized by remarkable heterogeneity as concerns both farmland and production concentration. Spatial heterogeneities are evident within and between countries, with noticeable clusters of neighboring highly concentrated regions contrasting with clusters of adjacent regions with significantly lower concentrations. Such clusters transcend national boundaries and often correspond to areas with known common historical and political processes (e.g., former Soviet bloc countries). We identified various time patterns that, however, vary significantly on both a national and an intra-national scale. Furthermore, we employed spatial autocorrelation analysis to identify cross-country areas exhibiting analogous patterns of land and output concentration.

The cross-country analysis revealed that, at the aggregate level, a more equal distribution (or less unequal) distribution of land and standard output was found in the area delimited to the west by Austria and western Germany, to the east by France, to the north by the Netherlands, and to the south by southern France and Austria. In contrast, Central (from eastern Germany) and Eastern Europe seemed to have a more unequal distribution in both indicators, especially the Czech Republic, Hungary, Romania, Bulgaria, and Slovakia. At the end of the 20th century, Central and Eastern European countries underwent significant changes in their agricultural sector, in particular in their approach to land distribution and migration from rural areas. Specifically, as van Vliet et al. (2015) argue, land use was strongly impacted by the shift to post-socialism, given that under socialism, most land was collectivized following "optimization" schemes run at the central level. The de-collectivization of lands and the return to private holdings, therefore, had significant effects on land usage and the migration from very poor rural areas. This could explain why these countries are now characterized by a highly unequal distribution of land, as large firms may have accrued monopolistic power and also acquired many small firms. Levers et al. (2018) showed that between 1990 and 2006, low-intensity and de-intensifying land systems dominated in Europe's east, in stark contrast to the dynamics in western Europe. Additionally, some countries in Southern Europe (namely, Spain, Italy, Portugal, and Croatia) seemed to have, on aggregate, a similar level of disparity, slightly higher than France and western Germany or the Benelux countries. Mediterranean European areas have different characteristics in terms of soil, degradation related to climate change, and other factors such as farmland abandonment (a common issue in Europe) compared to central Europe (e.g., see García-Ruiz & Lana-Renault, 2011; Malek et al., 2018).

Our analysis revealed interesting results within countries, often connected to the European historical paths. A key finding is represented by the marked differences in the national orientation toward land management. For instance, the difference between western and eastern Germany is connected to the country's historical dualism. In Spain, we found clear differences in terms of hectares disparity between northern and southern regions. This may result from differences in the climate, geography, and soil quality, which have consequences for the type of farming and the need for smaller or bigger firms, in some cases. Further, land abandonment has differed between the rural areas of regions like the Pyrenees and those of other regions (García-Ruiz, 2010). In contrast to these results, we did not find evidence of a clear difference in land distribution between northern and southern Italy (for a specific insight on Italy we refer the reader to Corti et al., 2013, which present an overview of the soil management practices through the time and in the different Italian physiographic districts, analysing their effects on soil conservation and fertility).

The development of rural areas remains one of the primary challenges of the EU's CAP strategy (Viaggi, 2008; Viegas, 2021). The capacity of the member states and the EU to facilitate the revitalization of rural areas and, thereby, counteract the ongoing process of desertification, enables enhanced social and territorial cohesion while also serving as a response to the substantial climate-related challenges confronting the region. Implementing the agroforestry mosaic, as one of the main eco-schemes[3] provided for in current CAP regulations, requires understanding the advantages of

[3] Eco-schemes provide support to farmers who implement agricultural practices beneficial to the environment and climate. These measures reward and incentivize farmers for acting towards more sustainable farm and land management with the objective of preserving public goods.

ensuring the viability of a scale of production that has been relegated to secondary importance for decades. Small and medium-sized farms recognize the productive potential of vast abandoned areas, which can be allocated to forestry and plant or animal production, feeding short marketing circuits, boosting local economies, and helping prevent the fires that have devastated much of Europe's forests in recent years.

5. Concluding remarks

The academic agenda on regional disparities among European farms is still evolving. The literature so far has largely focused on the influence of spatial disparity on productivity levels across regions. In contrast, the present analysis contributes to the scientific debate by providing a clear map of the statistical concentration of agricultural land size and production at the regional level for the EU27 countries. Furthermore, we presented novel evidence concerning the temporal evolution of the agricultural sector's concentration during the 2010–2020 decade.

This work calls for follow-up research. First, although the present analysis does not explicitly consider farm typologies, the evolution of the distribution of agricultural systems likely plays a role in shaping land and output concentration. According to Eurostat typology data, the past decade has seen notable shifts across EU regions, including the decline of small-scale grazing livestock holdings in Southern and Eastern Europe and the consolidation of field crop and granivore systems in more capital-intensive areas. These alterations may offer a partial explanation for the higher concentration in production we observed, particularly in regions where high-productivity systems (e.g., granivores, horticulture) have expanded. Concurrently, land concentration may have increased in regions where permanent crop systems, which are frequently associated with substantial estates, have gained ground. These structural shifts appear to align with broader CAP dynamics favoring scale and capital investment, and they may reinforce spatial inequality between farming systems. Therefore, a more detailed disaggregation contrasting organic and non-organic producers, as well as crops and livestock farmers, could enrich the literature on the drivers of concentration. It would also help determine whether the substantial heterogeneity in output can be attributed to these specific agricultural enterprises.

Furthermore, policy changes have contributed to the evolution of land and output concentration over the past decade. In particular, the reforms of the CAP (including the decoupling of direct payments, the introduction of greening measures, and the promotion of competitiveness and modernization) may have disproportionately benefited larger and more capitalized farms. These farms frequently possess a strategic advantage in meeting subsidy requirements and absorbing compliance costs, which may indirectly accelerate consolidation trends. Although the present analysis does not formally isolate the effects of policy, these institutional dynamics can reasonably be expected to interact with market forces in shaping structural inequality. Accordingly, future research could further explore the causal impact of specific CAP instruments on concentration patterns at the regional level.

Lastly, given the growing importance of sustainable agronomic practices, researchers should examine whether changes in regional farmland and output concentrations are associated with changes in pollution levels. This could assist policymakers in assessing whether a more equitable land distribution could contribute to a concrete reduction in the environmental impact of the agricultural industry and support climate-change mitigation policies.

Declarations

- Funding: Part of the authors were funded by the University of Milano-Bicocca (Italy) through the project "SCARFACE - Sequestering CARbon through Forests, AgriCulture, and land usE" (2024-ATEQC-0048).
- Data availability and codes: Data used in the paper are public (source Eurostat). Since we use only public data, no Special Permission is need to use copyrighted material from other sources (including the Internet). All results presented in this paper can be reproduced using the R software. The codes were developed entirely by the authors. Fore reproducibility purposes, all the scripts

and the data are made public through the following GitHub folder https://github.com/PaoloMaranzano/SB_PM_MV_AgroMarketConc.git

References

Anselin, L. (1995). Local Indicators of Spatial Association—LISA. *Geographical Analysis*, *27*(2), 93-115. https://doi.org/https://doi.org/10.1111/j.1538-4632.1995.tb00338.x

Bonanno, A. (1988). Theories of the State: The Case of Land Reform in Italy, 1944–1961. *The Sociological Quarterly*, *29*(1), 131-147. https://doi.org/10.1111/j.1533-8525.1988.tb01247.x

Brown, M. C. (1994). Using gini-style indices to evaluate the spatial patterns of health practitioners: Theoretical considerations and an application based on Alberta data. *Social Science & Medicine*, *38*(9), 1243-1256. https://doi.org/https://doi.org/10.1016/0277-9536(94)90189-9

Cerqueti, R., Maranzano, P., & Mattera, R. (2024). Spatially-clustered spatial autoregressive models with application to agricultural market concentration in Europe. *arXiv preprint: 2407.15874*. https://doi.org/https://doi.org/10.48550/arXiv.2407.15874

Corti, G., Cocco, S., Brecciaroli, G., Agnelli, A., & Seddaiu, G. (2013). Italian Soil Management from Antiquity to Nowadays. In E. A. C. Costantini & C. Dazzi (Eds.), *The Soils of Italy* (pp. 247-293). Springer Netherlands. https://doi.org/10.1007/978-94-007-5642-7_9

Elhorst, J. P. (2010). Applied Spatial Econometrics: Raising the Bar. *Spatial Economic Analysis*, *5*(1), 9-28. https://doi.org/10.1080/17421770903541772

Eurostat. (2022). Farms and farmland in the European Union—Statistics. In (pp. 1-9): Eurostat Luxembourg.

Eurostat. (2024a). *Main farm indicators by organic farming, utilised agricultural area, economic size, farm type of agricultural holding and NUTS 2*. https://doi.org/https://doi.org/10.2908/EF_M_ORG

Eurostat. (2024b). *NUTS - Nomenclature of territorial units for statistics*. Retrieved December 17th, 2024 from https://ec.europa.eu/eurostat/web/nuts

Ezcurra, R., Iraizoz, B., Pascual, P., & Rapún, M. (2008). Spatial disparities in the European agriculture: a regional analysis. *Applied Economics*, *40*(13), 1669-1684. https://doi.org/10.1080/00036840600905175

Fassò, A., Rodeschini, J., Moro, A. F., Shaboviq, Q., Maranzano, P., Cameletti, M., Finazzi, F., Golini, N., Ignaccolo, R., & Otto, P. (2023). Agrimonia: a dataset on livestock, meteorology and air quality in the Lombardy region, Italy. *Scientific Data*, *10*(1), 143. https://doi.org/10.1038/s41597-023-02034-0

García-Ruiz, J. M. (2010). The effects of land uses on soil erosion in Spain: A review. *CATENA*, *81*(1), 1-11. https://doi.org/https://doi.org/10.1016/j.catena.2010.01.001

García-Ruiz, J. M., & Lana-Renault, N. (2011). Hydrological and erosive consequences of farmland abandonment in Europe, with special reference to the Mediterranean region – A review. *Agriculture, Ecosystems & Environment*, *140*(3), 317-338. https://doi.org/https://doi.org/10.1016/j.agee.2011.01.003

Giannakis, E., & Bruggeman, A. (2018). Exploring the labour productivity of agricultural systems across European regions: A multilevel approach. *Land Use Policy*, *77*, 94-106. https://doi.org/https://doi.org/10.1016/j.landusepol.2018.05.037

Giller, K. E., Delaune, T., Silva, J. V., Descheemaeker, K., van de Ven, G., Schut, A. G. T., van Wijk, M., Hammond, J., Hochman, Z., Taulya, G., Chikowo, R., Narayanan, S., Kishore, A., Bresciani, F., Teixeira, H. M., Andersson, J. A., & van Ittersum, M. K. (2021). The future of farming: Who will produce our food? *Food Security*, *13*(5), 1073-1099. https://doi.org/10.1007/s12571-021-01184-6

Giorgi, G. M., & Gigliarano, C. (2017). THE GINI CONCENTRATION INDEX: A REVIEW OF THE INFERENCE LITERATURE. *Journal of Economic Surveys*, *31*(4), 1130-1148. https://doi.org/https://doi.org/10.1111/joes.12185

Guarín, A., Rivera, M., Pinto-Correia, T., Guiomar, N., Šūmane, S., & Moreno-Pérez, O. M. (2020). A new typology of small farms in Europe. *Global Food Security*, *26*, 100389. https://doi.org/https://doi.org/10.1016/j.gfs.2020.100389

Gutierrez, L. (2000). Convergence in US and EU agriculture. *European Review of Agricultural Economics*, *27*(2), 187-206. https://doi.org/10.1093/erae/27.2.187

Kearney, B. (1991). Rural society-disparities in incomes and alternative policies.

LeSage, J. P. (2008). An introduction to spatial econometrics. *Revue d'économie industrielle*(123), 19-44.

Levers, C., Müller, D., Erb, K., Haberl, H., Jepsen, M. R., Metzger, M. J., Meyfroidt, P., Plieninger, T., Plutzar, C., Stürck, J., Verburg, P. H., Verkerk, P. J., & Kuemmerle, T. (2018). Archetypical patterns and trajectories of land systems in Europe. *Regional Environmental Change*, *18*(3), 715-732. https://doi.org/10.1007/s10113-015-0907-x

Lobley, M., & Winter, M. (2009). *What is land for?: the food, fuel and climate change debate*. Earthscan.

Lowder, S. K., Sánchez, M. V., & Bertini, R. (2021). Which farms feed the world and has farmland become more concentrated? *World development*, *142*, 105455. https://doi.org/https://doi.org/10.1016/j.worlddev.2021.105455

Malek, Ž., Verburg, P. H., R Geijzendorffer, I., Bondeau, A., & Cramer, W. (2018). Global change effects on land management in the Mediterranean region. *Global Environmental Change*, *50*, 238-254. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2018.04.007

Mathijs, E. (2018). An historical overview of Central and Eastern European land reform. In *Political economy of Agrarian reform in Central and Eastern Europe* (pp. 33-53). Routledge.

Nolte, K., & Ostermeier, M. (2017). Labour Market Effects of Large-Scale Agricultural Investment: Conceptual Considerations and Estimated Employment Effects. *World development*, *98*, 430-446. https://doi.org/https://doi.org/10.1016/j.worlddev.2017.05.012

Tóth, B. I. (2023). Territorial capital in the European Union: measuring the territorial endowments of the EU-28 NUTS 2 regions over the 2010s. *Regional Statistics*, *13*(01), 3-35.

van der Ploeg, J. D., Franco, J. C., & Borras Jr, S. M. (2015). Land concentration and land grabbing in Europe: a preliminary analysis. *Canadian Journal of Development Studies / Revue canadienne d'études du développement*, *36*(2), 147-162. https://doi.org/10.1080/02255189.2015.1027673

van der Ploeg, J. D., Laurent, C., Blondeau, F., & Bonnafous, P. (2009). Farm diversity, classification schemes and multifunctionality. *Journal of Environmental Management*, *90*, S124-S131. https://doi.org/https://doi.org/10.1016/j.jenvman.2008.11.022

van Vliet, J., de Groot, H. L. F., Rietveld, P., & Verburg, P. H. (2015). Manifestations and underlying drivers of agricultural land use change in Europe. *Landscape and Urban Planning*, *133*, 24-36. https://doi.org/https://doi.org/10.1016/j.landurbplan.2014.09.001

Viaggi, D. (2008). Assessing the multiple Impacts of the Common Agricultural Policies (CAP) on Rural Economies (CAP-IRE).

Viegas, M. (2021). *A Política Agrícola Comum pós-2020: os desafios para Portugal*. Vida Economica Editorial.

Vollrath, D. (2007). Land Distribution and International Agricultural Productivity. *American Journal of Agricultural Economics*, *89*(1), 202-216. https://doi.org/https://doi.org/10.1111/j.1467-8276.2007.00973.x

Von Braun, J. (2005). Agricultural economics and distributional effects. *Agricultural Economics*, *32*(s1), 1-20. https://doi.org/https://doi.org/10.1111/j.0169-5150.2004.00011.x

Wegerif, M. C. A., & Guereña, A. (2020). Land Inequality Trends and Drivers. *Land*, *9*(4), 101. https://www.mdpi.com/2073-445X/9/4/101

Zimmermann, A., Heckelei, T., & Domínguez, I. P. (2009). Modelling farm structural change for integrated ex-ante assessment: review of methods and determinants. *Environmental Science & Policy*, *12*(5), 601-618. https://doi.org/https://doi.org/10.1016/j.envsci.2009.01.014