Spanish Journal of Agricultural Research
17 (1), e0102, 16 pages (2019)
eISSN: 2171-9292
https://doi.org/10.5424/sjar/2019171-13481
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, O.A, M.P. (INIA)

RESEARCH ARTICLE

OPEN ACCESS

A new classification of European Union regions: A decision support tool for policymakers

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Abstract

The classification of agricultural and territorial systems is essential to improve the comparability of regions for the development programmers of the Common Agricultural Policy (CAP), to give new tools of intervention to policymakers and to increase farmers' knowledge. Analysis of the principal characteristics of these systems is essential during a time in which the new CAP is being designed for the period 2021-2027. The research is focused on the analysis of the agricultural features of 228 regional areas (NUTS 2) of the 28 European Union (EU) countries. It considers two specific sets of environmental and socio-economic indicators provided by the Farm Accountancy Data Network (FADN). The main factors that differentiate agricultural systems in EU regions from one another were identified with the application of principal component analysis, while the classification of the same regions in homogeneous groups was carried out through hierarchical cluster analysis. The results clearly show that some groups of "homogeneous" EU regions such as *the Natura 2000 area* and *the family-run agricultural system*, which have weaker agricultural structures than the average of the 228 EU regions considered in this study, have a greater need for the restructuring of their agricultural systems than others (*e.g.*, *the professional agricultural system* and *the food industry system*). The results confirm that policy design should not consider EU agriculture as a whole, but should take into account the environmental and structural specificities of agricultural holdings, as well as the different training levels of farm managers.

Additional keywords: agricultural systems; common agricultural policy; Farm Accountancy Data Network; hierarchical cluster analysis; indicators; principal component analysis.

Abbreviations used: AWU (Annual Work Unit); CAP (Common Agricultural Policy); CV (Coefficient of Variation); E (Environmental); EC (European Commission); EU (European Union); FADN (Farm Accountancy Data Network); HA (Hectare); HCA (Hierarchical Cluster Analysis); NMCs (New Member Countries); NUTS (Nomenclature of Territorial Units for Statistics); PCA (Principal Component Analysis); SEC (Socio Economic); SS (Sum of Squares); UAA (Utilized Agricultural Area); UK (United Kingdom).

Authors' contributions: This manuscript has one author who conceived and designed the study, performed the data search, analyzed the data and wrote the manuscript.

Citation: : Fanelli, R. M. (2019). A new classification of European Union regions: A decision support tool for policymakers. Spanish Journal of Agricultural Research, Volume 17, Issue 1, e0102. https://doi.org/10.5424/sjar/2019171-13481

Received: 19 May 2018. **Accepted:** 08 Feb 2019.

Funding: The author received no specific funding for this work.

Competing interests: The author has declared that no competing interests exist.

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Introduction

There are big differences between and within individual regions of European Union (EU) which are driven by economic, social, structural and environmental factors. These diversities, which became even greater with the arrival of the New Member Countries (NMCs) from central and eastern Europe, have over time led to different levels of agricultural system development (EC, 2013; Ciutacu *et al.*, 2015). Agricultural systems have been put under pressure to change as a result of a range of globally and locally driven variables (Van Ittersum *et al.*, 2008). Since 1990, the implementation of the Common Agricultural Policy (CAP) has led to the creation of new structures reflecting the changing socio-economic, environmental and political circumstances affecting EU agriculture, and to changes in the agricultural, food and forestry sectors as well as in rural areas. The general objectives of the CAP are broken down into specific objectives, some of which are common to both Pillars I (direct payments and market measures) and II (rural development), whereas others are linked either to Pillar I or to Pillar II specifically. In Pillar I, direct payments are subordinated to respect for cross-compliance concerning environmental requirements and standards of good agricultural and

environmental practice. In Pillar II, rural development policy has emphasized the preservation of the rural environment and land management. The reform of the CAP for 2014-2020 aims to promote the following: greater competitiveness; efficient use of public goods; food security; preservation of the environment and specific action against climate change; respect for social and territorial equilibriums; and more inclusive rural development. In order to develop competitive EU agriculture, there is a need for structural change. The key factors that can help farm businesses respond to this need are: investing in physical infrastructure that can enhance productivity and human capital; improving the skills and knowledge of employees and managers; stimulating innovation and the use of technology; and favouring genuine competition to stimulate enterprise. These elements request behavioural changes that can be stimulated through the use of public policy. Many elements of the CAP reform proposals are driven by these factors (Swinnen, 2009; D'Oultremont, 2011).

Essentially, the CAP reform for the period 2014-2020 aims to make the EU agricultural sector more dynamic, competitive and effective in pursuing the objectives of the European Commission (EC) Report "*The CAP towards 2020: meeting the food, natural resources and territorial challenges of the future*" (EC, 2010). In relation to direct payments, the EC underlines the importance of redistribution, redesign, and better targeting of support, based on objective and equitable criteria, which must be easily understood by the taxpayer. A more equitable distribution of funds should be organized in an economically and politically feasible way with a transition period to avoid major disruption (Nazzaro & Marotta, 2016). The multilevel governance processes of integrated local development – with the active involvement of local stakeholders to mobilize material and immaterial resources as part of a wider sharing of participatory development projects (Peterson, 2013) – are at the center of Community-led local development for 2014-2020. They also serve as a model for collective and integrated action for programmed intervention on a territorial basis (EC, 2014). Important steps made by the EC were the introduction in 2003 of new policies for the development of agricultural systems and a subsequent impact assessment (EC, 2005). In order for these policies to be effective and to improve integrated assessment, it was very important for the EC to have more clear definitions of the peculiarities which determine the differences between regional areas of Nomenclature of Territorial Units for Statistics 2 (NUTS 2) of all EU countries (Parson, 1995; Harris, 2002). As a result of this, several scholars have researched different aspects of agricultural development (Morse *et al.*, 2001; Rigby *et al.*, 2001; Huylenbroeck & Durand, 2003; Scott & Storper, 2003; Potter, 2004; Qiu *et al.*, 2007; Cairol *et al.*, 2008; Janssen *et al.*, 2009; Bednarikova, 2015). Others have argued that the specific traits of each region can help focus political instruments and support analysis of the impact of agricultural policies (Hay, 2002; Rossing *et al.*, 2007; Verburg *et al.*, 2010; D'Amico *et al.*, 2013).

The existence of regional disparities in economic structures and performance poses relevant questions not only for researchers, but also for policymakers. In the relative literature, there are many studies on territorial agricultural systems based on the multivariate method. These studies – which aim to synthesize relevant data, highlight change or define the status of a certain aspect – include different indicators at the national, regional, and local level (Dent *et al.*, 1995; Gallopin, 1997; Molden *et al.*, 1998; Deller *et al.*, 2001; Fjellstad, 2001; Manly, 2004; Metzger *et al.*, 2005; Tabachnick & Fidell, 2005; Fanelli, 2006, 2007, 2018a; Andersen *et al.*, 2007; Madu, 2007; Pierangeli *et al.*, 2008; Hazeu *et al.*, 2009; Rodríguez-Moreno & Llera-Cid, 2011; D'Amico *et al.*, 2013; Cannata *et al.*, 2014; Hossain *et al.*, 2015; Moral *et al.*, 2016; Fanelli & Di Nocera, 2018). In line with these approaches, the identification of a new and different classification of EU agricultural systems is the main objective of this study, which focuses on the analysis of agricultural features in 228 NUTS 2 regional EU areas.

Material and methods

Data from farm accountancy data network

The first step of this study was to generate an environmental and socio-economic data set for EU regions. The data were extrapolated from the FADN. This database was established in 1965 as an information tool for collecting accountancy data from agricultural holdings in the European Economic Community (EEC, 1979). It was primarily set up to support the creation and assessment of the CAP. The system serves as a unique instrument for evaluating the assets of agricultural holdings, providing information about the economic conditions on European farms. The FADN is the only harmonized and standardized source of data obtained from a sample of individual farms across all member states. Given the common methodology, the network provides comparable data at the European level. Derived from national surveys, the FADN is the only source of microeconomic data available. The survey does not cover all the agricultural holdings in the EU. It only considers those that due to their size, can be considered commercial. Moreover, the FADN

is an important informative source for understanding the impact of the measures taken under the CAP on different types of agricultural holding (Hill & Bradley, 2016). Finally, FADN data can provide information about farmers which is necessary for making business decisions, and should in turn encourage successful businesses and contribute to the achievement of profit goals.

A total of 55 pieces of information were considered from 228 of the 281 EU regions (all data for 53 regions were not available) and were assembled in two sets of indicators: environmental (E1-E11) and socio-economic (SEC1-SEC44). On the one hand, the environmental information was made up of the following indicators: land cover, Utilized Agricultural Area (UAA) and forest area under the Natura 2000 programme. On the other hand, the following factors made up the socio-economic and structural information: employment by economic activity (agriculture, food industry and tourism); number of agricultural holdings; number of holdings with livestock; physical, economic and labour force size of the holdings; agricultural area; area under organic farming; irrigated land; livestock units; farm labour force; and the age structure and agricultural training of farm managers. The data refer to the most recent year available on the FADN database (EC, 2016), and are expressed, for each indicator considered, as a percentage of the total of 50 indicators. For the remaining five indicators – the total area of the holdings, the total number of hectares (HA) of the UAA utilized for farming, the total area of the UAA, the total number of people that make up the farm labour force and the total number of farm managers on the holdings (Table 1) – the data are expressed as absolute values.

The descriptive statistics and the multivariate analysis

The large dimension of the data matrix (228*55), - where the EU regions number 228 and the indicators 55 (reported in Table 1) - would make any spatial statistical analysis very complex. As a result, a specific univariate and multivariate analysis technique was adopted in order to simplify the structure of the data, with the aim of highlighting and identifying a smaller group of real or latent factors (Johnston, 1979; Moller, 1995). The identification and characterization of the homogeneous agricultural systems in the EU was carried out using descriptive statistics, namely PCA and HCA. Initially, the indicator values for each raster cell were normalized to a standard normal distribution. Following this, PCA and HCA were conducted using the PC STATA vers. 12.32 software. Descriptive statistics, mean, minimum, maximum, SD and the CV, were used to form a preliminary characterization of the EU regions in order to identify the homogeneity/heterogeneity of their agricultural systems. PCA is used to reduce the dimensionality of a data set in which there are a large number of interrelated variables. This reduction is achieved by transforming the principle components into a new set of variables which are uncorrelated, and which are ordered so that the first few retain most of the variation present in all of the original variables (Catell, 1966; Kline, 1994; Hair *et al.*, 1998). The first principal component has the greatest percent of variation explained, the second shows the second most important percent of variation not described by the first, and so forth.

The main reason for transforming the data using PCA is to compress them by eliminating redundancy (Rao, 1964). The result of the PCA is a multiband raster with the same number of bands as the specified number of components (one band per axis or component in the new multivariate space). In this study, the 55 components formed 55 orthogonal axes in the data space into which each cell was plotted. The similarity of cells within the 55-dimensional data space was then coded as Euclidean separation distance.

After performing the PCA, HCA was conducted with the resultant principal components explaining a cumulative variance. Ward's method for the classification of algorithms was used. This method is distinct from all others since it uses an analysis of variance approach to evaluate the distances between clusters. In short, this method attempts to minimize the Sum of Squares (SS) of any two (hypothetical) clusters that can be formed at each step. We can refer to Ward (1963) for details concerning this method. In general, this method is regarded as very efficient; however, it tends to create clusters of a small size. Ward (1963) proposed a clustering procedure, seeking to form the partitions Pn, Pn – 1, ..., P1 in a manner that minimizes the loss associated with each grouping, and to quantify that loss in a form that is readily interpretable. At each step in the analysis, the union of every possible cluster pair is considered and the two clusters whose fusion results in the minimum increase in the "information loss" are combined. The information loss is defined by Ward in terms of an error sum-of-squares criterion. As a result of this analysis, regions were aggregated with a hierarchical method and complete binding. As indicated, the advantage of using HCA is that the results of the numerical analysis can be clearly expressed by a dendrogram. The resulting groups (regions) were obtained by imagining the division points to lie at the mid points of the maximum distances obtained. It is quite helpful for the objective analysis and reasonable evaluation of the "similarities" and "dissimilarities" between the 228 EU regions.

Table 1. Selected indicators of Environmental (E) and Socio-Economic (SEC) assets.

Indicators	Groups of indicators	Unit of measure
Land cover		
E1	Agricultural area	% of total area
E2	Natural grassland	% of total area
E3	Forest area	% of total area
E4	Transitional woodland-shrub	% of total area
E5	Natural area	% of total area
E6	Artificial area	% of total area
E7	Other area (includes sea and inland water)	% of total area
UAA under Natura 2000		
E8	Agricultural area	% of UAA
E9	Agricultural area (including natural grassland)	% of UAA
Forest area under Natura 2000		
E10	Forest area	% of forest area
E11	Forest area (including transitional woodland-shrub)	% of forest area
Employment by economic activity		
SEC1	Agriculture	% of total
SEC2	Food industry	% of total
SEC3	Tourism	% of total
Agricultural holdings		
SEC4	Number of holdings	Total
SEC5	Holdings with livestock	% of total
SEC6	Physical size	ha of UAA/holding
SEC7	Economic size	EUR of SO/holding
SEC8	Labour size	Persons/holding
SEC9	Labour size	AWU/holding
SEC10	Less than 2,000 EUR	% of total
SEC11	From 2,000 to 3,999 EUR	% of total
SEC12	From 4,000 to 7,999 EUR	% of total
SEC13	From 8,000 to 14,999 EUR	% of total
SEC14	From 15,000 to 24,999 EUR	% of total
SEC15	From 25,000 to 49,999 EUR	% of total
SEC16	From 50,000 to 99,999 EUR	% of total
SEC17	From 100,000 to 249,999 EUR	% of total
SEC18	From 250,000 to 499,999 EUR	% of total
SEC19	500,000 EUR or over	% of total
Agricultural area		
SEC20	Agricultural area	Total of UAA in farms
SEC21	Arable land	% of total UAA
SEC22	Permanent grassland and meadow	% of total UAA
SEC23	Permanent crops	% of total UAA
Area under organic farming		
SEC24	Total area under organic farming	% of total UAA
SEC25	Fully converted to organic farming	% of total area under organic farming
SEC26	Under conversion to organic farming	% of total area under organic farming
Irrigated land		
SEC27	Irrigated land	% of total UAA

Table 1. Continued.

Indicators	Groups of indicators	Unit of measure
Livestock units		
SEC28	Livestock units	LSU of the holdings with livestock
Farm labour force		
SEC29	Total	Persons
SEC30	Males	% of total
SEC31	Females	% of total
SEC32	Sole holders working on the farm	% of regular labour force
SEC33	Members of sole holder's family working on the farm	% of regular labour force
SEC34	Family labour force (sole holders + family members)	% of regular labour force
SEC35	Non-family labour force	% of regular labour force
Age structure of farm managers		
SEC36	Total farm managers	Number
SEC37	Less than 35 years	% of total managers
SEC38	Between 35 and 54 years	% of total managers
SEC39	55 years and over	% of total managers
SEC40	Less than 35 years / 55 years and over	Number of young managers by 100 elderly managers
Agricultural training of farm managers		
SEC41	Total	Number
SEC42	Practical experience only	% of total
SEC43	Basic training	% of total
SEC44	Full agricultural training	% of total

UAA: utilized agricultural area. AWU: annual work unit. SO: farm holdings by economic size. LSU: livestock units. *Source*: Author's elaboration of data from the FADN database (EC, 2016).

Results

After processing all the environmental and socio-economic data, a preliminary characterisation of the EU regions was made. In order to do this, some descriptive statistics of the indicators were conducted to observe the distribution of the data. As shown in Table 2, significant differences may be observed in the CV between the indicators that refer to the 228 EU regions. The biggest difference (10.6) between the EU regions considered is in the number of holdings with an economic size with a value less than €2,000. The maximum number (79) was recorded in a region of Romania (Sud Muntenia) while the minimum (0) was recorded in 21 regions (9% of the total), situated mainly in the Netherlands (Noord Holland, Zeeland, Drenthe, Flevoland) and seven other regions. Another value of the CV close to the value of 1 was recorded for the number of holdings with an economic size ranging between €100,000 and €249,999 (9.4), with the maximum value (41) for Île de France and the minimum value (0) for sixteen EU regions belonging mainly to Romania, Spain and Portugal. Despite this dissimilarity, there was greater homogeneity between the same regions regarding the following holding characteristics: labour size (persons per holding, annual work unit (AWU) per holding), percentage of non-family labour force in the regular labour force, percentage of area dedicated to organic farming, and the percentage of irrigated land. This confirms that holdings with small, medium and large economic sizes coexist in the agricultural systems of the EU. The former, which have all the characteristics of family farms, are located mainly in the NMCs (Romania, Hungary and Poland) and in the Mediterranean EU regions (Spain and Portugal), while the latter operate mainly in the regions of the older member states (the Netherlands and France) and are more professional and have a greater economic dimension. Holdings with a small economic size require more restructuring and diversification.

Following the PCA, all 55 components were reported in Table 3, but only the first thirteen, with an eigenvalue more than 1 were considered for the axes of the data space. Table 3 also lists the eigenvalue and the percentage of variation explained by each component. The first principal component explained 23.4% of the total variance, the second principal component 9.2%, the third principal component 8.6%, and so on. The first thirteen principal components together explained almost 81% of the total variance. In this case PCA

Table 2. Descriptive statistics.

N°	Indicators	Mean	SD	Min	Max	CV
E1	Agricultural area	50.307	20.773	0	92	0.413
E2	Natural grassland	2.934	4.586	0	24	1.563
E3	Forest area	23.833	16.489	0	69	0.692
E4	Transitional woodland-shrub	3.241	4.115	0	23	1.270
E5	Natural area	6.610	9.523	0	58	1.441
E6	Artificial area	11.004	16.522	0	100	1.501
E7	Other area (includes sea and inland water)	2.048	3.777	0	41	1.844
E8	Agricultural area	7.649	7.491	0	44	0.979
E9	Agricultural area (including natural grassland)	9.693	8.479	0	48	0.875
E10	Forest area	27.417	20.186	0	96	0.736
E11	Forest area (including transitional woodland-shrub)	27.053	19.410	0	96	0.717
SEC 1	Agriculture	5.386	6.858	0	49	1.273
SEC 2	Food industry	2.461	1.329	0	7	0.540
SEC 3	Tourism	5.311	3.088	1	21	0.581
SEC 4	Number of holdings	86,951	290,621	40	3,629,660	3.342
SEC 5	Holdings with livestock	65.083	31.429	3	396	0.048
SEC 6	Physical size	42.557	39.234	0	221	0.922
SEC 7	Economic size	90,623	91,137	2,947	523,283	1.006
SEC 8	Labour size	2.404	0.782	1	7	0.000
SEC 9	Labour size	1.447	0.819	0	5	0.000
SEC 10	< 2,000 EUR	17.939	18.930	0	79	10.553
SEC 11	2,000−3,999 EUR	11.211	7.143	0	28	6.372
SEC 12	4,000−7,999 EUR	12.535	5.639	0	27	4.499
SEC 13	8,000−14,999 EUR	10.934	4.509	0	22	4.124
SEC 14	15,000−24,999 EUR	8.009	3.718	0	24	0.464
SEC 15	25,000−49,999 EUR	9.917	4.981	0	27	0.502
SEC 16	50,000−99,999 EUR	8.921	5.664	0	27	0.635
SEC 17	100,000−249,999 EUR	10.268	9.682	0	41	9.430
SEC 18	250,000−499,999 EUR	5.263	6.528	0	31	1.240
SEC 19	≥ 500,000 EUR	3.561	5.036	0	25	1.414
SEC 20	Agricultural area	1,164,391	2,049,285	2,150	1.69e+07	1.760
SEC 21	Arable land	56.548	25.828	0	99	0.457
SEC 22	Permanent grassland and meadow	36.724	24.675	0	105	0.672
SEC 23	Permanent crops	6.539	11.521	0	65	0.176
SEC 24	Total area under organic farming	4.697	5.576	0	30	1.187
SEC 25	Fully converted to organic farming	84.912	22.834	0	100	0.269
SEC 26	Under conversion to organic farming	9.908	12.735	0	76	0.129
SEC 27	Irrigated land	6.496	11.509	0	74	0.177
SEC 28	Livestock units	818,151	1,447,235	240	1.33e+07	1.769
SEC 29	Total	178,837	559,824	80	6,577,930	3.130
SEC 30	Males	64.882	7.262	51	83	1.119
SEC 31	Females	35.724	10.954	17	159	0.307
SEC 32	Sole holders working on the farm	41.912	10.706	9	73	0.255
SEC 33	Members of sole holder's family working on the farm	36.518	12.893	5	66	0.353
SEC 34	Family labour force (sole holders + family members)	78.417	18.728	14	100	0.239
SEC 35	Non-family labour force	21.671	18.738	1	86	0.086

Table 2. Continued.

N°	Indicators	Mean	SD	Min	Max	CV
SEC 36	Total farm managers	86,951	290,621	40	3,629,660	3.342
SEC 37	< 35 years	5.732	3.232	0	22	0.564
SEC 38	35−54 years	41.474	11.742	0	122	0.283
SEC 39	≥ 55 years	53.382	12.937	0	113	0.242
SEC 40	< 35 years / ≥55 years	12.382	10.468	0	51	0.845
SEC 41	Total	86,951	290,621	40	3,629,660	3.342
SEC 42	Practical experience only	60.618	27.003	0	99	0.445
SEC 43	Basic training	25.991	25.323	0	96	0.974
SEC 44	Full agricultural training	13.491	11.747	0	50	0.871

Source: Author's elaboration of data from the FADN database (EC, 2016).

Table 3. Total variance and percentage of individual components extracted with PCA

Component	Eigenvalue	Percentage of variance	Cumulative percentage of variance
1	12.88	23.40	23.40
2	5.10	9.30	32.30
3	4.73	8.60	41.30
4	4.02	7.30	48.60
5	3.21	5.80	54.40
6	2.83	5.10	59.60
7	2.81	5.10	64.70
8	1.93	3.50	68.20
9	1.70	3.09	71.30
10	1.53	2.78	74.08
11	1.32	2.40	76.48
12	1.26	2.29	78.78
13	1.17	2.13	80.91
14	0.97	1.77	82.68
15	0.89	1.61	84.30
16	0.78	1.42	85.71
17	0.71	1.29	87.00
18	0.61	1.10	88.11
19	0.59	1.08	89.19
20	0.56	1.02	90.21
21	0.53	0.97	91.18
22	0.48	0.88	92.06
23	0.47	0.86	92.92
24	0.44	0.80	93.72
25	0.39	0.71	94.44
26	0.38	0.69	95.12
27	0.36	0.65	95.77
28	0.30	0.54	96.31
29	0.27	0.49	96.80
30	0.24	0.44	97.24
31	0.21	0.37	97.61
32	0.20	0.36	97.97
33	0.19	0.35	98.31

Table 3. Continued.

Component	Eigenvalue	Percentage of variance	Cumulative percentage of variance
34	0.17	0.31	98.63
35	0.15	0.26	98.89
36	0.12	0.22	99.11
37	0.09	0.17	99.29
38	0.08	0.16	99.45
39	0.06	0.12	99.56
40	0.05	0.10	99.66
41	0.04	0.08	99.74
42	0.04	0.07	99.81
43	0.03	0.06	99.86
44	0.03	0.05	99.91
45	0.02	0.03	99.94
46	0.01	0.02	99.96
47	0.01	0.02	99.98
48	0.00	0.01	99.99
49	0.00	0.01	100.00
50	0.00	0.00	100.00
51	0.00	0.00	100.00
52	0.00	0.00	100.00
53	0.00	0.00	100.00
54	0.00	0.00	100.00
55	0.00	0.00	100.00

Source: Author's elaboration of data from the FADN database (EC, 2016).

was a good method to reduce the dimensionality of the environmental and socio-economic phenomena of the EU agricultural system.

The eigenvectors from the PCA indicate the correlation indexes among the 55 initial indicators and each of the components. These components represent the differentiation factors within the whole variable system in question (Table 4). As previously indicated, the greatest amount of variance was explained by the first principal component. This first component (23.4% of the explained variance) identifies *the family-run agricultural system*. This component is positively related to the family labour force (sole holders and family members, members of sole holder's family working on the farm, sole holders working on the farm), the smaller economic size (< €2,000, and between €2,000 and €3,999), and the high percentage of managers with practical experience only. High numbers of family-run holdings operate mainly within the agricultural and forestry sector and more specifically, in the sector of permanent crops. However, this component is negatively related to the following factors: a large physical, economic (between €100,000 and €249,999) and labour force size; the percentage of total area used for organic farming and the area fully converted to organic farming; the percentage of non-family labour force; and the percentage of male managers with an age of between 35 and 54 years with basic or full agricultural training. That means that from the positive to the negative values of the first component, we pass from the *family-run agricultural system* (regions of Spain, Portugal, Italy, Austria, Hungary, Romania, Bulgaria, Slovenia) to *the professional agricultural system* (regions of France, the Netherlands, the United Kingdom (UK), Denmark, Belgium and Croatia). In the first system, agriculture is more relevant in terms of the number of holdings, but less so in terms of income and the professional training of farm managers. However, the second system is characterized by a higher percentage of the agricultural area used for organic farming and the higher agricultural training of farm managers.

The second component explains 9.3% of total variance and identifies *the agricultural system at work force intensity.* This component is positively correlated to the total farm labour force and the total number of farm managers. These individuals operate mainly in the livestock sector. Moreover, the variables that best characterize this component are related to the number of holdings and the percentage of arable land (regions of Portugal, the UK, Cyprus, Austria, France, the Netherlands).

Table 4. Matrix of rotated components: correlation between indicators and components.

	Indicator/Component												
Indicator	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
E1	-0.073	0.105	-0.082	-0.101	-0.124	-0.205	0.217	0.149	0.363	-0.088	-0.061	0.179	0.155
E2	0.111	-0.124	-0.006	0.183	-0.024	0.207	0.051	0.107	-0.023	0.051	0.201	0.107	-0.147
E3	0.088	-0.018	0.206	-0.129	0.115	0.065	-0.117	-0.325	-0.116	-0.052	0.248	-0.209	0.027
E4	0.137	-0.114	-0.049	0.014	0.113	0.086	-0.054	-0.255	0.025	0.057	0.201	-0.045	-0.107
E5	0.097	-0.190	-0.046	0.228	-0.027	0.238	0.010	0.032	0.010	0.209	0.032	0.032	-0.078
E6	-0.109	0.056	-0.068	0.068	0.008	-0.004	-0.158	0.199	-0.295	-0.091	-0.326	-0.064	-0.180
E7	-0.034	0.002	0.028	0.009	0.107	-0.100	-0.019	-0.209	-0.233	0.460	0.161	0.059	0.304
E8	0.141	0.022	-0.099	-0.209	0.074	0.264	0.091	0.058	-0.056	-0.152	0.131	-0.069	0.183
E9	0.165	-0.010	-0.077	-0.114	0.107	0.306	0.106	0.048	-0.069	-0.109	0.214	-0.075	0.118
E10	0.115	0.046	-0.160	-0.158	0.168	0.196	0.208	0.162	-0.147	-0.135	-0.171	0.011	0.202
E11	0.110	0.052	-0.155	-0.166	0.172	0.193	0.212	0.166	-0.144	-0.141	-0.166	0.003	0.207
SEC1	0.153	0.049	-0.025	-0.106	-0.097	-0.018	0.034	0.037	0.177	0.231	-0.084	0.020	0.006
SEC2	0.082	0.033	-0.036	-0.144	-0.036	0.044	0.186	-0.048	0.373	0.015	0.067	0.277	-0.067
SEC3	0.091	-0.163	-0.120	0.199	0.062	0.197	0.012	0.148	-0.055	0.075	-0.060	-0.023	-0.061
SEC4	0.120	0.299	0.091	0.239	0.076	0.057	-0.010	0.017	-0.003	0.006	-0.079	-0.022	-0.009
SEC5	0.001	-0.006	0.113	0.070	0.055	-0.272	0.046	0.238	0.061	-0.339	0.303	-0.150	0.014
SEC6	-0.202	0.035	-0.049	0.059	-0.036	0.072	-0.213	-0.041	0.137	-0.210	0.034	-0.009	0.050
SEC7	-0.230	0.075	-0.090	0.044	0.112	-0.013	0.112	0.077	-0.069	0.200	0.114	0.082	0.090
SEC8	-0.124	0.046	-0.015	-0.047	0.207	0.070	-0.323	0.280	0.111	0.101	0.077	0.121	0.044
SEC9	-0.192	0.031	-0.057	-0.052	0.180	0.112	-0.182	0.145	0.184	0.113	0.137	0.050	0.045
SEC10	0.215	0.147	-0.134	-0.088	-0.108	-0.045	-0.082	0.022	0.022	0.022	0.002	-0.053	-0.018
SEC11	0.221	-0.028	0.014	-0.105	0.098	-0.035	-0.156	0.007	0.149	-0.054	0.002	-0.101	-0.013
SEC12	0.153	-0.160	0.130	-0.050	0.178	-0.021	-0.194	0.003	0.149	0.006	-0.036	0.009	0.085
SEC13	0.027	-0.267	0.205	0.059	0.173	-0.004	-0.110	-0.013	0.069	-0.096	-0.110	0.263	0.178
SEC14	-0.074	-0.244	0.205	0.123	0.099	0.039	-0.074	0.005	-0.051	-0.114	-0.125	0.326	0.074
SEC15	-0.138	-0.193	0.200	0.126	-0.022	0.100	0.086	-0.024	-0.169	-0.140	-0.103	0.121	0.001
SEC16	-0.201	-0.078	0.093	0.095	-0.064	0.123	0.146	-0.070	-0.108	-0.164	-0.004	-0.082	-0.115
SEC17	-0.225	0.069	-0.019	0.034	-0.075	0.060	0.209	-0.072	-0.041	-0.004	0.057	-0.166	-0.098
SEC18	-0.204	0.085	-0.063	0.040	-0.015	-0.048	0.219	0.032	-0.042	0.198	0.117	-0.062	0.037
SEC19	-0.198	0.081	-0.126	0.042	0.136	-0.030	0.083	0.108	-0.116	0.190	0.064	0.143	0.114
SEC20	0.076	0.230	0.142	0.235	0.072	0.109	0.033	-0.108	0.127	-0.092	0.070	0.067	0.121
SEC21	-0.072	0.222	-0.005	-0.195	0.165	-0.101	-0.005	-0.292	-0.118	-0.071	-0.120	0.214	-0.098
SEC22	0.012	-0.170	0.060	0.200	-0.266	0.068	-0.050	0.304	0.044	0.018	0.205	-0.199	0.206
SEC23	0.129	-0.145	-0.134	0.028	0.173	0.100	0.115	-0.009	0.185	0.137	-0.188	-0.052	-0.211
SEC24	-0.023	-0.051	0.145	-0.116	0.249	0.009	-0.028	-0.147	-0.058	-0.026	-0.102	-0.125	0.229
SEC25	-0.007	-0.112	0.148	0.028	0.095	-0.062	0.114	-0.033	0.239	0.215	-0.226	-0.380	0.235
SEC26	0.085	0.081	-0.079	-0.052	-0.144	0.055	-0.006	-0.091	-0.111	-0.127	0.304	0.325	-0.032
SEC27	0.079	-0.132	-0.089	0.053	0.250	0.027	0.175	-0.077	0.108	0.085	-0.026	0.097	-0.418
SEC28	0.024	0.165	0.142	0.226	0.071	0.081	0.108	-0.080	0.152	-0.034	0.142	0.132	0.144
SEC29	0.120	0.301	0.109	0.234	0.083	0.059	-0.012	0.023	0.007	0.008	-0.069	-0.002	-0.012
SEC30	-0.174	-0.116	-0.110	0.149	-0.076	0.152	0.109	-0.183	0.101	-0.115	-0.051	0.038	0.140
SEC31	0.121	0.070	0.148	-0.126	0.036	-0.083	-0.097	0.206	-0.136	0.126	0.086	-0.096	-0.179
SEC32	0.176	-0.083	-0.015	0.107	-0.184	-0.128	0.210	-0.188	-0.038	-0.056	-0.081	-0.089	0.087
SEC33	0.176	-0.034	0.156	-0.047	0.014	-0.167	0.010	0.228	-0.178	0.087	0.029	0.233	0.015
SEC34	0.222	-0.070	0.098	0.028	-0.098	-0.190	0.129	0.051	-0.145	0.027	-0.029	0.108	0.059

Table 4. Continued.

	Indicator/Component												
Indicator	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
SEC35	-0.221	0.070	-0.099	-0.028	0.098	0.189	-0.129	-0.051	0.145	-0.027	0.028	-0.110	-0.059
SEC36	0.120	0.299	0.091	0.239	0.076	0.057	-0.010	0.017	-0.003	0.006	-0.079	-0.022	-0.009
SEC37	0.017	0.049	0.315	-0.184	-0.169	0.192	0.045	0.035	0.099	0.017	-0.024	0.009	-0.064
SEC38	-0.090	0.020	0.270	-0.100	-0.121	0.147	0.159	0.045	0.027	0.181	-0.127	0.084	0.101
SEC39	0.073	-0.053	-0.215	0.175	0.075	-0.219	-0.093	-0.054	0.109	-0.143	-0.103	-0.010	0.126
SEC40	-0.005	0.050	0.331	-0.198	-0.156	0.190	0.056	0.061	0.054	0.076	-0.028	0.004	-0.135
SEC41	0.120	0.299	0.091	0.239	0.076	0.057	-0.010	0.017	-0.003	0.006	-0.079	-0.022	-0.009
SEC42	0.115	0.016	-0.191	0.029	-0.294	0.132	-0.235	-0.117	-0.036	0.085	-0.105	0.087	0.152
SEC43	-0.044	-0.065	0.120	0.031	0.327	-0.197	0.287	0.104	0.014	-0.067	0.164	-0.078	-0.128
SEC44	-0.170	0.101	0.180	-0.135	-0.025	0.122	-0.080	0.045	0.042	-0.051	-0.122	-0.040	-0.073

Source: Author's elaboration of data from the FADN database (EC, 2016).

The forest system area is synthesized by the third component that represents 8.6% of total variance. Here, positive values of the components are related to areas where forest represents a significant share of land cover. However, this component includes agricultural holdings with a medium economic size (from €8,000 to €49,999) and a higher percentage of young farm managers (regions of Austria, Poland, Finland, Sweden).

The fourth component explains 7.3% of the total variance and identifies *the livestock agricultural system*. Positive values of this component are related to the high percentage of natural area, namely the high presence of holdings with permanent grassland and meadow. The highest number of holdings with livestock characterizes this component (regions of Spain, the Netherlands, Austria, Denmark and the UK).

The fifth component explains 5.8% of the total variance and represents *the organic agricultural system*. This component is influenced by the large dimensions of holdings in terms of people, the high percentage of land used for organic farming and the high percentage of irrigated land. However, the variable that more than any other characterizes this component is the basic training of farm managers (regions of Finland, Belgium and Denmark.).

The sixth component explains 5.1% of the total variance and identifies *agricultural areas under Natura 2000*. This component shows a positive correlation with the highest share of agricultural land (including natural grasslands) under the Natura 2000 scheme (regions of Greece, Spain, Austria, Bulgaria and Croatia).

The *forest areas under Natura 2000* make up the seventh component that represents 5.1% of total variance. Positive values for this component are related to areas where forest represents a significant share of the UAA. However, this component includes holdings with direct management and a large economic size (between €100,000 and €249,999 and between €250,000 and €499,999). The variable that best characterizes this component is related to farm managers with basic training (regions of Italy, France, Greece, Spain and Belgium).

The eighth component explains 3.5% of the total variance and indicates a *female agricultural system*. This eighth component is positively correlated to the highest percentage of permanent grassland and meadow. In this context, holdings with livestock operate and they are characterized by a high percentage of women in their workforce (regions of the UK, Greece, Poland, Portugal, Hungary and Italy).

The ninth component explains only 1.7% of the total variance and is positively influenced by the high percentage of employment in the *food industry*. Regions with a strong presence of food processing activities and with holdings with a large physical size belong mainly to the UK, the Czech Republic, Slovakia and France.

The indicators that positively influence the tenth component are the percentage of other *area (includes sea and inland water)* on the total area, of natural area on the total area and the presence of employment in the agricultural sector (Table 4) and are seen mainly in regions of the Netherlands, Sweden and Finland.

Each of the last three components with an eigenvalue > 1 explain little more than 1% of the total variance and they are mainly characterized by the regions of EU countries with a high percentage of *forest area* (components 11 and 13) (regions of Sweden, Finland, Austria); of *employment in the food industry* (component 12) (regions of Spain, France and the UK); of *permanent grassland and meadow* (regions of Greece, Italy, Spain and Austria); and of holdings with a *medium economic size* (between €15,000 and €24,999) for component 12 (regions of Italy, Finland and the Czech Republic) (Table 4).

After PCA, the HCA was conducted to calculate a score per component with the aim of aggregating the

228 EU regions into "homogeneity" clusters. The final result was a classification map of EU regions, with six differentiated agricultural systems (Fig. 1).

The professional agricultural system, the first cluster (Fig. 1) is the largest (48 regions, 21.3% of the EU regions considered) and is characterized mainly by component 1 (with a negative sign) and component 2 (positively signed). Regions of this group belong to six EU countries (39.6% France, 22.9% Belgium, 22.9% the Netherlands, 10.4% Denmark, 2.1% Lithuania and 2.1% Malta). The high presence of French regions, in the main part, is indicative of an agricultural system based on holdings with high fragmentation and a small economic size (from €100,000 to €249,999). The EU regions of this group are characterized by a high percentage of land fully converted to organic farming (89% of the total area under organic farming), which is larger than the average of the 228 EU regions considered (85%

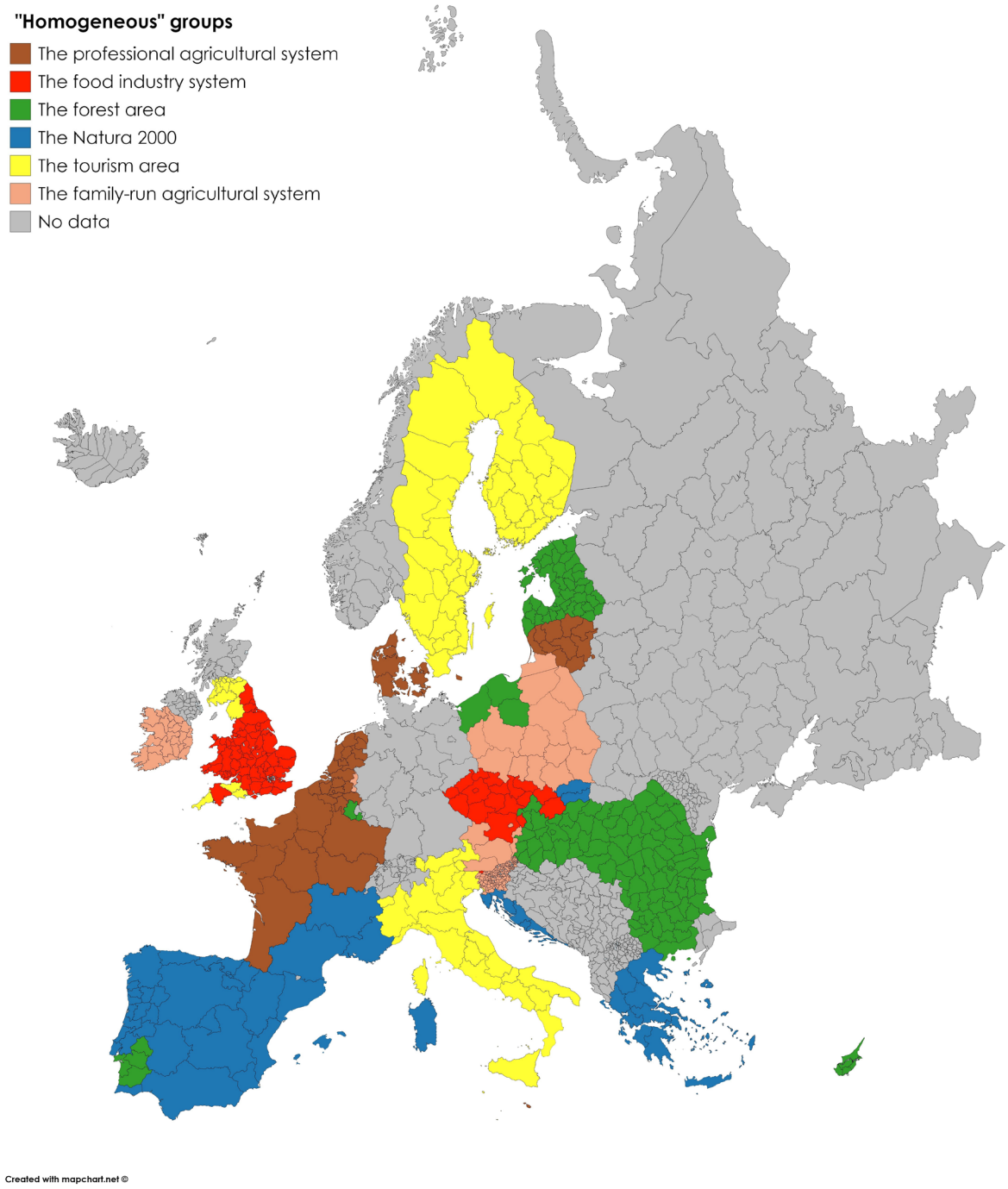

Figure 1. A new classification of the EU regions. *Source*: Author's elaboration of data from the FADN database (EC, 2016).

of the total area under organic farming). Finally, the farm managers of this agricultural system are young (only 14% are elderly) and have full agricultural training (19.8% *vs.* 13.5%).

The food industry system is the second group and includes 43 regions (18.9% of the total) from five EU countries (72.1% the UK, 18.6% the Czech Republic, 4.7% Slovakia, 2.3% Slovenia and 2.3% Austria). Forest areas under Natura 2000 (component 3) characterize the EU regions of this group. The group mainly represents the UK economic system with the highest percentage of employment in the food industry compared to other groups (4.5% of the total against an average of 2.5% in all the 228 regions) and with the greatest labour force size of the holdings (6% against an average of 2.5% in all the 228 regions). This group is positively influenced by components 9 and 12 (Table 4).

The forest area is the third cluster. Twenty-seven regions are grouped here (11.8% of the total), belonging to nine EU countries (25.9% Romania, 25.9% Hungary, 22.2% Bulgaria, 3.7% Estonia, 3.7% Cyprus, 3.7 Latvia, 3.7% Luxembourg, 3.7% Slovakia and 3.7% Portugal). This cluster makes up the third and the thirteenth components, the *forest system area*. This group is led by Romania, a country rich in forests with 26% of its surface covered in timber-rich, generally well-managed forest. In the regions of this cluster, the highest percentage of natural grassland is concentrated (almost 6% against an average of 3% in all the 228 regions). There is also a high percentage of transitional woodland-shrub (7.4% of total area *vs.* 3.2%) and artificial area (73% of total area *vs.* 11%). The holdings that operate in this agricultural sector have the greatest physical, economic and labour force size, compared to the other groups.

The Natura 2000 area is the fourth cluster and includes 40 regions (17.5% of the total) and is influenced by the sixth and eleventh components (*agricultural area under the Natura 2000 protection scheme*). Regions of this cluster are characterized by extensive subsistence agriculture. However, the agricultural area in these regions is mainly occupied by permanent grassland and meadow and by permanent crops. Here, farm managers have basic training (82.2% of the total against an average of 26% in all 228 regions). The regions of this group belong to Spain (42.5%), Greece (32.5%), Portugal (12.5%), France (5%), the Italian island of Sardinia (2.5%), Slovakia (2.5%) and Hungary (2.5%).

The tourism area, the fifth group, includes 47 EU regions (that represent 42.6% of the 228 EU regions considered). Almost all the Italian regions belong to this group, with the exception of Sardinia. Other EU regions from Sweden (17%), the UK (12.8%), Finland (10.6%), Austria (6.4%), Ireland (4.3%), France (2.1%), Croatia (2.1%) and Portugal (2.1%) are present in this group. Overall, tourism in these countries is an important economic sector that plays an important role in terms of employment (25% against an average of 5.3% in all the 228 regions). This sector, at a regional level, can help to solve the problem of unemployment and replace activities that have lost their competitive advantage (particularly in the agricultural sector). The development of tourism in these territories is favoured by the high percentage of natural areas (32.2% of total area against an average of 6.6% in all 228 regions) and the high percentage of sea and inland water (9.7% *vs.* 2%). In the agricultural sector, a high number of small holdings with a low economic size operate (80% have an economic size worth less than €2,000). In the main part, permanent grassland and meadow, in addition to permanent crops occupy the agricultural area.

The family-run agricultural system, the last group (sixth), is the smallest (23 EU regions, only 10.2% of the total). Sixty-five percent of the regions belong to Poland, almost 22% to Austria, 4.3% to the Netherlands, 4.3% to Romania and 4.3% to Slovenia. The agricultural sector has many aspects of a self-sufficient economy, with very small and fragmented family-run farms. Here, the agricultural holdings have the lowest physical (14.6% *vs.* 42.6%), economic (€23,349/holding *vs.* an average of €90,623/holding in all 228 regions) and labour size (1.1 *vs* 1.4 AWU/holding).

Discussion

The methodology described above brought about a classification of EU regions.

The classification can be summarized by grouping on one side those regions that have the most competitive and modernized agricultural systems and on the other, those that have the least developed and most marginal agricultural systems. On the former side are the two large and competitive agricultural systems labelled *the professional agricultural system* (made up of regions of France, the Netherlands, the UK, Denmark, Belgium and Croatia) and *the food industry system* (mainly regions of the UK), which ensure the security of the food supply chain and manage a major share of the rural space. In accordance with Brouwer & Lowe (2000), in these agricultural systems, CAP payments, coupled with the large quantities produced and surface area used, have contributed to the modernization and intensification of EU regional agriculture. This has led to landscape homogenization, the rationalization of farm size and structure and the consequent loss of many traditional features (hedges, trees, field margins and wet areas). In these areas income support will remain

an essential part of the future CAP beyond 2020 and will continue to be based on the farm size in hectares.

In contrast, holdings on the less developed side are made up of four agricultural systems labelled *the forest area* (mainly regions of NMCs), *the Natura 2000 area* (mainly EU Mediterranean regions), *the tourism area* (mainly regions of Italy and of Scandinavian countries) and *the family-run agricultural system* of the marginal and fragile areas (regions of Spain, Portugal, Italy, Austria, Hungary, Romania, Bulgaria and Slovenia), which represent models of small or alternative agriculture. In these EU regions, through direct payments and the Less Favoured Area Support Scheme, the CAP has promoted the maintenance of the status quo with respect to the continuation of farming in marginal areas, and more particularly the preservation of extensive grazing systems, thus contributing to the conservation of traditional rural landscapes (*Natura 2000* and *forestry area*), avoiding land abandonment and the disappearance of these landscapes. Moreover, the necessity to comply with good agricultural and environmental standards in order to receive the direct payments, decoupled from production, in addition to the implementation of agri-environmental payment schemes to encourage farmers to carry out agricultural activities favourable for the maintenance of the countryside, has positively influenced landscape provision (Table 5).

In light of the above, and in line with the results of the classification of EU regions carried out by D'Amico *et al.* (2013), this research shows that the presence of holdings managed by young farmers with full agricultural training is a key element of the differences between clusters. Holdings managed by individuals with a high level of education are mainly characteristic of the agriculture of continental EU regions. In contrast, holdings with farmers that have a low level of education are predominantly found in rural and

Table 5. The main characteristics of the obtained homogeneous clusters of EU regions.

Cluster	Regions	Labelling	Main charactheristics	CAP goals
Cluster 1	48	*The professional agricultural system*	Regions with high % of land fully converted to organic farming, with the highest % of young farm managers that have full agricultural training	To move toward a new model of organic farming payments and promotional activities. The CAP should include thematic sub programmes in the programmes specifically addressing the needs of young farmers.
Cluster 2	43	*The food industry system*	Regions with highest % of forest area under Natura 2000, the highest % of employment in the food industry	The CAP should be a truly common policy that promotes competitive and market-oriented agriculture. A more market-oriented CAP will help advance the competitiveness of EU producers and manufacturers at home and abroad.
Cluster 3	27	*The forest area*	Regions rich in forest area, with the highest % of natural grassland and transitional woodland-shrub	The CAP should be designed to promote and ensure an economically viable, competitive forestry sector, which is a prerequisite for the sustainable development of the environmental and social functions of forestry in Europe's rural areas.
Cluster 4	40	*The Natura 2000 area*	Regions with extensive subsistence agriculture, with the highest % of area under Natura 2000, with the highest % of permanent grassland and meadow and by permanent crops, with the highest % of farmer managers with basic training	To build an integrated package of support for Natura 2000 farmers that first ensures the economic viability of the extensive farming system on which the beneficial management depends, and secondly addresses the specific management practices needed for the conservation of the key habitats and species.
Cluster 5	47	*The tourism area*	Regions with the highest % of employment in the tourism sector, with the highest % of the natural areas, with the highest % of sea and inland water	The tourism entrepreneurship could be considered one viable option for present and future progress of non-urban areas.
Cluster 6	23	*The family-run agricultural system*	Regions with the self-sufficient economy, with very small and fragmented family-run farms	Special agricultural taxation arrangements that favour family-owned businesses such as partial or total exemption from property or inheritance taxes or social security taxes; and measures to facilitate access to farm credit or insurance.

CAP: common agricultural policy. *Source*: Author's elaboration of data from the FADN database (EC, 2016)

marginal EU regions. This factor has an effect on the economic size of the holdings and on the number of employees. The findings confirm that the conservation of the "diversity" of rural and agricultural systems should be included among the goals of the CAP. For CAP programmers it is very important to have a clearer vision of the diversity among and within agricultural systems present at regional level. Furthermore, such information is relevant when asking for diversified actions concerning the different roles of professional market-oriented farms and other types of farm (*e.g.*, social farms). Forms of support must increasingly be differentiated according to agricultural system type.

For the *professional agricultural system*, the CAP must mainly provide measures to stabilize agricultural income and employment, and encourage investment in innovation and aggregation (Fanelli, 2018b). Conversely, the public functions of alternative forms of agricultural system (*e.g.*, *The Natura 2000 area*, *tourism area*) such as strengthening rural society and protecting the environment should be recognized within the CAP and encouraged within territorial projects. In addition, at a regional level, the tourism sector, can help to solve the problem of unemployment and replace activities that have lost their competitive advantage (particularly in the agricultural sector). However, it also represents convergence and in accordance with Soukiazis & Proença (2008), can help EU regions to approximate their levels of development. Nevertheless, agriculture remains a key driver for rural jobs. Three quarters of jobs are in *family-run farms* and businesses and many of these are growing.

In conclusion, two important observations can be made. Firstly, a new and more accurate classification of EU regions in "homogeneous" territorial agricultural systems is essential to improve the comparability of EU regions for the development of future CAP programmes beyond 2020 (2021-2027). The differences between agricultural systems in the EU challenge policymakers, who must be able to respect the real needs and aspirations of all actors in EU regions. Distribution of support has to be considered in relation to policy objectives. In accordance with D'Amico *et al.* (2013) a policy that follows equity criteria should respect regional differences. Only in this way, can public support go to holdings that need or deserve it. The advantage of a new classification is reflected in the possibilities given to policymakers. The classification put forward by this research is a new tool for evaluating the real situation in the six agricultural systems identified. The instruments applied by the current European system of direct payment have failed to take into account territorial differences: the same rules apply regardless of the geographical area. Secondly, this paper underlines, in accordance with Nazzaro & Marotta (2016), the need to consider EU agriculture as a whole. Indeed, preferably, it should take into account productive and structural particularities as well as the different environmental and socio-economic contexts in which agricultural systems operate. This would allow policymakers and those involved in local government to have enhanced and more effective tools, as required by the ongoing CAP (2014-2020) and for future programming post 2020 (2021-2027). This is important for a more exact and better monitoring of policies for agricultural system development.

This research has assessed the viability of different actions of the CAP on the basis of the differences and analogies in the environmental, socio-economic and structural characteristics of agricultural systems among 228 EU regions. As a result regions with similar agricultural systems can be supported with similar intervention. The findings of this analysis and its follow-up will be useful for policymakers in order to define tools that guide producers towards a more sustainable and competitive use of natural, physical and human resources, an objective of the CAP beyond 2020. Furthermore, this paper supports the implementation of the CAP, from the perspective of a dynamic and diversified countryside, where different forms of agriculture can make EU farming flourish. Better harmonization between the CAP and national policies should be pursued. A fair minimum standard of living for farmers and others involved in agriculture should be assured by fiscal and social policy at the regional level.

The statistical techniques used were adequate for assessing the data from this research, but further analysis could be made to compare results obtained from different classification techniques. For example, the findings are consistent with similar recent studies, which used multivariate analysis (Serrao, 2003; D'Amico *et al.*, 2013; Fanelli, 2018a). Literature in this area remains scarce and therein lies the originality of this study.

Acknowledgements

The author thanks the reviewers' comments and the text revision made by Dr Amy Muschamp.

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