CHARACTERIZATION OF AGRICULTURAL SYSTEMS IN THE EUROPEAN UNION REGIONS: A FARM DIMENSION-COMPETITIVENESS-TECHNOLOGY INDEX AS BASE

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Abstract

The agricultural realities across the several regions belonging to the European Union (EU) present some significant differences, in terms of the socioeconomics, cultural, structural and environmental dimensions. In general, because it is difficult to consider all the realities, within each country, sometimes the public decision makers, in Europe, need to design common approaches for all countries and regions, despite there being some decentralization of decisions. In this scenario, this study aims to identify and characterize the main agricultural systems in the European Union, using statistical information available in the FADN (2017), for the periods 2007-2009 and 2012-2013. This was done, considering the utilized agricultural area (farm dimension), the machinery (farm technology and innovation) and the farm net value added (farm competitiveness) as principal indicators. From these variables the European Union countries and regions were grouped into agricultural systems through cluster approaches and based on a farm dimension-competitiveness-technology index obtained with factor analysis. This approach was complemented by spatial analysis, through the observation of spatial autocorrelation between European Union countries, as determining the farming characteristics in neighboring countries. Of stressing, the relevant differences in the farm characteristics, not only, among European countries, but also, inside each member state between regions. On the other hand, of highlighting the adequacy of the index considered as representative of the farming particularities.

Keywords: European Union regions, Farm Accountancy Data Network (FADN), Spatial approaches, Factor and clusters analysis

JEL classification: C21, C38, O13, O52, Q10

1. Introduction

The diversity observed in the agriculture for European Union regions, in terms of structure, production, management, soil and climate, among other aspects, whether are good for biodiversity and allow for some specialization, can sometimes create some difficulties when it is necessary to design a common strategy.

Indeed, the greatest challenge for institutions in the European Union, in the future, concerning agricultural sector interventions, will be to deal with the huge differences across the several countries and regions. The European Union countries have, also, various economic, social, cultural and environmental contexts with implications upon the dynamics for the agricultural sector.

In this framework, all contributions for the identification and characterization of farming systems in Europe may bring interesting insights, because this allows to identify and organize the countries and regions into sets where the farms have similar characteristics. These organizations facilitate all the decision-making processes in terms of strategical design for the agricultural sector in each dimension, private or public, local or regional, regional or national and national or supranational.

Considering what has been referred to before, the objective of the current study is the identification and characterization of agricultural systems across the European Union countries and regions, considering the statistical information available in the FADN (2017), for the periods 2007-2009 and 2012-2013. The reasons for considering these years are mainly related to the availability of data, the several changes across the years in the regions names, to take into account the effects of the Common Agricultural Policy modifications around 2007

and the adherence of Bulgaria and Romania to the European Union. The Farm Accountancy Data Network is an interesting database with data at farm level, allowing microeconomic analysis fundamental to support policies design (Marta-Costa, Martinho, and Santos 2017).

With this data the farms of the former 27 European Member States, and respective NUTs 2, were grouped into sets of countries and regions through cluster analysis and based on a farm dimension-competitiveness-technology index. This index was obtained through factor analysis with the farm utilized agricultural area (ha), machinery (euro) and farm net value added (euro). As showed in the following sections, this index is an adjusted factor, because the base variables capture a relevant part of the European Union farm characteristics.

In this process of grouping the farms other indicators were also observed, such as spatial autocorrelation, analyzed through the GeoDa (2015) software. The spatial autocorrelation is related with the possibility of a certain variable in a specific local, region or country may be autocorrelated with the same variable in the neighboring regions. The spatial autocorrelation is a statistical infraction, so dealing with this question increases the robustness of the results, but, also, helps in the decision-making process.

Considering the Food and Agriculture Organization of the United Nations (FAO) agricultural systems are a set of mechanisms that operate together within a limit to attain certain goals and objectives (http://www.fao.org/docrep/w7365e/w7365e04.htm#1.1 system definition and hierarchy). However, the objective in this work is a little broader and it is pretended to identify and characterize agricultural systems through representative farms with similar features, not necessarily inside the same boundary and with any explicit interactions. In fact, the main goal is to present a contribution that help in the definition of adjusted policies and decisions.

2. Literature review

The characterization of European Union farms, to try identifying homogeneous farming systems in European countries is crucial to facilitate the process of design and planning agricultural strategies and plans (D'Amico et al. 2013). The differences are, in many cases, not only a reality among countries, but also inside the countries between the several regions (Glauben, Tietje, and Weiss 2006).

Unadjusted strategies for the agriculture can promote reductions in the agricultural system's sustainability, with significant socioeconomic and cultural impacts (Dominguez Gomez and Relinque 2014), compromising the diverse dynamics that can be developed in rural zones, usually, with several weaknesses. In fact, the agricultural policies, namely those which come from the Common Agricultural Policy, have an influence upon farming systems, specifically in agricultural production, income, prices and biodiversity (Overmars et al. 2013). For example, Trubins (2013) found that the Common Agricultural Policy, namely after 2000, had significant implications upon Swedish agricultural systems, inducing the farmers´ production options for areas with higher quality.

On the other hand, the socioeconomics, climate, soil and conditions for innovation are, also, determinants in the way the rural territories and land are structured and organized (Audsley et al. 2008). In this way, Bacon et al. (2012), for instance, stressed the importance of considering the social aspects in the analysis related to agriculture. Dono et al. (2013), in its turn, analyzed the implications of climate change on water irrigation availability, namely in Mediterranean agricultural systems. The concerns with the climate encouraged several authors to develop new tools to analyze the exposures of the agricultural systems to the future changes, as the work presented by Eza et al. (2015).

Another aspect, as referred before, is about the soil. The questions related with the implications in the soil conditions, namely in terms of phosphorus were, also, studied by Senthilkumar et al. (2012). Mastrocicco et al. (2013), in its turn, analyzed aspects associated with the implications of drainage and soil nitrogen presence. The implications in the water pollution were, too, investigated by Gorton, Lowe, and Zellei (2005) in Lithuania, Poland and Slovakia. The relationship between the land utilization and the soil quality is an important question (Salvati and Colantoni 2015), considering the influence of the soil, as well the climate, in the choices and decisions of the farmers.

To identify and characterize the farming systems it is determinant to analyze the several practices developed by the producers in farms. For example, the agricultural practices

associated with environmental preservations and with the related production pathways influence the characterization of farming systems in olive groves (Santos et al. 2007), but also in another crop productions and in livestock activities. Animal production, often, has problems with soil pollution, but, also, with air contamination. The efficiency in livestock production is fundamental for sustainability, reducing inputs and costs and to preserve the environment (Gaspar et al. 2009).

There are some production pathways which are characteristic of certain countries and regions, defining specific agricultural systems. A typical farming system in Portugal, namely in the South, is the "Montado", where is produced cork, wood and animal production in extensive farming conditions (Borges et al. 2010). In Southern Spain, several agricultural systems are characterized by the use of brassicas as cover crops in orchards. These practices improve the sustainability and preserve the environment, through the biomass production, reduction in the use of fertilizers and increasing the soil porosity (Alcántara et al. 2009).

In general, the sustainable development will be the big challenge for many countries, regions and places. In fact, it is not easy to find a balance between the economic and the environmental dynamics (Almeida et al. 2017).

In the Northern and in Southern Italy, Ghisellini et al. (2014) found that the land use and the labor productivity are two determining factors in the dynamics of the agricultural systems in the Italian regions Emilia Romagna and Campania. The evolution of the farming systems in France, and in almost all countries in the European Union, experienced several transformations, due to various reasons (including political). In many European countries, such as France, the farms changed from diversified productions for the subsistence of the farmers´ family to farms which were more specialized and market-driven (Choisis et al. 2010). These authors found that the farm size is determined by the spatial and organizational agricultural systems.

Using cluster techniques Palma Lampreia dos Santos (2013) segmented the farms of the 27 European Union countries, identifying four types of farming systems based on the structural aspects (utilized agricultural area and others), financial questions and the relevant subsidies. The clusters found are: Germany, Austria, Belgium, Cyprus, Finland, France, Lithuania, Malta and Sweden; Bulgaria, Estonia, Slovenia, Greece, Hungary, Latvia, Poland, Portugal and Romania; Slovakia, the Czech Republic; Ireland, Luxembourg and the UK. López, Valiño, and Pérez (2008) classified and characterized agricultural systems in Spain considering the following variables: land utilization; farm dimension; and production systems.

Another aspect is about the multifunctionality/diversity in the farming systems. Indeed, the multifunctionality may improve the farmers' income, preserve the biodiversity and reduce the farm's risks (Nikolova and Linkova 2011). Namely, in the zones where agriculture is not profitable alone, the consideration of other non-agricultural activities that can be developed in rural regions may be an interesting complement for the return obtained in these lower profit agricultural systems. The multifunctionality of the farming systems and multidisciplinary approaches in the agricultural researches were highlighted, also, by Kragt et al. (2016).

Of stressing, also, that in general, factors such as the economic conditions, innovation and organizational orientations are more considered in literature, rather than factors related with social, cultural and demographic characteristics (van Vliet et al. 2015).

3. European agricultural systems

In this section, the agricultural systems (in a perspective of representative farms with similar characteristics) existent in the European Union countries will first be identified and then characterized. The European countries and regions will be grouped considering their structural, technological, competitiveness characteristics, through cluster analysis based on the farm index obtained by factor analysis. It was used data in average from the database available in the FADN (2017), over the periods 2007-2009 (disaggregated at country and regional level) and 2012-2013 (disaggregated at regional level), considered for the spatial analyses the procedures from the GeoDa (2015) software and followed for the factor and cluster analysis the procedures proposed by Stata (2017). The several methodologies related with the cluster and spatial approaches have diverse applications in the regional analysis (Leonidovich 2017; Yalyalieva and Napolskikh 2017).

The adequacy of the farm index proposed

To improve the analysis it was built a farm dimension-competitiveness-technology index obtained through factor analysis and based on the utilized agricultural (dimension), machinery (technology) and farm net valued added (competitiveness). In fact, as showed in the table 1, these three variables are linearly correlated, in the two periods, what claims for a factor exploration before using these indicators in the cluster analysis. The linear correlation is ever stronger between the technology (machinery) and the competitiveness (farm net valued added) in the two periods and among countries or regions. On the other hand, the several correlations are slightly stronger in the second period, sign that the interrelationships between the dimension-competitiveness-technology improved.

Table 1. Pairwise correlation matrix among the European Union countries and regions over the period 2007-2009 and 2012-2013, between the farm dimension, net valued added and machinery

	Total Utilised Agricultural Area	Farm Net Value Added	Machinery
By countries over the period 2007-2009			
Total Utilised Agricultural Area	1.000		
Farm Net Value Added	0.588*	1.000	
	(0.001)		
Machinery	0.588*	0.889*	1.000
	(0.001)	(0.000)	
By regions over the period 2007-2009			
	Total Utilised Agricultural Area	Farm Net Value Added	Machinery
Total Utilised Agricultural Area	1.000		
Farm Net Value Added	0.833*	1.000	
	(0.000)		
Machinery	0.850*	0.919*	1.000
	(0.000)	(0.000)	
By regions over the period 2012-2013			
	Total Utilised Agricultural Area	Farm Net Value Added	Machinery
Total Utilised Agricultural Area	1.000		
Farm Net Value Added	0.847*	1.000	
	(0.000)		
Machinery	0.851*	0.938*	1.000
	(0.000)	(0.000)	

Note: *, statistically significant at 5%.

On the other hand, the consideration of these variables to obtain the index proposed follows the literature review that shows that the farm structures, innovation and performance are interesting factors to characterize the farming systems (Choisis et al. 2010; López, Valiño, and Pérez 2008; Palma Lampreia dos Santos 2013; van Vliet et al. 2015).

To explore the adequacy of the farm index obtained, the table 2 provides the summary statistics for the European Union countries and regions over the periods considered and the table 3 presents a pairwise correlation matrix among this index and other relevant variables of the farm characteristics.

Table 2. Summary statistics for the farm dimension-technology-competitiveness index obtained for the European Union countries and regions over the period 2007-2009 and 2012-2013

Variable	Number of observations	Mean	Standard Deviation	Min	Max
Farm index (first period at country level)	27	2.070e-09	0.949	-1.014	1.997
Farm index (first period at regional level)	135	8.380e-10	0.970	-0.810	5.033
Farm index (second period at regional level)	134	-1.150e-09	0.976	-0.725	5.319

Table 3. Pairwise correlation matrix among the European Union countries and regions over the period 2007-2009 and 2012-2013, between the farm index and other farm variables

By countries over the period 2007-2009

	Farm index	Labour input	Total Utilised Agricultural Area	Total livestock units	Total output	Total Inputs	Farm Net Value Added	Total assets	Total current subsidies
Farm index	1.000								
Labour input	0.606*	1.000							
	(0.000)								
Total Utilised Agricultural Area	0.661*	0.944*	1.000						
	(0.000)	(0.000)							
Total livestock units	0.939*	0.602*	0.690*	1.000					
	(0.000)	(0.000)	(0.000)						
Total output	0.952*	0.688*	0.717*	0.942*	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)					
Total Inputs	0.917*	0.792*	0.825*	0.916*	0.978*	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				
Farm Net Value Added	0.969*	0.539*	0.588*	0.938*	0.952*	0.885*	1.000		
	(0.000)	(0.003)	(0.001)	(0.000)	(0.000)	(0.000)			
Total assets	0.795*	0.206	0.308	0.822*	0.784*	0.717*	0.799*	1.000	
	(0.000)	(0.300)	(0.117)	(0.000)	(0.000)	(0.000)	(0.000)		
Total current subsidies	0.750*	0.892*	0.956*	0.756*	0.768*	0.864*	0.670*	0.404*	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.036)	

By regions over the period 2007-2009

	Farm index	Labour input	Total Utilised Agricultural Area	Total livestock units	Total output	Total Inputs	Farm Net Value Added	Total assets	Total current subsidies
Farm index	1.000								
Labour input	0.758*	1.000							
	(0.000)								
Total Utilised Agricultural Area	0.902*	0.847*	1.000						
	(0.000)	(0.000)							
Total livestock units	0.845*	0.634*	0.800*	1.000					
	(0.000)	(0.000)	(0.000)						
Total output	0.980*	0.775*	0.875*	0.859*	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)					
Total Inputs	0.978*	0.821*	0.910*	0.855*	0.990*	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				
Farm Net Value Added	0.969*	0.700*	0.833*	0.791*	0.970*	0.945*	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
Total assets	0.804*	0.509*	0.654*	0.815*	0.815*	0.786*	0.783*	1.000	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
Total current subsidies	0.952*	0.810*	0.952*	0.816*	0.920*	0.952*	0.895*	0.690*	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

By regions over the period 2012-2013

	Farm index	Labour input	Total Utilised Agricultural Area	Total livestock units	Total output	Total Inputs	Farm Net Value Added	Total assets	Total current subsidies
Farm index	1.000								
Labour input	0.809*	1.000							
	(0.000)								
Total Utilised Agricultural Area	0.896*	0.863*	1.000						
	(0.000)	(0.000)							
Total livestock units	0.857*	0.669*	0.809*	1.000					
	(0.000)	(0.000)	(0.000)						
Total output	0.984*	0.814*	0.873*	0.876*	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)					
Total Inputs	0.983*	0.851*	0.903*	0.876*	0.994*	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				
Farm Net Value Added	0.980*	0.795*	0.847*	0.816*	0.984*	0.972*	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
Total assets	0.819*	0.587*	0.701*	0.820*	0.824*	0.806*	0.792*	1.000	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
Total current subsidies	0.936*	0.849*	0.931*	0.804*	0.910*	0.942*	0.898*	0.701*	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

Note: *, statistically significant at 5%.

As relevant and representative variables it were considered, from the FADN (2017) database, despite the farm index built, the total labour (hours), the total utilized agricultural area (ha), the total livestock units (LU), total output (euros), total inputs (euros), farm net value added (euros), total assets (euros) and total current subsidies (euros). The table 3 reveals that there are a strong and significant relationship among the farm index obtained and the main characteristics of the European Union farms. In fact, the farm dimension is interrelated with the possibility of using new technologies and innovation, what have implications in the competitiveness of the agricultural sector. Considering the particularities of the agri-food sector, the competitiveness is an important indicator to take into account (Dovgal et al. 2017).

Identifying farming systems

Exploring the farm dimension-competitiveness-technology index with cluster analysis, the several countries and regions were grouped, over the periods considered, into four clusters in each case (taking into account the dendrograms showed in the figure 1) as presented in the tables 4, 5 and 6.

The table 4 shows that the results found with cluster analysis for the former twenty seven European Union countries, over the period 2007-2009, have some similarities with those obtained by Palma Lampreia dos Santos (2013). The clusters presented in the table 4 are: Belgium, Germany, Estonia, France, Austria, Finland and Sweden; Czech Republic, Netherland and Slovakia; Denmark, Luxembourg and United Kingdom; Bulgaria, Cyprus, Greece, Spain, Hungary, Ireland, Italy, Lithuania, Latvia, Malta, Poland, Portugal, Romania and Slovenia. In the cluster 1 the Estonia is the country with greater average (over the period) utilized agricultural area, but with lower technology and competitiveness. On the other hand, Belgium and Germany have the better competitiveness and Germany and Sweden the higher average values for the machinery. In the cluster 2, the Netherlands has the lower area, but the better competitiveness. In the cluster 3, United Kingdom has the greater average area and competitiveness and Luxembourg the higher values for the mean machinery. For the cluster 4, Latvia has the greater area, Italy the best average competitiveness and Malta the best values for the machinery.

The results presented in the table 4 for the cluster found seems to reveal that there are not spatial linkage inside each group of countries, indicating that the farms with similar characteristics inside the European Union area not within a European zone with a spatial limit or border. To explore these findings and to explore this analysis, it was observed for the period 2007-2009, and for the variables used to obtain the farm index built, the global and local spatial autocorrelation, at country level, through cross-section analysis, using georeferenced methodologies (Martinho 2015). The results are presented in figures 2 and 3.

Figure 2 shows the global spatial autocorrelation, considering the statistics from Moran´s I. The global spatial autocorrelation analyzes the hypothesis of the values of a variable being correlated across all the countries analyzed. Positive values for Moran´s I signify that there is positive spatial autocorrelation (the values of a variable are correlated in all the countries and evolve in the same way and vice-versa). In fact, Anselin (1995) referred that the local indicator for local association (LISA) for each observation provides the dimension of significant spatial grouping of similar values close to that observation and the sum of that LISAs for all observations gives the global indicator for spatial association. On the other hand, the Moran´s I can assume values among -1 and 1, where values close to 1 represent positive spatial autocorrelation (tendency to clustering) and close to -1 indicate negative spatial autocorrelation (tendency to dispersion), as referred, for example by the ESRI (http://resources.esri.com/help/9.3/arcgisengine/java/gp_toolref/spatial_statistics_tools/spatial_autocorrelation_morans_i_spatial_statistics_.htm).

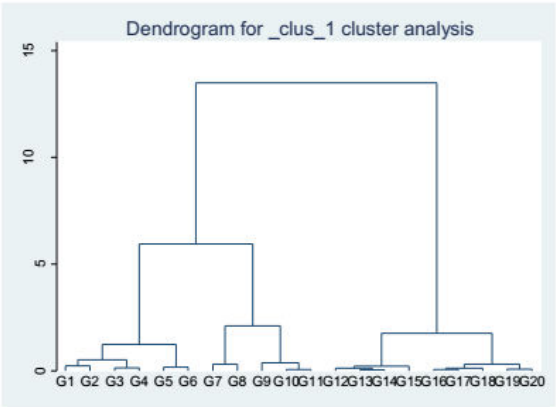
On the other hand, the local spatial autocorrelation analyzes the possibility that the values of a determinate variable in a country be correlated with the values of the same variable in the neighboring countries (figure 3). In figure 3, the values high-high means positive local spatial autocorrelation for high values, and the values low-low signify positive autocorrelation for low values. The values low-high and high-low represent negative autocorrelation. All the results for the high-high, low-low, low-high and high-low represent spatial autocorrelation (positive or negative) with statistical significance (GeoDa 2015).

Figure 2 shows that the values of Moran´s I are close to 0 for the three indicators considered (negative and closer to 0 relative to the utilized agricultural area and positive for the farm net value added and the machinery value). These facts demonstrate that the global spatial autocorrelation, for the variables analyzed, is weak, so these indicators are not correlated among the neighboring countries.

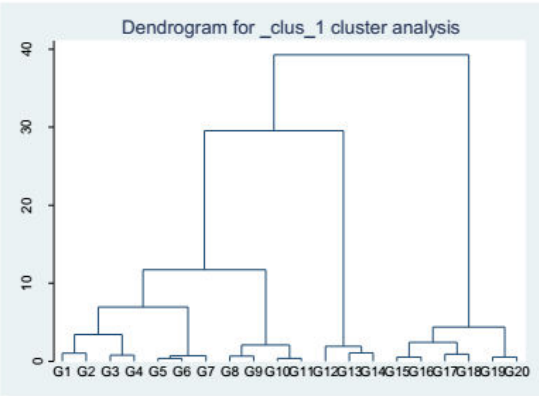
The values in figure 3 confirm this description and the local spatial autocorrelation is, also, weak. However, there are some signs of negative spatial autocorrelation for Poland (and neighbors), in the three variables, and positive low-low autocorrelation in Bulgaria (and neighbors) for the farm net value added (showing signs of low competitiveness in these countries).

These results for the global and local spatial autocorrelation confirms that there are few spatial linkage among the European Union farms with similar characteristics, what reinforce the propose presented in this work to consider the concept of agricultural systems in a broader approach for the European context.

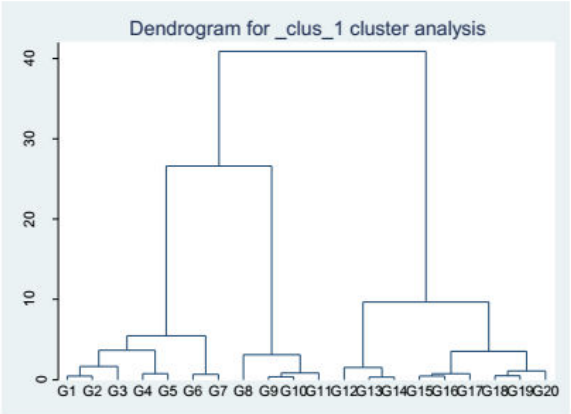
Figure 1. Dendrograms for cluster analysis over the European Union countries and regions over the periods 2007-2009 and 2012-2013



By countries over the period 2007-2009



By regions over the period 2007-2009



By regions over the period 2012-2013

Figure 2. Global spatial autocorrelation for the indicators used (Utilized agricultural area – ha, farm net value added – euro, machinery value – euro)

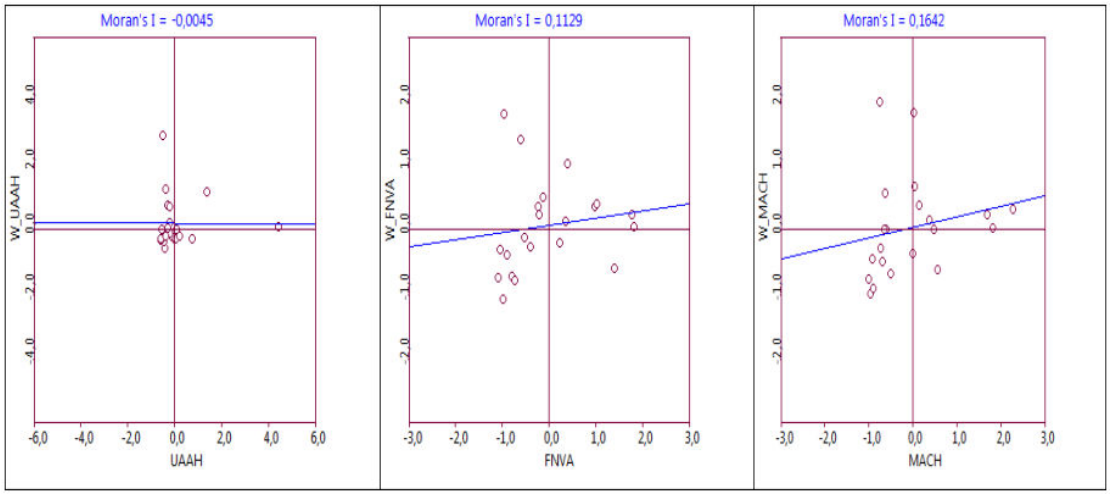


Figure 3. Local spatial autocorrelation for the indicators used (Utilized agricultural area – ha, farm net value added – euro, machinery value – euro)

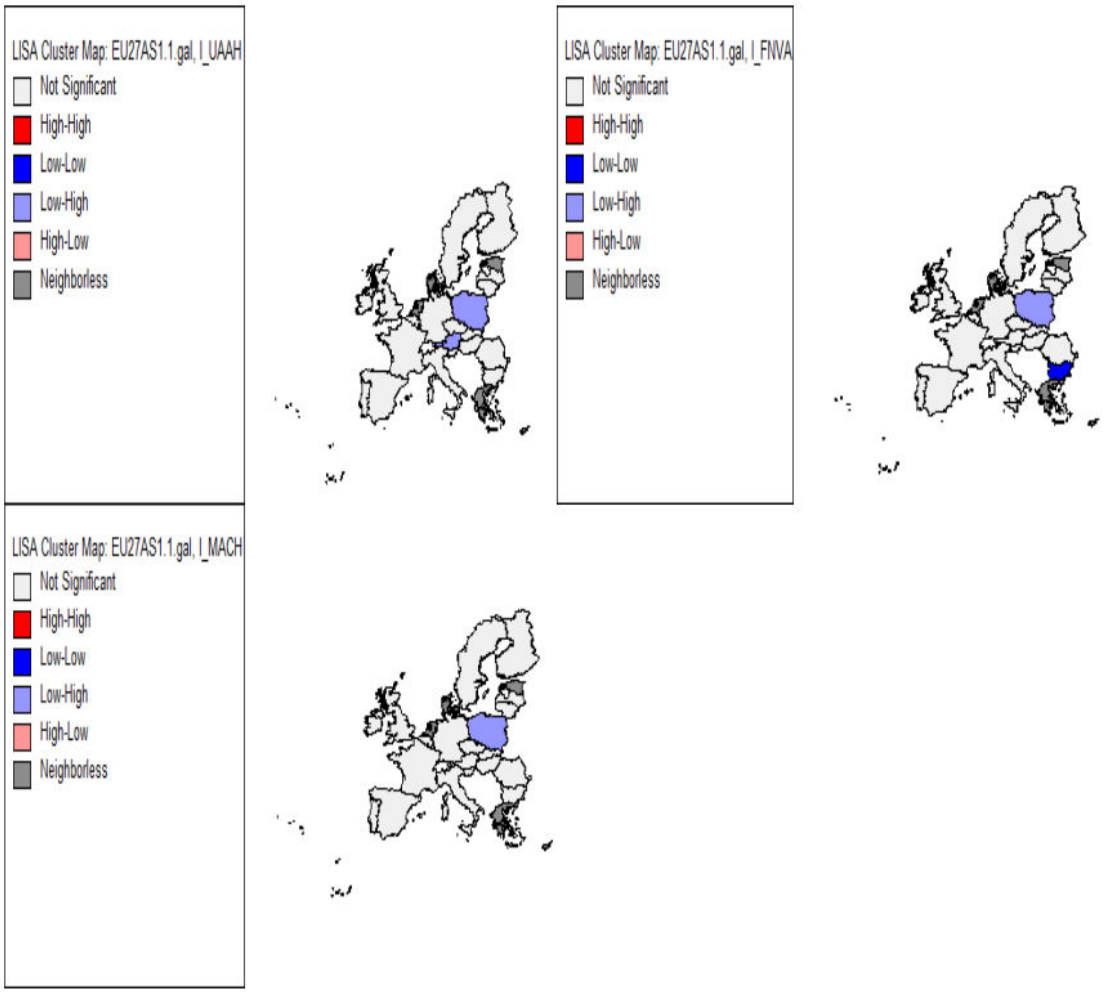


Table 4. Identification of agricultural systems through the farm index obtained for the European Union countries, over the period 2007-2009

Country	Cluster
Belgium Germany Estonia France Austria Finland Sweden	1
Czech Republic Netherlands Slovakia	2
Denmark Luxembourg United Kingdom	3
Bulgaria Cyprus Greece Spain Hungary Ireland Italy Lithuania Latvia Malta Poland Portugal Romania Slovenia	4

Table 5. Identification of agricultural systems through the farm index obtained for the European Union regions, over the period 2007-2009

Country	Region	Cluster
Germany	Schleswig-Holstein	1
Germany	Hamburg	
Germany	Niedersachsen	
Germany	Nordrhein-Westfalen	
Germany	Hessen	
Germany	Rheinland-Pfalz	
Germany	Baden-Württemberg	
Germany	Bayern	
Germany	Saarland	
France	Champagne-Ardenne	
France	Haute-Normandie	
France	Centre	
France	Basse-Normandie	
France	Bourgogne	
France	Nord-Pas-de-Calais	
France	Lorraine	
France	Alsace	
France	Franche-Comté	
France	Pays de la Loire	
France	Bretagne	
France	Poitou-Charentes	
France	Aquitaine	
France	Midi-Pyrénées	
France	Limousin	
France	Rhône-Alpes	
France	Auvergne	
France	Provence-Alpes-Côte d'Azur	
France	Corse	
Italy	Aosta	
Italy	Piemonte	
Italy	Lombardia	
Italy	Veneto	
Italy	Friuli-Venezia	

Italy	Toscana	
Belgium	Vlaanderen	
Belgium	Wallonie	
United Kingdom	England-North	
United Kingdom	England-West	
United Kingdom	Wales	
United Kingdom	Northern Ireland	
Austria	Austria	
Finland	Etela-Suomi	
Finland	Sisa-Suomi	
Finland	Pohjanmaa	
Finland	Pohjois-Suomi	
Sweden	Slattbygdslan	
Sweden	Skogs-och mellanbygdslan	
Sweden	Lan i norra	
Estonia	Estonia	
Hungary	Közép-Dunántúl	
Hungary	Nyugat-Dunántúl	
Hungary	Dél-Dunántúl	
France	Île-de-France	
France	Picardie	
Luxembourg	Luxembourg	
Netherlands	The Netherlands	
Denmark	Denmark	2
United Kingdom	England-East	
United Kingdom	Scotland	
Czech Republic	Czech Republic	
(SVK) Slovakia	Slovakia	
Germany	Brandenburg	
Germany	Mecklenburg-Vorpommern	
Germany	Sachsen	3
Germany	Sachsen-Anhalt	
Germany	Thueringen	
France	Languedoc-Roussillon	4
Italy	Trentino	
Italy	Alto-Adige	
Italy	Liguria	
Italy	Emilia-Romagna	
Italy	Marche	
Italy	Umbria	
Italy	Lazio	
Italy	Abruzzo	
Italy	Molise	
Italy	Campania	
Italy	Calabria	
Italy	Puglia	
Italy	Basilicata	
Italy	Sicilia	
Italy	Sardegna	
Ireland	Ireland	
Greece	Makedonia-Thraki	
Greece	Ipiros-Peloponissos-Nissi Ioniou	
Greece	Thessalia	
Greece	Sterea Ellas-Nissi Egaeou-Kriti	
Spain	Galicia	
Spain	Asturias	
Spain	Cantabria	
Spain	Pais Vasco	
Spain	Navarra	
Spain	La Rioja	
Spain	Aragón	
Spain	Cataluna	
Spain	Baleares	
Spain	Castilla-León	
Spain	Madrid	
Spain	Castilla-La Mancha	
Spain	Comunidad Valenciana	
Spain	Murcia	
Spain	Extremadura	
Spain	Andalucia	
Spain	Canarias	
Portugal	Norte e Centro	
Portugal	Ribatejo e Oeste	
Portugal	Alentejo e do Algarve	
Portugal	Açores e Madeira	

Cyprus	Cyprus	
Hungary	Közép-Magyarország	
Hungary	Észak-Magyarország	
Hungary	Észak-Alföld	
Hungary	Dél-Alföld	
Latvia	Latvia	
Lithuania	Lithuania	
Malta	Malta	
Poland	Pomorze and Mazury	
Poland	Wielkopolska and Slask	
Poland	Mazowsze and Podlasie	
Poland	Małopolska and Pogórze	
Slovenia	Slovenia	
Bulgaria	Severozapaden	
Bulgaria	Severen tsentralen	
Bulgaria	Severoiztochen	
Bulgaria	Yugozapaden	
Bulgaria	Yuzhen tsentralen	
Bulgaria	Yugoiztochen	
Romania	Nord-Est	
Romania	Sud-Est	
Romania	Sud-Muntenia	
Romania	Sud-Vest-Oltenia	
Romania	Vest	
Romania	Nord-Vest	
Romania	Centru	
Romania	Bucuresti-Ilfov	

From the table 5 it is possible to observe that the majority of the Germanic, French and British regions are grouped in the cluster 1, as well some regions from Italy and Hungary. In turn, all regions from Belgium, Austria, Finland, Sweden and Estonia are here clustered. In the cluster 2 are some regions from France (Île-de-France and Picardie) and from United Kingdom (England-East and Scotland). Countries with only 1 region as Netherlands, Denmark, Luxembourg, Czech Republic and Slovakia area also part of this cluster 2. The Germanic regions of Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt and Thueringen constitute the cluster 3. The cluster 4 has the majority of the Italian regions, all regions from Greece, Spain, Portugal, Poland, Bulgaria and Romania and other countries with only 1 region as Cyprus, Malta, Latvia, Lithuania and Slovenia. There are here some similarities with the analysis made before at country level, however, this analyses at region level shows that inside each country there are significant differences.

The results showed in the table 6 (at region level and for the period 2012-2013), in general, are similar with those presented in the table 5, however the differences evidenced reveal that the year among the period 2007-2009 and 2012-2013 promoted changes in the European Union farming dynamics.

Table 6. Identification of agricultural systems through the farm index obtained for the European Union regions, over the period 2012-2013

Country	Region	Cluster
Germany	Schleswig-Holstein	1
Germany	Niedersachsen	
Germany	Nordrhein-Westfalen	
Germany	Hessen	
Germany	Rheinland-Pfalz	
Germany	Saarland	
France	Île-de-France	
France	Champagne-Ardenne	
France	Picardie	
France	Haute-Normandie	
France	Centre	
France	Basse-Normandie	
France	Bourgogne	
France	Nord-Pas-de-Calais	
France	Lorraine	
France	Alsace	
France	Franche-Comté	
France	Pays de la Loire	
France	Bretagne	
France	Poitou-Charentes	
Belgium	Vlaanderen	
Belgium	Wallonie	
Luxembourg	Luxembourg	

Netherlands	The Netherlands	
Denmark	Denmark	
United Kingdom	England-North	
United Kingdom	England-East	
United Kingdom	England-West	
United Kingdom	Wales	
United Kingdom	Scotland	
Sweden	Slattbygdslan	
Sweden	Skogs-och mellanbygdslan	
Sweden	Lan i norra	
Czech Republic	Czech Republic	
Slovakia	Slovakia	
Germany	Brandenburg	
Germany	Mecklenburg-Vorpommern	
Germany	Sachsen	2
Germany	Sachsen-Anhalt	
Germany	Thueringen	
Germany	Hamburg	
Germany	Baden-Württemberg	
Germany	Bayern	
France	Aquitaine	
France	Midi-Pyrénées	
France	Limousin	
France	Rhône-Alpes	
France	(0193) Auvergne	
France	Languedoc-Roussillon	
France	Provence-Alpes-Côte d'Azur	
France	Corse	
France	Martinique	3
Italy	Lombardia	
Italy	Friuli-Venezia	
United Kingdom	Northern Ireland	
Spain	Navarra	
Austria	Austria	
Finland	Etela-Suomi	
Finland	Sisa-Suomi	
Finland	Pohjanmaa	
Finland	Pohjois-Suomi	
Estonia	Estonia	
Hungary	Dunántúl	
France	Guadeloupe	4
France	La Réunion	
Italy	Aosta	
Italy	Piemonte	
Italy	Trentino	
Italy	Alto-Adige	
Italy	Veneto	
Italy	Liguria	
Italy	Emilia-Romagna	
Italy	Toscana	
Italy	Marche	
Italy	Umbria	
Italy	Lazio	
Italy	Abruzzo	
Italy	Molise	
Italy	Campania	
Italy	Calabria	
Italy	Puglia	
Italy	Basilicata	
Italy	Sicilia	
Italy	Sardegna	
Ireland	Ireland	
Greece	Makedonia-Thraki	
Greece	Ipiros-Peloponissos-Nissi Ioniou	
Greece	Thessalia	
Greece	Sterea Ellas-Nissi Egaeou-Kriti	
Spain	Galicia	
Spain	Asturias	
Spain	Cantabria	
Spain	Pais Vasco	
Spain	La Rioja	
Spain	Aragón	
Spain	Cataluna	
Spain	Baleares	

Spain	Castilla-León
Spain	Madrid
Spain	Castilla-La Mancha
Spain	Comunidad Valenciana
Spain	Murcia
Spain	Extremadura
Spain	Andalucia
Spain	Canarias
Portugal	Norte e Centro
Portugal	Ribatejo e Oeste
Portugal	Alentejo e do Algarve
Portugal	Açores e Madeira
Cyprus	Cyprus
Hungary	Észak-Magyarország
Hungary	Alföld
Latvia	Latvia
Lithuania	Lithuania
Malta	Malta
Poland	Pomorze and Mazury
Poland	Wielkopolska and Slask
Poland	Mazowsze and Podlasie
Poland	Małopolska and Pogórze
Slovenia	Slovenia
Bulgaria	Severozapaden
Bulgaria	Severen tsentralen
Bulgaria	Severoiztochen
Bulgaria	Yugozapaden
Bulgaria	Yuzhen tsentralen
Bulgaria	Yugoiztochen
Romania	Nord-Est
Romania	Sud-Est
Romania	Sud-Muntenia
Romania	Sud-Vest-Oltenia
Romania	Vest
Romania	Nord-Vest
Romania	Centru
Romania	Bucuresti-Ilfov

Characterizing agricultural systems

Considering the differences found in the characteristics of the European Union farms between the two periods analyzed, it was considered only the clusters obtained at regional level in the more recent period (2012-2013). With the results for the four clusters obtained for this second period it was obtained means for the variables available in the FADN (2017) database across the regions inside each cluster, getting one agricultural system for each cluster (AS1 for the cluster 1 and so on). The results are those presented in tables 7 to 12 and are considered to characterize the European agricultural systems.

From the table 7 (with values for the economic size, labour, area and land occupation) it is possible to observe that the agricultural system 2 (AS2) for the Germanic regions of Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt and Thueringen has the larger economic size (710.33 euros), labour input (17164.18 hours), utilized agricultural area (440.99 ha), namely for cereals (207.34 ha) and forage crops (138.62 ha). In turn the AS4 is the agricultural system with, in general, lower values for the variables considered in this table, exception for the permanent crops.

The table 8 for the values related with the livestock units and with the crops output confirms the tendency referred before for the values presented in the table 7, however, there are some relevant differences. In fact, the AS2 shows the greater values for the livestock units, exception for the sheep and goats (higher in the AS1). The lower values are again verified in the AS4 for the animal activities dimensions. About the crops output, the AS2 does not reveals the greater performance in the total crops output by ha (area productivity), where presents the lower values, in the fruits output (including citrus fruit), wine and grapes and olive and olive oils. The AS4 has the best values for the olive and olive oils. About the livestock outputs (table 9) the results confirm the high performance in the AS2 (exception again in the sheep and goat productions) and the low dynamics in the AS4.

The AS2 in line with the higher values for the area and agricultural outputs has too the greater indicators for the inputs and respective costs (table 10), exception for specific crop

costs by ha that presents the lower value (AS3 is the agricultural systems with more specific crop costs/ha), what are in consonance with the findings in the table 8 for the area productivity in the AS2.

Table 7. Characterization of agricultural system through the economic size, labor and agricultural area occupation

	Economic size (euro)	Labour input (hours)	Paid labour Input (hours)	Unpaid labour input (hours)	Total Utilised Agricultural Area (ha)	Rented U.A.A. (ha)	Cereals (ha)	Energy crops (ha)
AS1	198.81	4820.21	2098.66	2721.55	122.50	89.54	42.28	0.76
AS2	710.33	17164.18	14994.76	2169.42	440.99	334.26	207.34	5.23
AS3	107.12	3537.41	1142.10	2395.30	56.67	35.58	16.49	0.08
AS4	39.73	3108.01	744.66	2363.35	25.60	13.06	8.41	0.01

	Vegetables and flowers (ha)	Vineyards (ha)	Permanent crops (ha)	Olive groves (ha)	Orchards (ha)	Forage crops (ha)	Total agricultural area out of production (ha)	Woodland area (ha)
AS1	0.83	0.64	0.35	0.00	0.27	60.83	1.82	1.07
AS2	1.24	0.01	1.31	0.00	0.73	138.62	5.28	5.18
AS3	0.39	1.80	1.05	0.08	0.89	31.37	1.70	1.96
AS4	0.27	0.73	1.88	0.92	0.94	10.06	1.56	1.61

Table 8. Characterization of agricultural system through the livestock units, total output and crops output

	Total livestock units (LU)	Dairy cows (LU)	Other cattle (LU)	Sheep and goats (LU)	Pigs (LU)	Poultry (LU)	Milk yield (Kg/cow)	Total output (euro)	Total output crops & crop production (euro)	Total crops output / ha (euro)	Cereals (euro)
AS1	96.62	20.16	38.89	7.29	20.78	9.12	7407.26	261774.33	127216.83	1373.94	52543.69
AS2	251.96	62.71	74.73	3.63	97.28	12.80	8777.22	1029078.20	498802.80	1137.65	259904.20
AS3	42.42	7.74	19.00	3.87	8.36	3.27	7059.50	126827.43	69521.98	3620.85	15960.83
AS4	15.51	2.59	4.71	2.47	3.53	2.08	5341.20	42717.31	25985.71	2029.21	6561.50

	Potatoes (euro)	Sugar beet (euro)	Oil-seed crops (euro)	Industrial crops (euro)	Vegetables & flowers (euro)	Fruit (euro)	Citrus fruit (euro)	Wine and grapes (euro)	Olives & olive oil (euro)	Forage crops (euro)
AS1	7911.00	6039.23	12583.04	1040.57	16138.56	2185.06	0.00	12165.67	1.00	10662.59
AS2	12178.20	23690.10	113694.00	1053.20	31073.00	5487.90	0.00	158.40	0.00	41456.80
AS3	945.59	487.72	2735.63	579.35	18576.22	7937.33	1254.11	13800.07	287.50	5094.65
AS4	661.84	153.06	1455.70	794.41	4331.50	3350.84	643.01	3248.90	1471.20	2042.02

Table 9. Characterization of agricultural system through the livestock and others outputs

	Total output livestock & livestock products (euro)	Total livestock output / LU (euro)	Cows' milk & milk products (euro)	Beef and veal (euro)	Pigmeat (euro)	Sheep and goats (euro)
AS1	116626.96	1223.36	52584.49	24839.79	21056.94	3383.34
AS2	393024.70	1567.45	193143.00	42181.10	131424.10	1546.70
AS3	49222.28	1176.27	21366.80	12385.52	7555.04	1930.50
AS4	15316.77	1049.45	5110.38	2870.00	2533.63	990.86

	Poultrymeat (euro)	Eggs (euro)	Ewes' and goats' milk (euro)	Other output (euro)	Farmhouse consumption (euro)	Farm use (euro)
AS1	5225.33	3529.99	1004.64	17930.50	423.24	14931.94
AS2	12309.10	6883.20	543.50	137250.60	117.00	41749.20
AS3	1766.46	623.13	1794.72	8083.28	283.65	7391.09
AS4	1010.79	669.15	1251.58	1414.84	380.43	1975.63

Table 10. Characterization of agricultural system through the several inputs

	Total Inputs (euro)	Total specific costs (euro)	Specific crop costs / ha (euro)	Seeds and plants (euro)	Fertilisers (euro)	Crop protection (euro)	Specific livestock output / LU (euro)	Feed for grazing livestock (euro)	Feed for pigs & poultry (euro)
AS1	256257.14	107139.87	440.16	11054.70	17336.99	11265.26	640.95	33449.73	20405.97
AS2	1070433.60	407224.40	406.52	36705.90	72830.00	50149.20	897.74	92639.70	95778.50
AS3	127557.35	45455.63	1077.79	5822.54	7316.50	3755.67	637.31	15634.98	6290.41
AS4	34797.35	15009.44	434.42	1630.94	2521.98	1455.39	566.99	5128.05	2723.37

	Forestry specific costs (euro)	Machinery & building current costs (euro)	Energy (euro)	Contract work (euro)	Depreciation (euro)	Wages paid (euro)	Rent paid (euro)	Interest paid (euro)	Taxes (euro)
AS1	42.00	15917.16	18341.76	14889.77	37323.66	20458.17	14364.49	8267.31	2171.07
AS2	350.40	67981.60	87287.40	39378.10	106611.40	183758.90	60379.60	26249.90	8300.20
AS3	18.70	10355.52	10001.87	7494.22	20728.57	12133.78	5294.13	2455.83	1530.37
AS4	3.28	1820.32	3460.53	1332.54	5168.09	3628.95	1593.40	384.41	646.62

Table 11. Characterization of agricultural system through the economic results and financial indicators

	VAT on investment (euro)	Gross Farm Income (euro)	Farm Net Value Added (euro)	Total assets (euro)	Total fixed assets (euro)	Land, permanent crops & quotas (euro)	Buildings (euro)	Machinery (euro)	Breeding livestock (euro)
AS1	1109.33	126037.83	88714.13	920140.71	722903.79	437790.37	120732.63	120433.06	43947.70
AS2	463.40	500150.50	393539.20	2146017.80	1475276.40	660947.20	293575.50	420171.30	100582.60
AS3	417.87	67741.46	47012.76	456180.89	343155.70	196055.28	66436.39	59439.63	21224.30
AS4	146.18	26449.30	21281.15	231066.30	178280.92	124378.13	27163.76	19868.19	6870.86

	Total current assets (euro)	Non-breeding livestock (euro)	Stock of agricultural products (euro)	Total liabilities (euro)	Long & medium-term loans (euro)	Short-term loans (euro)	Net worth (euro)	Gross Investment (euro)	Net Investment (euro)	Cash Flow (euro)
AS1	197237.00	35884.66	37570.26	252427.29	192161.01	60266.19	667713.47	46022.63	8699.03	81817.91
AS2	670741.10	75598.30	50420.70	767290.50	521448.50	245842.10	1378727.20	197713.10	91101.80	230665.30
AS3	113025.17	14752.15	21033.30	89698.63	60476.93	29221.63	366482.39	22645.59	1916.98	49012.57
AS4	52785.36	3989.57	3693.08	8785.49	5842.25	2943.28	222280.77	6706.42	1538.30	20455.11

Table 12. Characterization of agricultural system through the several subsidies

	Total subsidies - excluding on investment (euro)	Total subsidies on crops (euro)	Set aside premiums (euro)	Total subsidies on livestock (euro)	Subsidies dairying (euro)	Subsidies other cattle (euro)	Subsidies sheep & goats (euro)	Other livestock subsidies (euro)	Environment subsidies (euro)
AS1	41146.24	338.89	0.00	1748.13	498.29	1032.94	91.33	125.59	4160.27
AS2	172115.10	782.70	0.00	1040.90	-90.70	0.00	0.00	1131.80	15508.50
AS3	28792.00	3297.20	0.00	4138.89	1427.04	1950.39	360.00	401.43	3787.57
AS4	8135.91	977.53	0.00	663.29	121.69	331.94	94.61	115.06	819.82

	LFA subsidies (euro)	Total support for rural development (euro)	Other rural development payments (euro)	Subsidies on intermediate consumption (euro)	Subsidies on external factors (euro)	Decoupled payments (euro)	Single Farm payment (euro)	Single Area payment (euro)	Subsidies on investment (euro)
AS1	2478.80	6766.40	127.29	766.40	275.49	30120.49	25879.07	4241.41	1710.11
AS2	6010.30	21601.00	82.20	13019.50	1651.30	130917.00	130917.00	0.00	4669.40
AS3	4491.48	8457.76	178.70	331.59	31.65	11531.15	10429.87	1101.28	1832.26
AS4	541.28	1515.35	154.26	78.89	4.84	4452.05	3133.05	1319.00	492.50

About the economic results and financial indicators (table 11) the tendencies for the greater values in the AS2 and lower indicators for the AS4 are again observed, however for the several subsidies (table 12) there are relevant differences. In fact, the AS2 evidences the higher values (and the AS4 the lower results) for the total subsidies (excluding on the investments), other livestock subsidies, environment subsidies, LFA subsidies, total support for rural development, subsidies on intermediate consumption, subsidies on external factors, decoupled payments, single farm payment and subsidies on investments. The total subsidies on crops, total subsidies on livestock, subsidies dairying, subsidies other cattle, subsidies sheep and goats and other rural development payments are higher in the AS3.

4. Conclusions

The work developed here intends to identify and characterize the agricultural systems (in a broader perspective considering representative farms) in European Union countries and regions, grouping the several countries, through cluster analysis, in sets where the respective farms have similarities in variables related with the structural, economic, policy and financial questions. It was considered as main indicators the utilized agricultural area (for the size of the farms), the farm net value added (competitiveness) and machinery (innovation and technology). These indicators represent the main aspects referred to in literature as being the principal factors that characterize the farming system. Considering the linear correlation among these indicators it was obtained through factor analyze a farm dimension-competitiveness-machinery index whose adequacy as representing the main European farming characteristics was confirmed. The cluster analysis was complemented with spatial autocorrelation observation, to examine the spatial linkage in the European farm characteristics.

The literature review revealed the diversity of farming systems in several European countries, with specifics in each country, and sometimes in each region or local, and showed the need in trying to find homogeneous sets for the European farms in order to better design and plan the strategies for the sector which are intended to be adjusted for the reality in each case and each particularity. But at the least adjusted for each country, what is not always easy when it is necessary to define common policies.

With the farm index obtained they were obtained four clusters for period 2007-2009 (at country and regional level) and four clusters for the period 2012-2013 (at regional level). Considering that the farm index taken into account represents the main characteristics of the European farms, these clusters were considered as agricultural systems. The results, for the period 2007-2009 at country level, from the cluster and spatial data analysis show that the spatial autocorrelation is weak for the indicators considered, signaling that the neighboring countries have not, in general, great agricultural similarities and are not strongly spatially auto correlated. This was verified for the global, but also for the local spatial autocorrelation. There is some evidence of negative local autocorrelation in Poland (and neighbors) and positive low-low in Romania (and neighbors), namely for the farm net value added. The results at regional level for the two periods considered (2007-2009 and 2012-2013) reveal that there are some similarities with the results obtained at country level, however there are significant differences inside each country and the differences among the two periods.

For each agricultural system found it were calculated means with the values for the several variables available in the FADN (2017) database and across the different regions. About the characterization of the agricultural systems with the data for the period 2012-2013 (the more recent period and considering that there are differences between the two considered) of stressing the greater values, in general, for the agricultural system constituted by the Germanic regions Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt and Thueringen. In general, the lower indicators are observed in the agricultural system that integrate the all regions from Greece, Portugal, Poland, Bulgaria and Romania, countries with only one region as Cyprus, Malta, Latvia, Lithuania and Slovenia, the majority of the regions from Spain (exception for Navarra) and Italy (exception for Lombardia and Friuli-Venezia) and some regions from France (Guadeloupe and La Réunion) and from Hungary (Észak-Magyarország and Alföld).

These found may be an interesting contribution for the policymakers helping in the design of more adjusted strategies and for the agricultural operators supporting in the structural

decisions. In future research it will be important to complement these results with information obtained through surveys to complement information available in public databases.

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