

Dynamic analysis of European organic agricultural areas in the context of sustainable development

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Abstract

The aim of this research was to analyze changes in the size of the European organic agricultural areas between 2000 and 2014 and assess the factors that influenced and differentiated EU member states in this context. The analyses showed the development potential of the EU countries for extension of organic agricultural areas in a comparative manner, based on their future economic development capacities. The article used two multivariate statistical methods, principal components analysis and multiple regression method, to establish and assess the influence of the main factors that contributed to changes in the size of national organic areas. The main factors in 2014 were the European financing for agriculture and rural development, and the migration phenomenon.

Keywords

Principal components analysis, econometric model, sustainability, migration phenomenon

Introduction

The principles of sustainability assume the development of current agriculture to satisfy people's needs without negatively influencing future generations (Seufert, 2012). Since 1980, research has tried to show that organic agriculture is an important alternative agricultural production system, bringing significant benefits to both the economy as well as to social cohesion in rural areas (Annunziata and Vecchio, 2016; Wheeler, 2008). In recent years, researchers have studied the efficacy of organic and nonorganic farming according to the four pillars of sustainability, namely, economy, environment, productivity, and community well-being. Some believe that organic agriculture cannot meet the increasing demand for food and cannot be considered a sustainable form of farming in the future (Reganold, 2016; Seufert, 2012; Trewavas, 2001). The sustainability of organic agriculture is measured by economic profit, the social benefits for communities, and its contribution to environmental conservation (Bengtsson et al., 2005; Halberg et al., 2005; Lotter et al., 2003). Scientists argue that the most visible advantages of organic agriculture include conserving soil and water resources, improving soil and water quality, enhancing species' diversity, sustaining farming yield, producing quality products, and natural control of pests with reduced environmental pollution (Altieri, 2002; Eickhout, Meijl, Tabeau, and Rheen, 2007). There are studies that show organic agriculture can generate profitable yields for farmers and can protect and improve the

environment, while being safer for farm workers (Reganold and Wachter, 2016). There are many factors that influence the profitability of organic agriculture including crop yields (Nink, 2015). The economic sustainability of organic agriculture depends on adequate prices for organic products and accessibility to international organic markets. To enhance the social sustainability of organic agriculture, ecological certification costs should be kept to a minimum, and ideally supported by both consumers and producers. While organic agriculture has the potential to contribute to feeding a growing population, some significant barriers hinder expansion (Reganold, 2016). The development of the organic sector at country level is influenced by a wide range of factors, including not only the economic development level but also the educational level of population regarding the consumption of organic products. Consumers need to be educated in order to understand the benefits of organic food and the sustainability concept for living and maintaining a clean environment. The total organic area in the European Economic Area (EEA), excluding Malta for

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which data were missing in the period analyzed, and EFTA countries (Norway, Switzerland, Iceland, and Liechtenstein) has increased from 4,373,731 ha in 2000 to 10,446,850 ha in 2014. The increase in the organic area between 2013 and 2014 was 2.3% (Eurostat, 2016). Based on these considerations, this article aims to analyze the size and evolution of organic agricultural areas in European countries and identify the factors that have most influenced their differential expansion.

Methodology

The purpose of this research was to analyze changes between 2000 and 2014 and identify those factors that influenced the growth in organic agricultural areas in the EU member states. Using principal components analysis (PCA), the development potential of organic agricultural areas and main influencing factors were determined. PCA is a descriptive method that helps examine the relationships between interrelated variables in a data set, which belong to the basic structure of a domain. PCA reduces the number of variables by combining them and representing the structure of the domain in terms of usually at least two new dimensions, called main components. A main component is a linear combination of those variables that are most correlated with this new dimension, either in a negative or a positive way. The component then gathers those variables that are most correlated with it. The higher the correlation coefficient of a variable with the component, the more it is considered linked to that component. The two components are considered to be the new main factors. They are abstract variables that receive names according to the meaning of the variables' combination. The names of the new components are defined by the researcher who also interprets these new dimensions, based on the meaning of the related variables' content. The first component corresponds to the Ox axis and the second corresponds to the Oy axis in a figure termed "the circle of correlations." Even if this figure does not represent a circle, it could be imagined as one with the radius of 1, based on the interval of the correlation coefficient's limits. In this figure, the first component on the Ox axis has the directly correlated variables on the right side, to which there are opposed the inversely correlated variables on the left side. For the second component, the positively correlated variables are close to the Oy axis on the upper side of the figure and on the downside are the inversely correlated variables with the second component. Using the IBM SPSS Statistics 23 software, PCA was implemented with factors identified as having contributed to different size developments in EU organic agricultural areas in 2014. The following variables were considered:

- organic area (ha) in 2014 and proportion in national agriculture land (Eurostat, 2016);
- direct payments for rural development (Euro) in 2014 prices, from a breakdown of overall amounts of the Multiannual Financial Framework of CAP, for the period 2014–2020. The European financing programs for agriculture and rural development also

contain direction measures for organic farming (Eurostat, 2016);

- national population (% of total population) on January 1, 2014 and number of immigrants and emigrants in 2013, to explain the influence of the migration phenomenon and contribution to agricultural development (Eurostat, 2016);
- unemployment rates in 2013 and 2014 (Eurostat, 2016);
- gross national income (GNI) per capita in 2014 (2011 Purchasing Power Parity (PPP) \$) (Eurostat, 2016);
- Human Development Index (HDI) in 2013 and 2014, an aggregate coefficient representing a measure of wealth, health, and education level of population (Eurostat, 2016);
- Corruption Perceptions Index (CPI) in 2014, to characterize public administration. CPI is calculated on a scale 0–100; a higher value meaning a better perception of the population for low levels of public administration corruption (Countryeconomy.com, 2016);
- distribution of population by degree of urbanization (%) in 2013 and 2014 (Eurostat, 2016);
- material deprivation rate expressed as a percentage of total population in 2014 (Eurostat, 2016);
- activity rates of population from 15 to 64 years (%) in 2013 and 2014 (Eurostat, 2016); and
- Overall Life Satisfaction Index (OLSI) in 2013 and the evaluation of the meaning of life, rated from 1 to 10, based on Eurostat population surveys (Eurostat, 2016).

Some variables were considered for both 2013 and 2014 because of inertia acting in the socioeconomic development, caused not only by aspects related to the behavior of production and consumption, habits, education, and cultural aspects and expectations, but also by wealth and health levels previously attained. The econometric approach is an explanatory method, which is applied here for an analysis of the influence of different factors on the size variation in organic areas in the European Union countries. The explanatory variables in the econometric model were the variables initially considered in PCA. The econometric model for explaining the size variation contained exactly the same variables as the description of the organic development component of PCA. A modern approach is to build an econometric model based on the results of a PCA. In this article, the econometric approach was used to check the PCA results and validate the identified variables as being important factors for the different development of the organic sector in EU countries.

Results and discussion

Evolution of national organic areas in Europe between 2000 and 2014

Over the last decade, the number of organic producers as well as the area under organic production has grown

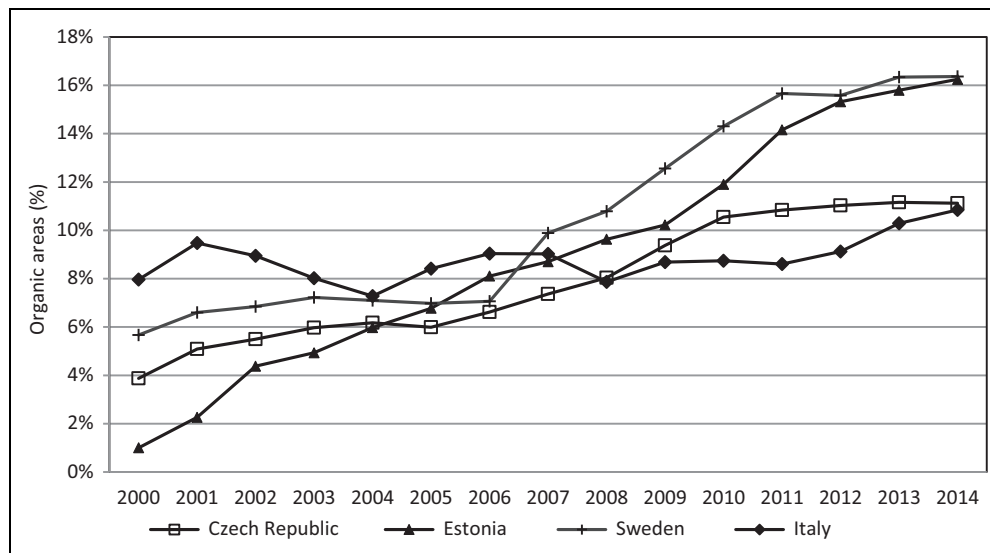


Figure 1. The highest organic area proportions (%) in selected EU countries between 2000 and 2014. EU: European Union.

steadily. Each year, 500,000 hectares of agricultural land have been converted to organic production in the European Union (Europa, 2016). Since 2000, the size of the European organic area and their proportions nationally experienced large change (FAO, 2016). Figure 1 shows countries with the greatest proportion of organic areas in their national agricultural lands in 2014. Estonia had the fastest growth in organic area proportion, from 1% in 2000 up to 16.2% in 2014. Sweden had the greatest weight of organic agricultural area in 2014; rising from 5.7% in 2000 up to 16.4% in 2014. Similarly, the Czech Republic grew from 3.9% in 2000 to 11.1% in 2014. From the developed countries, Italy had an oscillating evolution with cycles of 4 years, with an almost constant rate of between 8% in 2000 and 10.8% in 2014. The other European countries had lower percentages of organic areas in their agricultural lands, typically less than 10%, between 2000 and 2014, but with a gradual increasing tendency. The proportions of organic areas in selected countries from this group include Finland from 6.6% to 9.4%, Norway from 2% to 4.6%, Germany from 3.2% to 6.3%, Slovakia from 2.7% to 9.5%, Spain from 1.5% to 6.9%, France from 1.3% to 4.1%, and Slovenia from 1.1% to 8.9%. Liechtenstein increased its organic area from 19.5% to 30.9%, while the United Kingdom remained stable at 3%. For all countries, the extension of organic areas was not affected by the economic crisis between 2008 and 2009.

Development potential of organic agricultural areas in the European Union (2014)

The total organic area in the EU-28 (i.e. the area fully converted to organic production and under conversion) was 10.3 million ha in 2014. The national organic areas offer a basis for analyzing the development of organic production in Europe (Figure 2). The Oy axis shows the size of the organic area in all European countries in 2014, and on the Ox axis, the average dynamic rates recorded by each country of the change in the organic area between 2000 and

2014. The average level of organic areas of the EU countries in 2014 defines two frames: EU countries having organic areas greater than the European average are positioned above the horizontal line and countries with lower values are below. The average of the dynamic rates of organic area change between 2000 and 2014 on the Ox axis is a vertical line, on which defines two frames: EU countries having dynamic rates lower than the average situated on the left side of this line and countries with values higher than the average on the right-hand side. The intersection of the two average lines defines four frames in which the countries are located. The countries have relative positions; their distances to the intersection of averages show the starting level of the indicator in 2014, and on the Oy axis, and the development potential for the future, on Ox axis, assuming conditions will remain the same. Figure 2 shows the relative positions of each EU country in 2014, regarding the size of organic area compared to average level and the development potential compared to the average of the national dynamic rates between 2000 and 2014, with in four frames termed *Leaders*, *Followers*, *Trailers*, and *Catching up* (Gottinger and Goosen, 2011).

In the first frame *Leaders*, only Poland is placed above the average level of organic areas of all the countries in 2014, having a high level of annual dynamic growth (27.5%). The second frame *Followers* contains countries with high levels of organic areas, above the European average, but with dynamic rates that are less than the average rate of all European countries. These include Spain, Italy, Germany, and France, which have an area in excess of 1,000,000 ha, forming a subgroup. Another subgroup is identified around 500,000 ha consisting of the United Kingdom, Austria, Czech Republic, and Sweden. The first two frames, *Leaders* and *Followers*, comprise countries with organic areas greater than the European average. The third and fourth frames, *Trailers* and *Catching up*, include countries under the European average size for organic areas. The *Trailers* countries also have lower dynamic rates than the average rate; they can hardly extend their organic agricultural

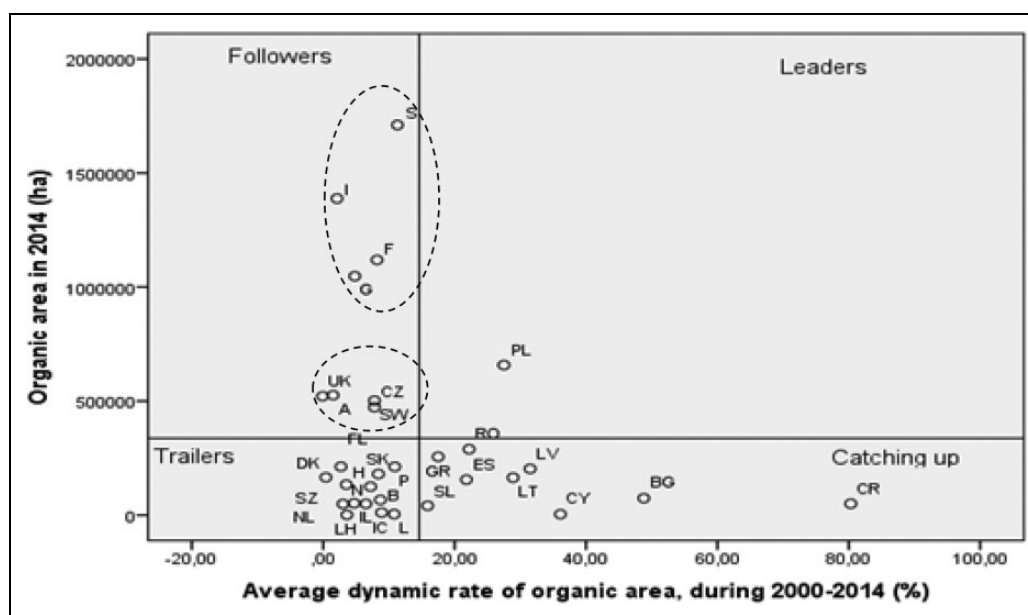


Figure 2. Analyzing the development potential of European organic areas in 2014.

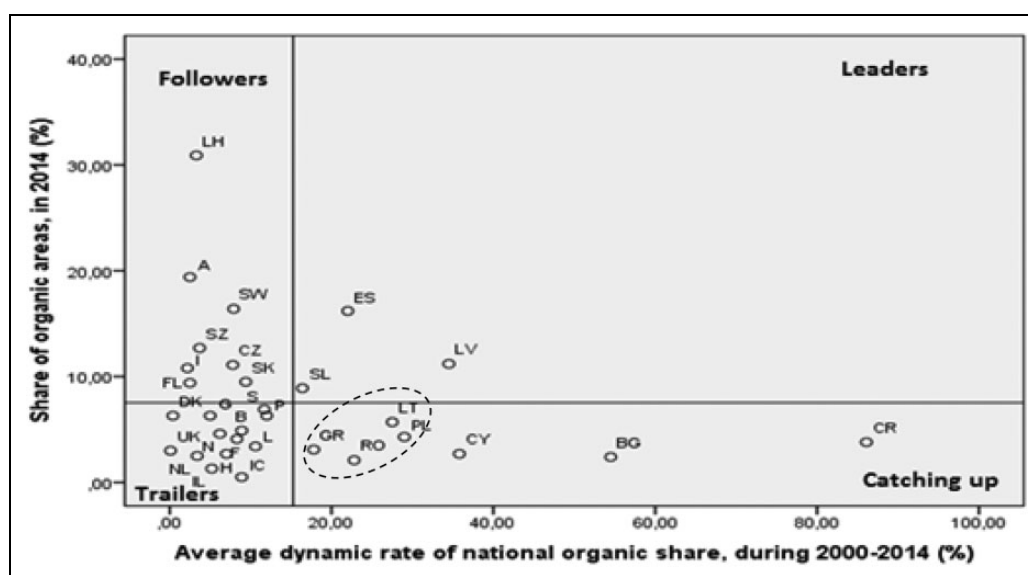


Figure 3. Development potential of organic proportion (%) in national agricultural lands in 2014.

areas. The countries in the fourth frame all have opportunities to catch up with countries in the first frame; they have high dynamic rates in the organic area. Croatia was an outlier in this frame, with the highest change rate. Bulgaria has had an annual increase of more than 40%, followed by Cyprus, Latvia, Lithuania, Romania, and Estonia, with dynamic rates between 20% and 40%. Greece and Slovenia are also part of this frame, with dynamic rates below 20%, but higher than 15%.

A similar analysis regarding the proportion of organic areas in the national agricultural lands and their annual change was completed (Figure 3). Such an analysis shows the countries' correlation with their geographical agricultural land potential and better emphasizes the organic area development. In Figure 3, at EEA level, the *Leaders* and *Followers* frames contain countries with high percentages of organic

areas in their national agricultural lands, above the European average in 2014. Estonia and Latvia are the *Leaders*. In the *Followers*, Liechtenstein has the highest proportion of organic land, followed by Austria, Sweden, and other developed countries. In the *Catching up* frame, Croatia is an outlier, followed by Bulgaria and Cyprus. A group of four countries including Poland, Lithuania, Romania, and Greece, all placed under the European average, have high development potential with annual dynamic rates around 20%.

Identifying the main influence factors for the development of EU organic agricultural areas

Using PCA, the initial model with two components explains close to 58% of the entire variance of units, that

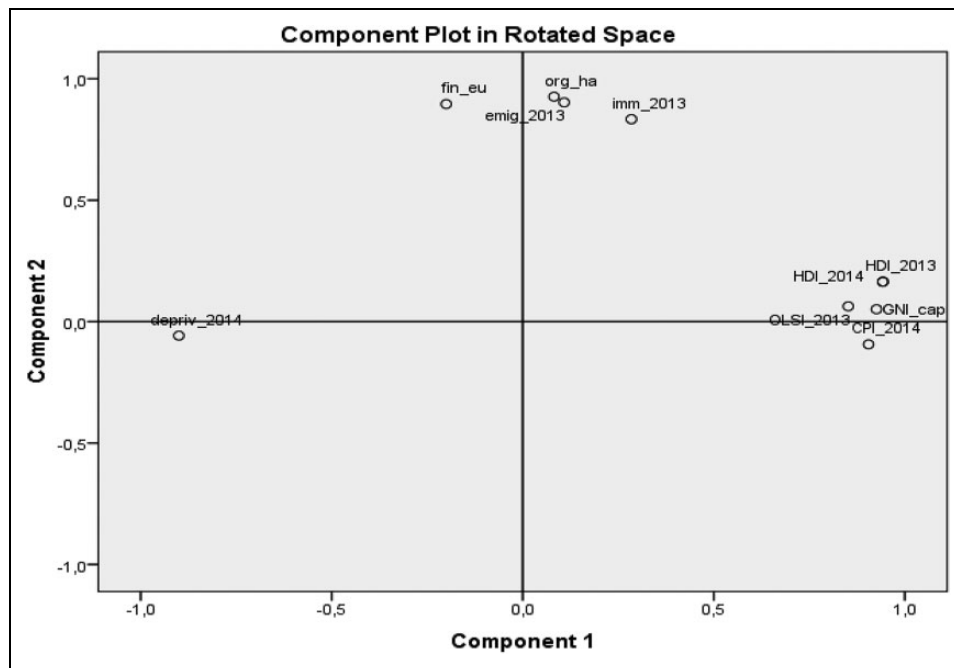


Figure 4. The circle of correlations with the components of the socioeconomic development and the development of organic farming (2014).

is, the EU-28 countries. The model performs better when it has a high determination coefficient, meaning a better explanation of the units' variation depending on the two new defined dimensions, termed the main components. For each component, the SPSS software provides the proportion of variation explained in the total variation of units. The sum of the explained variation by the two components represents the determination coefficient, which reflects model validity. We eliminate from the PCA model the variable having a low correlation with the component it describes. Keeping the strongly correlated variables with the components leads to a better model. In successive PCA iterations, certain variables were gradually eliminated, including activity rates in 2013 and 2014, the proportion of organic areas, the proportions of non-national population, and meaning of life; the resulting model then explained 83.7% of the variation across the EU countries. The circle of correlations (Figure 4) emphasizes two components, namely (i) socioeconomic development level which includes HDI in 2013 and 2014, OLSI in 2013, GNI per capita in 2014, CPI in 2014, all opposed to material deprivation rate in 2014; and (ii) the development of organic farming, with direct payments for rural development, immigrants' number, emigrants' number in 2013, and organic area size. The migration phenomenon was also identified as being important for the second component of EU organic farming. Considering the influence of migration on the development of organic agriculture, the number of emigrants in 2013 is more strongly correlated with the second component, as shown in Figure 4, reflecting emigrants from less developed countries who had gone to work in countries including Spain, Italy, Germany, Poland, and the United Kingdom.

An improved model was found by eliminating further variables including OLSI in 2013, immigrants, emigrants in 2013, and CPI in 2014; the revised model had a

determination coefficient of 90.6%: the first component explaining 60.4% and the second of 30.2%. *The component of socioeconomic development* is defined by GNI per capita and HDI for the 2 years on the positive side and by the deprivation rate on the other side. *The component of organic development* consists of two variables: European financing and organic areas. Figure 5 shows the position of countries depending on these two described components. The group of well-developed countries with large projections on the positive side of the first component includes Denmark, the Netherlands, Luxembourg, and Sweden. These are at more than one standard deviation (SD) from the average level of the first component, but within an interval of 1 SD for the second component—organic agriculture development. Germany and France, with Spain and Italy, have a well-developed level of organic areas and are the largest beneficiaries of European funds in this sector. Poland is an outlier; it benefitted from a large amount of EU funding support and is at more than 1 SD from the average of the second component. Romania and Bulgaria are more than 2 SD from the first component; both countries could benefit from additional EU support for socioeconomic development, as both have high rates of material deprivation.

Eliminating the variable European financing from the PCA model resulted in an improved determination coefficient (91.7%). The best descriptive model was obtained with the second component consisting only of the size of the national organic area in the EU member states. The fact that the European financing programs did not significantly contribute to the extension of organic areas can be explained by the different ways of using funds for agricultural and rural development, and not only for land conversion into organic production. Figure 6 shows the relative positions of countries depending on the same two

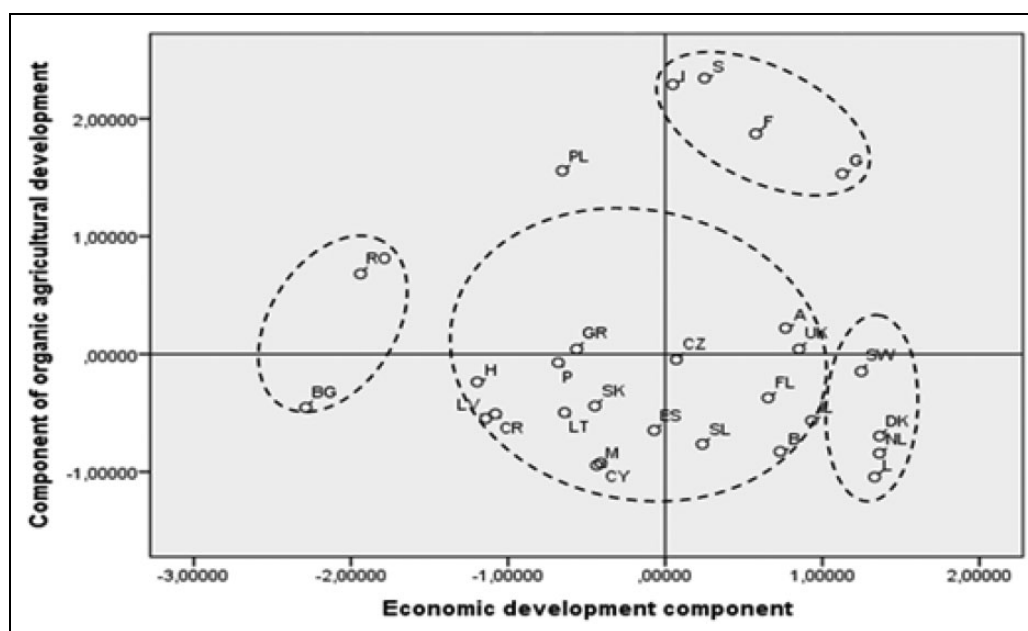


Figure 5. The EU countries' relative positions considering organic area and European funds, within the second component (2014). EU: European Union.

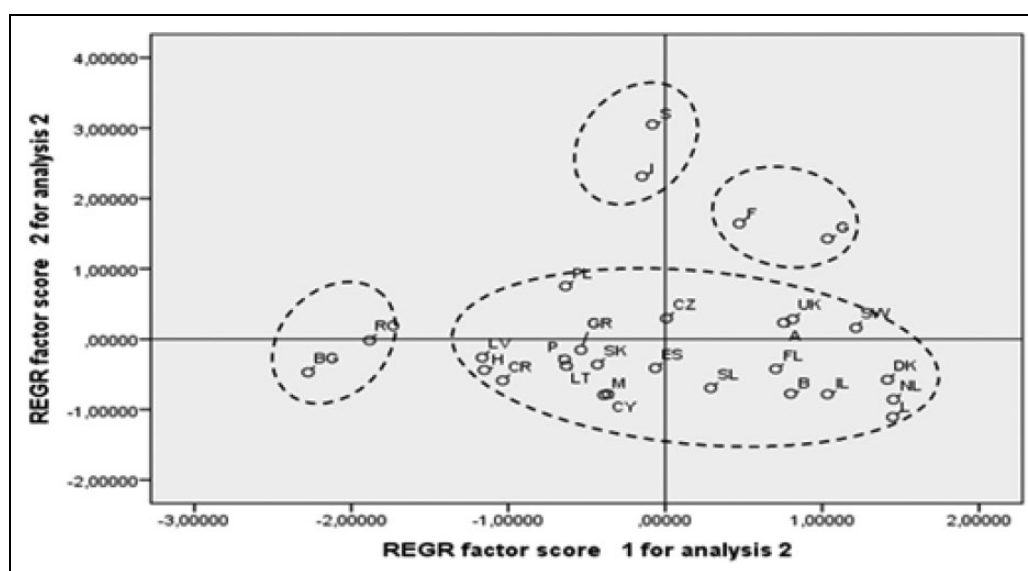


Figure 6. The EU countries' positions considering only organic area in the second component (2014). EU: European Union.

components. Organic agricultural areas are higher in Spain, Italy, France, and Germany. The PCA results for these countries can be explained through the positive influence of EU financing programs from previous years prior to 2014. The improved positions of Poland, Romania, and Bulgaria shown in Figure 5, compared to Figure 6, highlight the positive impact of EU funds on agriculture and rural development. All the PCAs showed very good models with determination coefficients around 90%.

Factors influencing the extension of national organic areas at EU level—an econometric approach

The descriptive results from PCA emphasized two components, namely socioeconomic development and organic

agricultural development. The second component has been considered in PCA as different combinations of variables, including organic area size and European funds in 2014, then only organic areas, another with organic areas and emigrants in 2013, and other with organic areas, emigrants in 2013, and European funds in 2014. In the econometric approach, in order to explain the variation in organic area size in EU countries—the dependent variable (y), all the variables presented in the previous PCA were considered as explanatory variables. The econometric model of national organic area development in EU agriculture, based on the initial variables, resulted in the same results as the PCA. The highly correlated explanatory variables with the size of an organic area were exactly those variables that were also identified with the PCA: European financing ($r = 0.804$),

Table 1. Extract from the regression table, without intercept, depending on European financing and emigrants' number.

Included observations: 28

$$y = C(1) \times x_1 + C(2) \times x_7$$

	Coefficient	Standard error	t Statistic	Probability
C(1)	0.000436	0.000113	3.845127	0.0007
C(2)	1.583966	0.481114	3.292292	0.0029

emigrant number ($r = 0.795$), and immigrant number ($r = 0.699$). In building the econometric model, all the explanatory variables describing the first component of socioeconomic development in PCAs were eliminated. Some variables are correlated, as HDI in 2014 and 2013, HDI with GNI per capita, and HDI with OLSI, CPI, and the material deprivation rate. To avoid the multicollinearity phenomenon these variables were eliminated. The difference between the organic area sizes of EU countries depended only on the factors that have defined the second component of the PCA, that is, organic agriculture development. The significant factors were the European funds for Common Agriculture Policy (CAP) for each country in 2014 (x_1) and the number of emigrants in 2013 (x_7). Using the sample of 28 countries in the European Union, the regression equation had the free term (intercept) insignificant; an extract of the regression model is given in Table 1.

$$\hat{y}_i = 0.00044x_{1i} + 1.584x_{7i}, \quad i = 1 \text{ to } 28$$

The determination coefficient (0.8534) shows that the two factors explain 85% of the variation between EU countries regarding the size of the organic area. The regression equation shows that for an increase of 1000 Euro for their allocated European funds in 2014, the national organic area increased on average by 0.44 ha. For each emigrant who left their birth country to go to another EU country, the organic area of the country increased by 1.584 ha. Many EU countries face the challenge of migration which cannot be ignored, with emigrants tending to work in the agriculture sector. Another aspect of the migration phenomenon is that migrants leave and abandon their own farmland to find a better life elsewhere. Usually migrants are poor people from the countryside. In Figure 7, the countries are presented in the descending order of organic area size, together with their theoretical areas estimated using the econometric model. The highest ranked countries are Leaders and Followers (see Figure 2), including Spain, Italy, France, Germany, and Poland. Some countries, including Poland, United Kingdom, Romania, and others, have theoretical values that are higher than their reported areas, meaning they still have development potential to extend their organic areas. Some of these countries are those in the Catching up category (Figure 2).

Implications and methodological limitations

The national profiles of organic area provide a basis for discussion in analyzing the development of organic agricultural production in Europe and the main countries

impacting on the organic product market (Figure 1). The country with the biggest organic development potential is Poland (Figure 2). This sector has evolved steadily since Poland's accession into the European Union in 2004. The increase is due in part to the composition of Polish agriculture, where small farms which are easily converted are often "organic by default," and chiefly driven by the objectives of EU Greening policy through subsidization for organic operations (Global Agricultural Information Network, 2013).

The limitations of this analysis include defining the meaning of "development potential" as being the average dynamic rate, calculated for a period during which the level indicator should have had a constant evolution, without great variability and also the assumption that past conditions will be similar in future. We found that the crisis in 2008–2009 had no influence on the organic farming sector, and that the growth in the area was almost constant across all EU countries. The advantage is in combining the static and dynamic aspects of a level indicator, in this case organic area size.

The organic area of each country depends on various social, cultural, geographical, educational, economic, and managerial nature factors. These all act in a specific way within each nation, thus influencing the expansion of organic agriculture. Within the PCA, the first principal component (socioeconomic development) comprises all these influences with a proportion of about 60%. The organic area development was the second main component of the PCA, with a proportion of about 30%. One limitation of the PCA approach is in the descriptive nature of the relative positions of the statistical units, which are valid only for the specific period studied. A qualitative analysis should recognize that the position of the countries depends on the socioeconomic variables, which have hardly changed over time; the conclusion being that these positions have some stability over time. The advantages of PCA are in reducing the number of variables usually for two components, identifying variables that describe a main component, and the proportions of the explained variation by components for the statistically analyzed units.

The spatial econometric model considered the 28 EU member states for 2014. The limitation of the model is the meaning of the coefficient estimates which measured the influence of the significant factors in 2014. In this case, the theoretical values (Figure 7) could also be understood as referring to the potential for future organic farming area development, especially for countries where these values are higher than the reported values for 2014. The model is valid only for the given data. The future analysis should

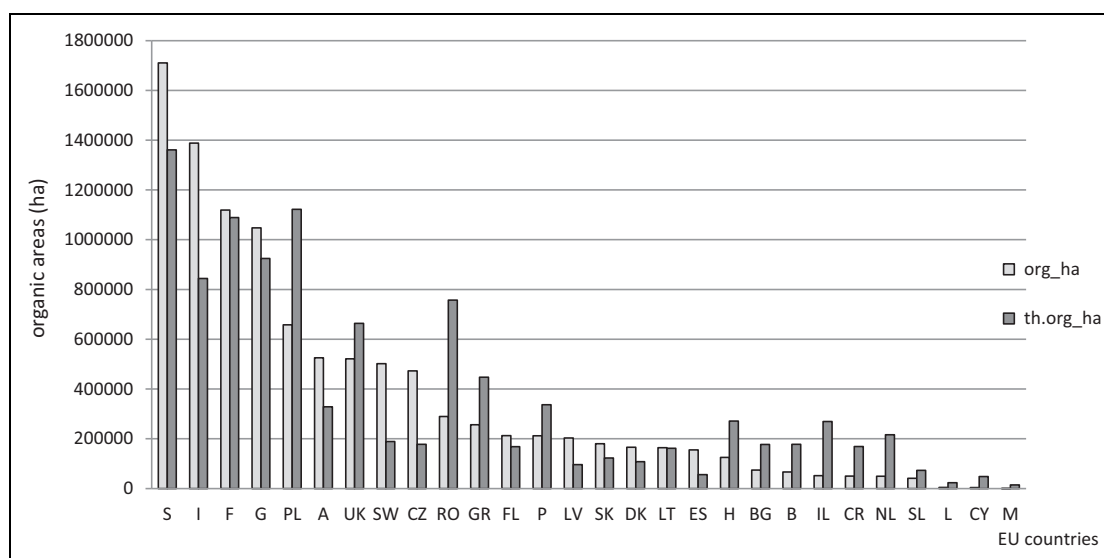


Figure 7. EU countries considering the organic area and their theoretical values (2014). EU: European Union.

consider future years in order to establish the sustainability of the influencing factors. The lack of data regarding organic agricultural production was a reason for considering the organic area. We consider that an area is a very important factor for organic production. The yields of organic farming are typically constant, due to the natural way of production. Future research could analyze aspects concerning organic consumption and international trade transactions in this sector.

Conclusions

The article studied various factors that could be used to differentiate EU countries concerning the extension of their organic production. The results are strongly linked to European financing and migration flows. By 2030, around 3–4% of farmland is expected to be abandoned in the European Union due to a number of institutional and physical factors (FIBL, 2016). The EU budget for organic research has increased from 767,000 Euro in 1993 to more than 6 million Euro in 2013 (IFOAM, 2014). From 2014 onward, the measures of the new CAP for EU member states promote the sustainability under the conditions of climate change for all rural areas and all farmers. Between 2014 and 2020, the European Union will invest over 100 billion Euro in rural areas to help farming meet the challenges of soil and water quality, biodiversity, and climate change (European Commission, 2014). At least 30% of the budget for rural development programs will have to be allocated to agro-environmental measures and to support organic farming or projects associated with environmentally friendly investment or innovation measures (European Commission, 2016). The benefits of this article can be considered from three perspectives: the business opportunities, the implications for European policies, and the scientific approach. The results of the dynamics and the identified influence factors could lead investors to choose countries having agricultural areas with high organic potential. The

European decision makers could account for the financing plans of the countries with potential for organic area expansion and coordinate migration policies according to the development of EU organic agriculture. As a scientific approach, the article combines useful methods for describing the evolution of organic areas and for explaining the situation of EU countries in 2014 and their potential for development, based on the average dynamic rates between 2000 and 2014.

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