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Article

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Daniela ŠPIRKOVÁ – Beáta STEHLÍKOVÁ** – Mária ZÚBKOVÁ* – Marcel ŠEVELA*** – Dušan STIGLIC***

Abstract

In this paper we investigate the position of agriculture in the economy of EU countries. Agriculture in the EU is highly heterogeneous – we characterise the sector by using the share of agriculture workers of total employment, the share of agriculture in total GDP, and the value added in agriculture per worker. To quantify the economic importance of agriculture per country for acquired specific condition, we construct the Agricultural Index-Total (AGRIT) and Agricultural Index (AGRI). We utilize the fuzzy set theory to contribute to the correct quantification of a country gap from the aimed-for condition of agricultural position. Using cluster analysis, we identify those countries with a similar position in agriculture. We test the efficacy of EU agrarian policy with the verification of sigma and beta convergence. The Eurostat database provides data for the evaluated 2005 – 2015 period.

Keywords: *agriculture position, cluster analysis, beta convergence, fuzzy membership function*

JEL Classification: A11, O13, Q19

Introduction

The agricultural sector has historically represented an important yet changing contribution to economic development. Johnson (1993) summarised the classical view of agriculture by underlining that both Malthus and Ricardo viewed

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agriculture as a barrier to economic progress. Over the past two centuries, there have been major changes in the role or roles attributed to agriculture in economic development.

Disparities in the development level of developed and developing countries are also related to the role of national agriculture. Developed countries passed through structural transformation of agriculture much earlier (Gollin, Parente and Rogerson, 2002) a process accelerated by the integration and opening of internal markets and a stronger competitive environment. Ten countries joined the European Union (EU) in 2004 and two in 2007, ten of which are from Central and Eastern European Countries (CEEC). These accessions added over 500 000 km^2 of agricultural area to the EU. The development of interactions between CEEC agriculture and EU agricultural policies have been profoundly affecting the overall ecological status of European ecosystems. New member states adopted the Common Agricultural Policy (CAP) and gained access to EU markets (Stoate et al., 2009).

The central role of agriculture in EU countries has been analysed in numerous papers. Initial literature considered the role of agriculture in economic development as an industrial sector – such as ensuring the supply of affordable food for workers in other sectors (Lewis, 1954). Agricultural growth also contributes to economic activity in the input, processing, distribution, and storage industries, thereby generating multiplier effects far beyond agriculture itself (Hazell and Roell, 1983). As agriculture is an important economic sector for most new member states, agricultural adaption was therefore a major challenge both for the EU and accession countries (Kiss, 2011). The adjustment process for the Bulgarian agricultural sector is assessed, along with its changing role in the economy since the start of the transition period, by Ivanova et al. (2000). The role of the agricultural sector in the transition to a market economy in Slovakia was investigated by Bozik et al. (2000). Doucha and Ratinger (2007) examined the role of agriculture in rural development during the transition period in the Czech Republic. Issues of Slovak agriculture within the European Union are discussed in depth by Ciaian, Pokrivcak and Bartova (2005) in their work. Falkner and Treib (2007) discuss the similarities and differences between 'old' and 'new' EU member states.

A comparative analysis of EU countries in terms of the economic role of agriculture has been performed by numerous methodological approaches, one of which is presented in this paper. It is questionable to determine an indicator to measure the economic role of agriculture in a national economy since the formulation of this task leads to a multidimensional classification of countries in terms of several partial indicators (Sojkova and Stehlikova, 2004).

The underlying policy objective of creating and retaining jobs and employment in rural areas is linked to persistent structural problems in EU rural areas, such as worker emigration, low employment rates and high unemployment rates, mismatch between skills and human capital, and lack of opportunities for women and young people (European Commision, 2012). Dries et al. (2012) study the mechanism of job creation and destruction in EU agriculture. Ciaian, Kancs and Swinnen (2010) state that land market and farmland size changes represent the most pressing factors analysed in terms of understanding the new agricultural systems' transformation under agricultural reforms.

According to Renwick et al. (2013), CAP reforms' process of agricultural structural change could lead to higher efficiency. Governmental policies universally fail to accept the transfer of labour from farms to non-agricultural jobs as essential for the economic health of the farming population. If such labour transfer occurs slowly relative to shifts in demand for and supply of labour to agriculture, the incomes of farming families will grow more slowly than incomes in the rest of the economy. In economies with a large percentage of labour force engaged in agriculture (i.e. 25% and over), rural per capita incomes are significantly less than their urban counterparts. Consequently, labour transfer must be at a rate both to absorb the annually generated excess supply of labour in rural areas, and to further reduce agricultural employment arising from the nullification of differences in labour returns for individuals with comparable human capital (Johnson, 1993).

Productivity is another measure closely linked to agricultural production performance. Higher equality across Europe in the productivity of agriculture and income has been a central goal of the European Community since the dawn of European economic integration, with various policy measures introduced to help achieve this goal (Cappelen et al., 2003). A negative relationship exists between agricultural productivity and both GDP per capita and the share of employment in agriculture. This same relationship holds for the relative productivity of agriculture to non-agriculture. Evidence also shows a positive relationship between growth in a country's agricultural productivity, and labour movement from agriculture. This relationship also holds if we consider growth in food output per capita rather than agricultural productivity (Gollin, Parente and Rogerson, 2002). Beyond that point, there will be no more employment opportunities and disguised unemployment. According to Hayami and Ruttan (1971), the public sector plays a key role in developing agricultural technology. Successful agricultural growth is believed to be founded on ecologically-adapted and economically-viable agricultural technology, which involves on-going adaptation to available resources, as well as a positive response from cultural, economic and political forces. Blaas (2004) also studied the productivity of work in the agriculture.

Technical changes from new and more productive inputs may be induced primarily to save labour or protect land. The non-agricultural sector is shown to play a vital role in this process, as the supplier of technical inputs which can be substituted for land and labour in agricultural production. It is then hypothesised that developed countries' high agricultural productivity is based on the development of an industrial sector that can transfer increased productivity to agriculture as cheaper services, and the capacity of the state to continually generate technical innovation (Hayami and Ruttan, 1971). This implies that countries experiencing increases in agricultural productivity can release labour from agriculture into other economic sectors. As noted above, an important contribution of agriculture to economic growth was the transfer of labour to the non-farming sector. Rizov, Pokrivcak and Ciaian (2013) investigated the impact of CAP subsidies on farm total factor productivity in the European Union.

The role of agriculture in national economies is best characterised by agriculture's contribution to GDP, which is declining worldwide (Csaki and Jambor, 2009). The future outlook largely depends on CAP reform, the new EU budget, and the domestic economic and agricultural status of new member states (Kiss, 2011).

The remainder of the paper is organised as follows and aims to:

1. quantify the position of agriculture in the economy of specific EU countries, i.e. the national economic importance of agriculture;

2. identify groups of countries with similar agricultural status in the national economy;

3. quantify the gap in particular indicators which countries must overcome to attain the required position of agriculture;

4. assess possible convergence of EU countries in terms of the required importance of agriculture.

The suggested methodology is general: with the appropriate indicators, the methodology is applicable for any sector – not only agriculture.

1. Methodology and Materials

Ad 1. Further, we will describe how the index – that quantifies the economic importance of agriculture – is compiled. The indicators "share of agricultural employees in overall employment", "agriculture of GDP" indicator and "agriculture added value per worker" are accepted for the evaluation of national agriculture, and used as the basis for the index construction of the required economic importance of agriculture. We used fuzzy set theory to model indicators. Thus constructed indicators can be understood as linguistic variables (see e.g. Mendes, Morooka and Guilhermeb, 2003).

The indicator share of employment in agriculture (% of total employment) *x*, we model using the fuzzy membership function

$$\mu_{emp}(x) = (max - x) / (max - min) \quad (1)$$

where *max* is the maximum value of the reference variable, and *min* is the minimum value of the observed employment in agriculture (% of total employment) in the analysed year at the level of EU member states. From the construction of fuzzy membership function, it results that the higher values *x* of employment in agriculture (% of total employment) correspond to the lower value of fuzzy membership function μ_{emp}. Using simple adjustments, we obtain $\mu_{emp}(x) = max/(max - min) - (1/(max - min))x$, which means there is an indirect linear dependence between the values *x* and μ_{emp}. That low values of employment in agriculture (% of total employment) are desirable is a condition that corresponds with subsequent statements accepted by the professional and scientific community. Countries with high employment in agriculture show a high proportion of people falling below the poverty line, as a natural consequence of the average agriculture sector wage being lower than other sectors. It is appropriate and in accordance with EU agricultural policy that the share of agricultural employment is not too high according to total employment compared to agricultural output.

We model the share of agriculture in GDP country *x* using the fuzzy membership function

$$\mu_{GDP}(x) = (max - x) / (max - min) \quad (2)$$

where *max* is the maximum value of the reference attribute, and *min* is the minimum value of the observed agriculture in GDP in the observed year at the level of EU member states. Similarly as in the previous case, we see an indirect linear dependence between the values *x* and μ_{GDP}. Higher values *x* of agriculture in GDP in the given country correspond to the lower value of the fuzzy membership function μ_{GDP}. The form of fuzzy membership function results from a condition not in accordance with EU policy to have a high share of agriculture in GDP creation.

The agriculture value added per worker *x* indicator we model using the fuzzy membership function

$$\mu_{av}(x) = 1 - (max - x) / (max - min) \quad (3)$$

where *max* is the maximum value and *min* is the minimum value of agriculture value added per worker in the observed year at the level of EU member states. With simple adjustments, we get $\mu_{av}(x) = - min/(max - min) + 1/(max - min)x$. This indicates a direct linear dependence between the values *x* and μ_{av}. Higher agriculture value added per worker *x* corresponds to the higher value of membership function μ_{av}. In each sector, it is necessary to have work productivity as high as possible. Agriculture is not an exception, so high values of agriculture value added per worker *x* and high values of $\mu_{av}(x)$ are desirable.

Aggregation of several input values into one, in some sense the most informative value, is a basic processing method in any field dealing with quantitative information. The arithmetic mean of membership functions is an aggregation function (see e.g. Kacprzyk and Pedrycz, 2015; Klir and Yuan, 1995). The required economic significance of the agriculture AGRIT in a country with employment in agriculture (% of total employment) *a*, share of agriculture in GDP *b*, and agriculture value added per worker *c* is modelled using the arithmetic mean of membership functions of these three indicators

$$AGRIT = \frac{\mu_{emp}(a) + \mu_{GDP}(b) + \mu_{av}(c)}{3} \tag{4}$$

From the construction of fuzzy membership functions μ_{emp}, μ_{GDP} and μ_{av}, it results that the higher the economic importance of agriculture in a country, the higher the AGRIT index values. The higher the AGRIT value, the closer the position of agriculture in the evaluated country to the required economic importance of agriculture.

The AGRI indicator is constructed in a similar way. The AGRI index for a country is

$$AGRI = \frac{\mu_{emp}(a) + \mu_{GDP}(b)}{2} \tag{5}$$

From economic theory we know the strong dependence of agriculture value added per worker in agriculture and the share of employment in agriculture. We examined the dependence of these two indicators using nonlinear regression, which proved more suitable than frequently used linear relations, and we evaluated the intensity of dependence using the coefficient of determination. Finally, we tested the statistical significance of regression coefficients in selected nonlinear models (see e.g. Long and Freese, 2006). The non-linearity of relation alone causes slight deviations in the evaluation of the economic importance of agriculture. Good availability, stable, and invariable methodology of presenting employment indicators in agriculture (% of total employment), and the share of agriculture in GDP supports AGRI for the approximate evaluation of the condition of economic importance in agriculture.

Ad 2. Cluster analysis was used to create clusters of similar EU countries regarding the status of agriculture in their economies, an approach that allows clusters of similar objects to be created by simultaneously considering multiple attributes (Anderberg, 2014). In cluster analysis, we used the Euclidean distance and Ward's method as characterised by forming compact clusters. The AGRIT index reflects the state of intensification of agriculture in a country. The compilation of indicators allows us to identify sequence clusters that indicate the status of agriculture in EU economies.

Ad 3. Membership functions for particular indicators are constructed so that their values correspond with the rate of meeting the required ideal condition in the given characteristic. Hence, we might consider the values $1 - \mu_{emp}$, $1 - \mu_{GDP}$ and $1 - \mu_{av}$ for the gap in a particular country in the evaluated field. From the aforementioned and the AGRI and AGRIT indices compilation, it results that the values 1 – AGRI or 1 – AGRIT represent the overall gap a country must overcome to achieve the required position of the agriculture in the country's economy.

Ad 4. When analysing the position of agriculture in the economies of individual EU countries, we were interested in convergence towards the desired state. Kane (2001) states several methods to test for convergence: the sigma convergence test is based on an examination of standard deviations; while for testing beta convergence we use the regression model

$$\frac{1}{t}\ln\frac{Y_{i,t}}{Y_{i,0}} = a + b\ln Y_{i,0} + \varepsilon_i \tag{6}$$

where $Y_{i,t}$ is the value of the observed indicator in the state i in time t, $Y_{i,0}$ is the initial value observed indicator in state i, and ε_i is error. A negative value of coefficient b is interpreted by Baumol (1986) as evidence of convergence.

All used indicators were taken from the Eurostat database. SAS and MS Excel software were used in the calculations.

2. Results

Ad 1. This paper focuses on the aggregated approach, hence the AGRIT was used, which aggregates all the above-mentioned basic variables to describe more general trends in the agricultural sector that are key for national economies. As mentioned, such comprise three partial indicators: agriculture in GDP, employment in agriculture (% of total employment), and agriculture value added per worker. The AGRIT index is formulated as a "deficiency rate" (or "surfeit rate") of a country in all three individual fields. The highest AGRIT index values in 2015 were achieved by the Netherlands, Belgium, Sweden, United Kingdom and Luxembourg. Romania, Bulgaria, Greece, Croatia and Poland had the lowest AGRIT index value. AGRIT index values for all EU countries (2000 – 2015) are shown in Table 1.

T a b l e 1

Agricultural Indices – AGRIT and AGRI

Country /year	AGRIT							AGRI						
	2000	2005	2008	2009	2014	2015	Order in 2015	2000	2005	2008	2009	2014	2015	Order in 2015
Belgium	0.839	0.834	0.863	0.866	0.876	0.880	**2.**	0.967	0.964	0.956	0.964	0.966	0.948	**4.**
Bulgaria	0.271	0.336	0.285	0.371	0.294	0.278	**26.**	0.367	0.453	0.384	0.511	0.405	0.380	**25.**
Czech Republic	0.618	0.663	0.618	0.655	0.576	0.573	**15.**	0.838	0.845	0.819	0.837	0.733	0.734	**11.**
Denmark	0.776	0.821	0.786	0.792	0.780	0.821	**6.**	0.899	0.927	0.920	0.925	0.852	0.886	**5.**
Germany	0.752	0.756	0.808	0.826	0.796	0.797	**7.**	0.968	0.965	0.943	0.950	0.962	0.956	**2.**
Estonia	0.565	0.567	0.578	0.594	0.532	0.523	**17.**	0.767	0.770	0.762	0.771	0.645	0.607	**18.**
Ireland	0.673	0.697	0.650	0.687	0.615	0.597	**14.**	0.835	0.889	0.868	0.903	0.792	0.751	**10.**
Greece	0.452	0.471	0.449	0.433	0.349	0.307	**25.**	0.588	0.582	0.595	0.566	0.420	0.353	**26.**
Spain	0.682	0.670	0.678	0.682	0.658	0.647	**11.**	0.792	0.793	0.768	0.760	0.717	0.686	**14.**
France	0.792	0.802	0.820	0.834	0.780	0.781	**8.**	0.898	0.882	0.863	0.870	0.834	0.810	**8.**
Croatia	0.451	0.367	0.331	0.291	0.353	0.327	**24.**	0.614	0.505	0.439	0.380	0.472	0.429	**24.**
Italy	0.741	0.763	0.722	0.728	0.688	0.665	**10.**	0.861	0.854	0.810	0.807	0.773	0.729	**12.**
Cyprus	0.741	0.728	0.649	0.660	0.602	0.604	**13.**	0.826	0.821	0.791	0.783	0.736	0.702	**13.**
Latvia	0.452	0.432	0.453	0.421	0.438	0.403	**21.**	0.654	0.615	0.634	0.569	0.589	0.537	**21.**
Lithuania	0.383	0.377	0.434	0.461	0.384	0.372	**22.**	0.557	0.548	0.606	0.643	0.535	0.514	**22.**
Luxembourg	0.993	0.887	0.795	0.866	0.776	0.845	**5.**	0.990	0.994	0.989	0.996	0.997	1.000	**1.**
Hungary	0.553	0.611	0.579	0.567	0.443	0.458	**20.**	0.737	0.737	0.665	0.673	0.539	0.587	**19.**
Netherlands	0.849	0.839	0.831	0.858	0.883	0.881	**1.**	0.905	0.883	0.856	0.857	0.824	0.821	**7.**
Austria	0.696	0.699	0.654	0.656	0.648	0.634	**12.**	0.900	0.881	0.826	0.836	0.831	0.809	**9.**
Poland	0.463	0.395	0.385	0.388	0.377	0.351	**23.**	0.684	0.585	0.570	0.567	0.550	0.512	**23.**
Portugal	0.531	0.495	0.461	0.461	0.480	0.481	**19.**	0.754	0.709	0.661	0.658	0.670	0.652	**17.**
Romania	0.006	0.000	0.006	0.000	0.000	0.016	**27.**	0.010	0.000	0.009	0.000	0.000	0.024	**27.**
Slovenia	0.572	0.539	0.525	0.508	0.465	0.494	**18.**	0.798	0.757	0.740	0.720	0.664	0.675	**16.**
Slovakia	0.562	0.598	0.542	0.591	0.537	0.558	**16.**	0.779	0.771	0.644	0.691	0.538	0.539	**20.**
Finland	0.717	0.765	0.710	0.724	0.715	0.713	**9.**	0.831	0.826	0.768	0.751	0.706	0.684	**15.**
Sweden	0.848	0.965	0.922	0.922	0.892	0.880	**3.**	0.931	0.948	0.883	0.883	0.884	0.860	**6.**
United Kingdom	0.841	0.876	0.871	0.862	0.830	0.845	**4.**	0.990	0.988	0.973	0.971	0.965	0.949	**3.**

Source: Own calculations based on Eurostat database (2016).

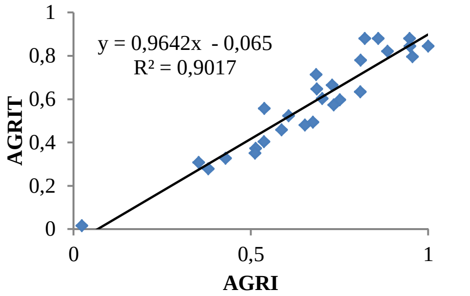
Best placed in terms of the AGRI index are Luxembourg, Germany, the United Kingdom, Belgium and Denmark. The worst placed in terms of the AGRI index are Romania, Greece, Bulgaria, Croatia and Poland. The order of all the countries is shown in Table 1.

The values of AGRIT and AGRI indices are very similar (see Figure 1). It is advisable to use the AGRIT index, as it reflects the status of agricultural intensification in each country.

The strong dependence of AGRIT and AGRI is due to the strong dependence of agriculture value added per worker in agriculture and the share of employment in agriculture, as can be seen from Figure 2. Figure 2 highlights the fact that the lower the share of agricultural employment, the higher the productivity, as evidenced by the previous statement about the order of EU member states.

Figure 1

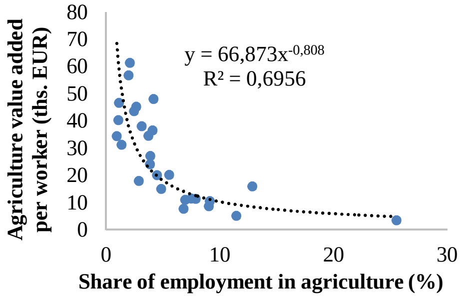
Dependence of Indices: AGRIT and AGR



Source: Own calculations.

Figure 2

Dependence of Indicators



Source: Own calculations.

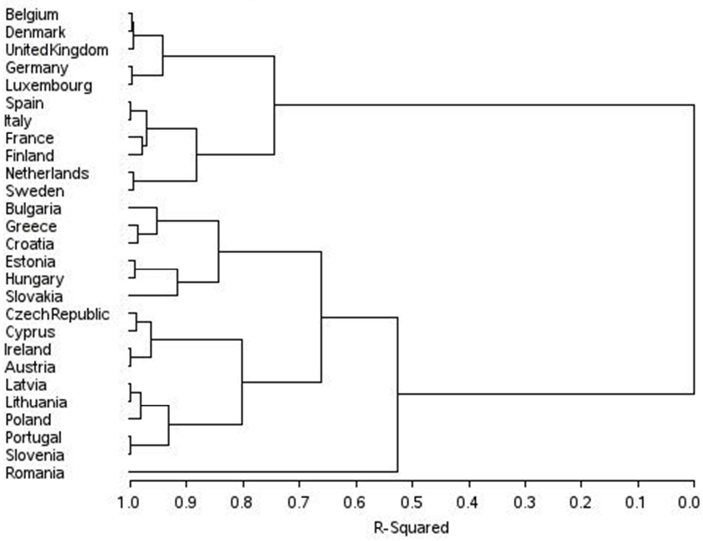
The volume of agricultural production can be achieved by a country in two ways: increasing labour productivity in agriculture or increasing agricultural employment. It can be stated that a more economically-developed country is one with higher productivity of labour in agriculture. From the constructed model

$$y = 66.873x^{-0.808} \tag{7}$$

we can see that an increase (decrease) of the share of agricultural employment by 1% leads to a decrease (increase) of the indicator agriculture value added per worker by 0.808%. The value of the coefficient of determination is 69.56%, which can be considered satisfactory. The regression model as a whole is suitable. Both coefficients are significant (p-values are 7.6 E-19, respectively 6.5 E-08).

Figure 3

Similarity of Countries – Dendrogram



Source: Own calculations.

Ad 2. Figure 3 shows the result of cluster analysis based on the fuzzyficated indicators entering the AGRIT index. The dendrogram in Figure 3 visually presents five clusters of EU countries.

Table 2

Centroids of Clusters and their Characteristics (AGRIT Values)

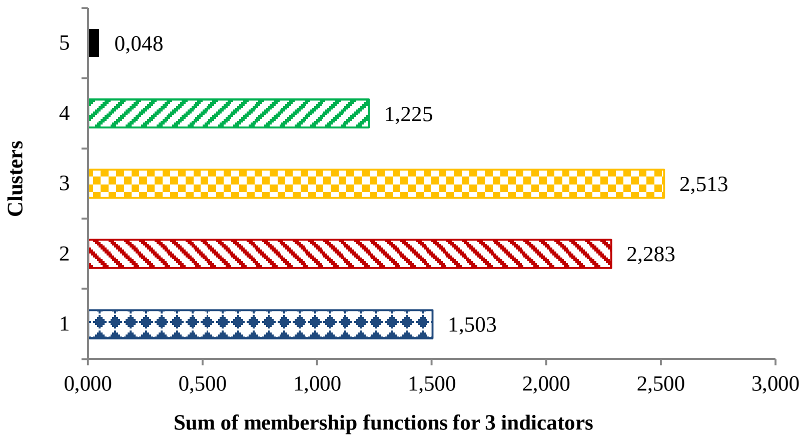
Number of cluster	Number of countries	Variable	Average	Standard Deviation	Minimum	Maximum
1	8	Share of Agriculture Employees in the Total Employment	0.769	0.110	0.572	0.921
		Agriculture Value Added per Worker	0.195	0.120	0.028	0.408
		Share of Agriculture in GDP	0.539	0.137	0.357	0.762
		Characteristic of achievement of the desired state of economic importance of the agriculture	*1.503*			
2	6	Share of Agriculture Employees in the Total Employment	0.911	0.040	0.868	0.957
		Agriculture Value Added per Worker	0.753	0.185	0.535	1.000
		Share of Agriculture in GDP	0.619	0.111	0.500	0.762
		Characteristic of achievement of the desired state of economic importance of the agriculture	*2.283*			
3	7	Share of Agriculture Employees in the Total Employment	0.981	0.025	0.938	1.000
		Agriculture Value Added per Worker	0.617	0.109	0.479	0.744
		Share of Agriculture in GDP	0.914	0.060	0.833	1.000
		Characteristic of achievement of the desired state of economic importance of the agriculture	*2.512*			
4	5	Share of Agriculture Employees in the Total Employment	0.763	0.150	0.515	0.910
		Agriculture Value Added per Worker	0.261	0.191	0.073	0.596
		Share of Agriculture in GDP	0.202	0.123	0.000	0.333
		Characteristic of achievement of the desired state of economic importance of the agriculture	*1.226*			
5	1	Share of Agriculture Employees in the Total Employment	0.000		0.000	0.000
		Agriculture Value Added per Worker	0.000		0.000	0.000
		Share of Agriculture in GDP	0.048		0.048	0.048
		Characteristic of achievement of the desired state of economic importance of the agriculture	*0.048*			

Source: Own calculations.

Ad 3. The desired status of agricultural economic importance is achieved when the sum of fuzzy membership functions of the three indicators of the cluster centroid (as well as individual countries) equals 3. From Figure 4 and Table 2, we can see that the third cluster contains countries with the most desirable agricultural status in economies of EU countries: Belgium, Denmark, Germany, Luxembourg, and the United Kingdom. It shows the desirable state of agriculture with no need for major changes in agricultural policy. The gap of the third cluster centroid is just 0.487. Slightly worse is the second cluster of countries of Finland, France, Italy, Netherlands, Spain and Sweden. The gap of the second cluster centroid is just 0.717 – they also needn't change agricultural policy significantly. The gap of the first cluster (Czech Republic, Cyprus, Ireland, Austria, Latvia, Lithuania, Poland, Portugal and Slovenia) centroid is 1.497, and the gap of the fourth cluster (Bulgaria, Greece, Croatia, Estonia, Hungary and Slovakia) centroid is 1.775. Countries in the first and fourth cluster require significant changes in agricultural policy to achieve the desirable state of countries in the second and third cluster. Romania's status is unique – with very low labour productivity in agriculture yet extremely high share of employment in agriculture. The sum of the three membership functions is only 0.048 with a very high gap of 2.952. Distinctive changes are needed in agricultural policy to achieve the required economic importance of agriculture in a country.

Figure 4

Characteristics of Cluster Centroids in Terms of Desired State of Economic Importance of Agriculture



Source: Own calculations.

Ad 4. The EU aims for the gradual convergence of economies of individual member states, including agriculture. Beta and sigma convergence are the analytical tools that allow us to examine these trends, which we have applied to individual indicators and AGRIT and AGRI indices. Using sigma convergence on values of fuzzy membership functions of the three indicators, we concluded that there is no sigma convergence. We also achieved a similar result with the use of the original indicator values. AGRIT and AGRI indices do not show sigma convergence either.

We are aware that sigma convergence implies beta convergence, but we also know that the opposite need not apply – hence we started the application of beta convergence. If the regression coefficient in the case of the indicator share of agriculture employees being positive, that means beta convergence has not been confirmed. The regression coefficient of agriculture value added per worker indicator is negative (–0.012), and the p-value is 0.025, which is less than 0.05.

That means it is significant at the significance level of 0.05. Based on the above, we can conclude that in the case of agriculture value added per worker indicator, beta convergence is confirmed. The regression coefficient for agriculture of GDP is –0.015. Its 0.0302 p-value indicates statistical significance, which means for agriculture in the GDP indicator there is beta convergence (see Table 3).

T a b l e 3

Beta Convergence of Partial and Aggregated Indicators

Indicator	**Regression coefficients and their standard error**		**p-value**	**R^2 (%)**
Share of Agriculture Employees	a	–0.00075 (0.00103)	0.475959	0.76
	b	**0.001915 (0.004479)**	**0.672756**	
Agriculture Value Added per Worker	a	–0.00048 (0.008744)	0.956638	19.16
	b	**–0.01193 (0.005003)**	**0.025317**	
Agriculture on GDP	a	–0.0273 (0.0056)	5.3E-05	14.69
	b	**–0.0152 (0.0066)**	**0.03024**	
AGRIT	a	0.01037 (0.0022)	4.9E-5	56.98
	b	**–0.01137 (0.001976)**	5.37E-06	
AGRI	a	–0.01249 (0.001985	1.39E-06	62.52
	b	**–0.01349 (0.002089)**	9.17E-07	

Source: Own calculations.

Finally, we were interested in the beta convergence of AGRIT and AGRI indices. The value of regression coefficient for the AGRIT index is –0.011. The corresponding p-value is 5.37E-06, indicating the statistical significance of the regression coefficient. This confirms the beta convergence of the AGRIT index. We also get similar results for the AGRI index (Table 3). These results confirm the beta convergence of the AGRI index.

3. Discussion

3.1. Discussion of the Methods

An alternative way to obtain the AGRIT or AGRI index should be the use of multicriteria methods or ranking methods. In order to compare the results have used average ranks method. Average ranks method uses, as the name suggests, individual rankings to derive an overall ranking. The best value of the indicator will be assigned rank 1, the next, 2, and so on. The final ranking is obtained by ordering the average ranks. The results using the AGRIT index and average ranks method are not contradictory.

Some units of measure may cause some signs to appear dominant, while other signs hardly influence the result at all. A frequently used solution is data transformation to unit interval, including min-max normalization. The values of fuzzy membership functions and "formulas" of this transformation are identical from the formal perspective. Using such a procedure, some known indices are constructed such as the Human Development Index (HDI). The values are equal; the difference is that the values are not considered values of membership function.

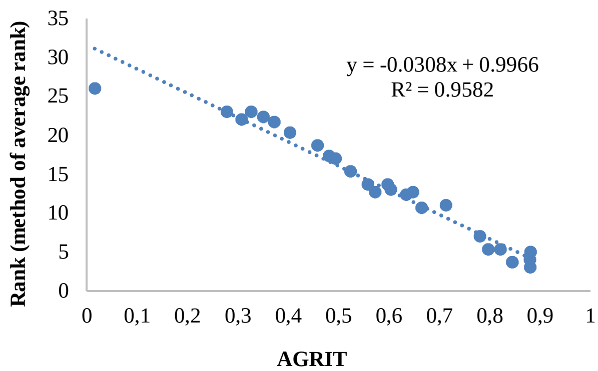
The approach from the position of fuzzy set theory is useful. This theory enables the detection of the gap between particular countries in the investigated indicators, and the desirable position of agriculture in country's economy.

Ad 1. Firstly, we investigate the AGRIT values and country order gained using average order. The orders for particular values of indicators we assign so that first is the country with the best value. The final order is an arithmetical average of partial orders. The quotient of determination for the regressive line is a high 0.9582. Both quotients of the regressive line are significant (p-value is 6.45E-24, or 9.43E-19).

From Figure 5 we see that the higher the AGRIT value – i.e. the gap of the country since meeting the desirable ideal condition of economic importance – the lower the order of the country, i.e. the better the condition. So, in prominent places are countries closer to the desirable ideal condition of economic importance of agriculture. The statistically significant confirmation of dependence of both methods allows us to state the suggested procedure as suitable for the evaluation of achieving the desirable economic importance of agriculture in a given country.

F i g u r e 5

Dependence of AGRIT and Ranking Gained Using the Average Order Method



Source: Own calculations.

Ad 2. We now focus on the interpretation of each cluster's common characteristics, and their reflection in individual countries. The first best cluster includes third cluster countries – studied indicators demonstrated the effectiveness of agriculture in economies of the given cluster. Regarding the share of agricultural employment, the mean value of fuzzy membership function is 0.981, which is an almost perfect condition. The same is the share of agriculture of GDP (0.914). Closest to the desirable state is Belgium, which has the third lowest agricultural employment, the fourth lowest share of agriculture in GDP, and the fourth highest productivity. Luxembourg and Germany have a low share of employment in agriculture, and also a low share of agriculture in GDP due to the structure of the countries' economy. Germany is a typical industrially-oriented country. Denmark is in seventh place for employment in agriculture, fifth place for share of agriculture in GDP, and sixth place for productivity. Hence it can be characterised as a country with developed agriculture.

The second-best cluster consists of countries of the second cluster. Total score of second cluster averages is slightly less (2.283) than the third (2.513) cluster. Average share of employment is almost perfect (0.911). Regarding productivity, the status is better than the third cluster; productivity has a fuzzy membership function at 0.753. The average share of agriculture in GDP is considerably larger (0.619) than in the third cluster (0.914). The Netherlands, Sweden and Finland have the highest productivity in agriculture in the EU. They are in the second cluster due to their high share of agriculture in GDP. Spain is in ninth place in highest productivity, and directly followed by Italy in tenth. Closest to the desired position of agriculture are countries characterised as:

- developed, industry-oriented countries with little employment in agriculture, low share of agriculture in GDP, and high productivity;
- developed countries with a focus on agriculture, high productivity, higher employment corresponds to a higher share of agriculture in GDP.

The third best cluster consists of first cluster countries. These countries have an average share of agricultural employment (0.769), the share of agriculture in GDP is 0.539, but productivity is only 0.195. In sixteenth place for employment and productivity is Austria, which has extensive livestock in Alpine counties. This supports the seventh lowest share of agriculture in GDP. Ireland ranked eighteenth in agricultural employment, and fifteenth in productivity with a 10% share of agriculture in GDP. These facts highlight an industrialised country but with high agricultural employment with relatively low productivity, indicating extensive farming. Countries in the fourth cluster have employment level of 0.763. Productivity with value of 0.261 compared with desired state of 1 is at very low level, but countries in the cluster have a relatively high proportion of desired state of 1 of GDP (0.202).

As there was little difference between the second and third clusters according to the desirable state of agriculture, there's also a small difference between the first and fourth clusters (1.503 and 1.225). In the fourth cluster are countries in last place (Bulgaria, Croatia). Another group includes countries with relatively good status of productivity, but opposite share of employment in agriculture and agriculture in GDP (Slovakia, Estonia). This highlights the overall weak economic performance of these countries. It is necessary to realise that the same value of agriculture share in GDP is lower due to lower performance as well as a weak economy. The achieved desired state of agriculture in these countries can increase economic growth so that agriculture represents a lower share in GDP. Another option is also the intensification of agriculture. In the fifth cluster is Romania, furthest from the desired position of agriculture.

Ad 3. Based on the gap values from the required economic importance of agriculture, we recommend fundamental agro-policy changes in the Czech Republic, Cyprus, Ireland, Austria, Latvia, Lithuania, Poland, Portugal and Slovenia, respectively Bulgaria, Greece, Croatia, Estonia, Hungary, Slovakia and Romania. Gap is caused by the various size structures of agricultural farms. Small farms cannot compete with large holdings in terms of implementing new technologies, which causes lower work productivity. The more small farms, the less intensive the agriculture. New technologies also increase value added per worker.

Despite some structural changes, the farm structure of new EU member states is still characterised by a high share of small farms (Kiss, 2011).

Ad 4. In old EU member states, the redistribution of the agrarian population to other economic branches was a lengthy process from 1970 to 2010. The active population employed in the agricultural sector has dramatically declined due to the massive transformations in the agricultural sector resulting from the CAP impact on intensive agriculture (Ciutacua, Chivu and Andrei, 2015). As new member states could not completely use CAP benefits from the first day of EU accession, especially in the case of direct payments, a significant difference remained between old and new member states' agricultural subsidy level. As this gap was accompanied by high productivity difference, the competitive edge of old member states has been retained (Kiss, 2011). Different geographical conditions will always preclude the complete convergence of agriculture performance of various member countries.

Conclusion

The agricultural sector in the EU is highly heterogeneous – it's troublesome to find indicators that describe the position of agriculture in a nation's economy. As it's ambiguous to assess agriculture through a number of variously-calibrated indicators, it's appropriate to derive one overall index from such indicators. Using methodology (AGRIT and AGRI indices) allows us to properly quantify the position of agriculture as well as the deviations of selected countries from the desired status.

The statistical methods applied herein allow for the description and quantification of the similarities and dissimilarities of EU member states in terms of agriculture. A benefit is also the quantification of EU member states' gap from the desired state of agriculture in their respective economies.

We detected that the closest to the desired position of agriculture there are countries characterised as developed, industry-oriented countries with little employment in agriculture, low share of agriculture in GDP, and high productivity or developed countries with a focus on agriculture, high productivity, higher employment corresponds to a higher share of agriculture in GDP. In the paper, there are determined the countries (most of them belong to the new member states), requiring significant changes in agricultural policy to achieve the desired state.

References

ANDERBERG, M. R. (2014): Cluster Analysis for Applications: Probability and Mathematical Statistics: A Series of Monographs and Textbooks. New York: Academic Press. ISBN 9780120576500.

BAUMOL, W. J. (1986): Productivity Growth, Convergence and Welfare: What the Long-Run Data Show. American Economic Review, *76*, No. 5, pp. 1072 – 1085.

BLAAS, G. (2004): Productivity of Factors in the Enlarged EU. Agricultural Economics, *50*, No. 11, pp. 509 – 513.

BOZIK, M. et al. (2000): The Role of the Agriculture Sector in the Transition to a Market Economy: Slovak Case Study. In: POGANIETZ, W. R. at al. (eds): Perspectives on Agriculture in Transition: Analytical Issues, Modelling Approaches, and Case Study Results. Kiel: Wissenschaftsverlag Vauk, Kiel KG, FAO, IAMO, pp. 200 – 256.

CAPPELEN, A. et al. (2003): The Impact of EU Regional Support on Growth and Convergence in the European Union. JCMS, *41*, No. 4. pp. 621 – 644.

CIAIAN, P. – KANCS, D. A. – SWINNEN, J. F. (2010): EU Land Markets and the Common Agricultural Policy. Brussels: CEPS, 343 pp.

CIAIAN, P. – POKRIVCAK, J. – BARTOVA, L. (2005): Slovak Agriculture in the European Union. Ekonomický časopis/Journal of Economics, *53*, No. 7, pp. 736 – 752.

CSAKI, C. – JAMBOR, A. (2009): The Diversity of Effects of EU Membership on Agriculture in New Member States. [Policy Studies on Rural Transition, No. 2009-4, 44 pp.] Budapest: FAO Regional Office for Europe and Central Asia.

CIUTACU, C. – CHIVU, L. – ANDREI, J. V. (2015): Similarities and Dissimilarities between the EU Agricultural and Rural Development Model and Romanian Agriculture. Challenges and Perspectives. Land Use Policy, *44*, March, pp. 169 – 176.

DOUCHA, T. – RATINGER, T. (2007): The Role of Agriculture in Rural Development During the Transition, the Case of the Czech Republic. In: CRISTOIU, A. – RATINGER, T. – PALOMA, S. G. (eds): Sustainability of the Farming Systems: Global Issues, Modelling Approaches and Policy Implications. Luxembourg: European Commission, Institute for Prospective Technological Studies, pp. 197 – 214.

DRIES, L. – CIAIAN, P. – KANCS, d'ARTIS. (2012): Job Creation and Job Destruction in EU Agriculture. Food Policy, *37,* No. 6, pp. 600 – 608.

EUROPEAN COMMISSION (2012): A View on Employment, Growth and Innovation in Rural Areas. [Commission Staff Working Document.] Brussels: EC, March 7, 2012.

EUROSTAT (2016): Gross Domestic Product (GDP), Agriculture, Forestry and Fishing 90958. Available at: <http://ec.europa.eu/eurostat/web/products-datasets/-/tipsau10>.

FALKNER, G. – TREIB, O. (2007): Three Worlds of Compliance or Four? The EU15 Compared to New Member States. [Working Paper, No. 112.] Vienna: HIS, Political Science Series.

GOLLIN, D. – PARENTE, S. – ROGERSON, R. (2002): The Role of Agriculture in Development. The American Economic Review, *92,* No. 2, pp. 160 – 164.

HAZELL, P. B. R. – ROELL, A. (1983): Rural Growth. [Research Report, 41.] Washington, DC: International Food Policy Research Institute (IFPRI).

HAYAMI, Y. – RUTTAN, V. W. (1971): Agricultural Development: an International Perspective. Baltimore, Md/London: The Johns Hopkins Press. ISBN 0801812593.

IVANOVA, N. et al. (2000): The Role of the Agriculture Sector in the Transition to a Market Economy: Bulgarian Case Study. In: POGANIETZ, W. R. at al. (eds): Perspectives on Agriculture in Transition: Analytical Issues, Modelling Approaches, and Case Study Results. Kiel: Wissenschaftsverlag Vauk, Kiel KG, FAO, IAMO, pp. 78 – 139.

JOHNSON, D. G. (1993): Role of Agriculture in Economic Development Revisited. Agricultural Economics, *8*, pp. 421 – 434.

KACPRZYK, J. – PEDRYCZ, W. (2015): Handbook of Computational Intelligence. Berlin – Heidelberg: Springer. ISBN 978-3-662-43504-5.

KANE, M. T. (2001): Current Concerns in Validity Theory. Journal of Educational Measurement, *38*, No. 4, pp. 319 – 342.

KISS, J. (2011): Some Impacts of the EU Accession on the New Member States' Agriculture. Eastern Journal of European Studies, *2*, No. 2, pp. 49 – 60.

KLIR, G. J. – YUAN, B. (1995): Fuzzy Sets and Fuzzy Logic. New Jersey: Prentice Hall.

LEWIS, W. A. (1954): Economic Development with Unlimited Supplies of Labour. Manchester School of Economics and Social Studies, *22*, No. 2, pp. 139 – 191.

LONG, J. S. – FREESE, J. (2006): Regression Models for Categorical Dependent Variables using Stata. College Station, TX: Stata Press. ISBN-13: 978-1-59718-111-2.

MENDES, J. R. P. – MOROOKA, C. K. – GUILHERMEB, I. R. (2003): Case-based Reasoning in Offshore Well Design. Journal of Petroleum Science and Engineering, *40*, No. 1 – 2, pp. 47 – 60.

RENWICK, A. et al. (2013): Policy Reform and Agricultural Land Abandonment in the EU. Land Use Policy, *30*, January, pp. 446 – 457.

RIZOV, M. – POKRIVCAK, J. – CIAIAN, P. (2013): CAP Subsidies and Productivity of the EU Farms. Journal of Agricultural Economics, *64*, No. 3, pp. 537 – 557.

SOJKOVA, Z. – STEHLIKOVA, B. (2004): Comparative Analysis of the Economic Role of Agriculture in the EU Countries. Journal of Agriculture Economics, *50*, No. 8, pp. 369 – 375.

STOATE, C. et al. (2009): Ecological Impacts of Early 21st Century Agricultural Change in Europe – A Review. Journal of Environmental Management, *91*, No. 1, pp. 22 – 46.