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SIMILARITY OF THE EUROPEAN UNION COUNTRIES IN TERMS OF FARM SIZES

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ABSTRACT

The purpose of the paper is to divide the European Union countries into groups of most similar distributions of farm size. As a measure of the degree of similarity of distributions D statistic was used, which is the maximum absolute value of the difference between two cumulative distribution functions. On the basis of the value of the D statistic calculated for each of the pairs of distributions the countries were divided into five relatively uniform classes. This division resulted in the creation of one single-element group, one two-elements group, one four-elements group and two ten-elements groups.

KEYWORDS

farm size, distribution, the European Union, dendrite method

1. INTRODUCTION

There are many different measures that can be used to summarize the scale of an agricultural operation, for example labour input, output volume, output value, or value added. One of such possible dimensions is also the physical size of the farm most commonly characterised by the number of hectares of utilised agricultural area. It is easily measurable, available for all farms as univocal information and already extensively used in the literature for political, statistical and economic analyses. However, it is worth emphasizing that the sole number of hectares is not enough to fully characterise holdings. In fact, this criterion does not consider a variety of important factors such as the diverse needs of cropland depending on the type of farming, the land fertility, the irrigation system, etc. As an example, it is well known that farms specialised in horticulture or pig and poultry breeding generally have a smaller than average utilised agricultural area (*What is*…, 2011, pp. 5–6).

Numerous studies confirm the following regularity: countries with higher GDP *per capita* tend to have larger average farm size and fewer small farms. But it should be noted that the share of family workers in total farm labour does not vary systematically with GDP *per capita* and in many advanced countries the family is still the main source of farm labour (Eastwood *et al.*, 2010, p. 3325).

Management skills is one of the crucial factors responsible for scale economies in farming. Moreover, good farm managers are more likely than poor managers to find it optimal to manage larger farms. To the extent that the availability of new seeds, fertilizers, and pesticides, together with the possibility of obtaining credit to pay for land and capital, has increased, the impact of schooling on agricultural productivity is substantially higher (Eastwood *et al.*, 2010, p. 3345).

Greater market orientation of agriculture, coupled with productivity gains largely supported by technological progress (e.g. mechanisation, development in crop and animal genetics), are driving a process of structural change towards fewer and larger farms in the European Union countries (Stępień, Polcyn, 2015, p. 162). However, significant numbers of small farms exist in many Member States. In this context it has to be mentioned that small farms play an important role in supporting rural employment and maintaining the social fabric of rural areas and thus contribute to the objective of balanced territorial development. In addition, structural diversity in the farming systems contributes to the attractiveness and identity of rural regions (*What is*…, 2011, p. 1).

The identification of the European Union countries that are characterized by very similar farm size distributions, and those countries which differ from others in terms of the distribution of the

variable, has become the objective of this paper. The objective will be achieved by carrying out the following research tasks:

1) selecting a statistic that allows for making comparisons of distributions,
2) determining the values of this statistic for each pair of distributions,
3) dividing the analysed countries into groups with similar size distributions of holdings.

Table 1 presents information on the structure of farms in the twenty-seven* European Union countries covered by the study (data for 2013).

Table 1a. The structure of farms by size

Farm size	AT	BE	BG	CY	CZ	DE	DK	EE	ES
Less than 2 ha	11,0%	5,3%	75,9%	75,0%	11,4%	5,2%	3,2%	11,5%	28,4%
From 2 to 4.9 ha	19,7%	9,2%	10,9%	14,9%	7,2%	3,4%	2,3%	21,6%	24,1%
From 5 to 9.9 ha	17,4%	13,2%	4,3%	5,0%	18,8%	15,6%	20,3%	20,7%	14,6%
From 10 to 19.9 ha	21,6%	18,1%	2,7%	2,5%	17,6%	20,7%	18,0%	17,4%	11,5%
From 20 to 29.9 ha	11,9%	13,1%	1,3%	0,9%	9,0%	10,1%	10,3%	7,3%	5,3%
From 30 to 49.9 ha	10,4%	18,0%	1,3%	0,8%	9,0%	14,9%	11,4%	6,2%	5,5%
From 50 to 99.9 ha	6,2%	17,3%	1,2%	0,6%	9,4%	17,6%	14,1%	6,0%	5,2%
100 ha or over	1,8%	5,8%	2,4%	0,3%	17,6%	12,3%	20,6%	9,3%	5,4%

Table 1b. The structure of farms by size – continued

Farm size	FI	FR	GB	GR	HR	HU	IE	IT	LT
Less than 2 ha	1,9%	12,7%	2,3%	51,4%	38,8%	75,9%	1,7%	27,6%	14,2%
From 2 to 4.9 ha	3,5%	11,9%	4,6%	25,3%	30,6%	8,7%	5,3%	31,1%	39,1%
From 5 to 9.9 ha	11,3%	8,7%	14,7%	12,2%	15,7%	5,2%	11,2%	17,1%	22,4%
From 10 to 19.9 ha	20,2%	9,5%	15,7%	6,4%	8,0%	4,1%	24,5%	11,4%	11,7%
From 20 to 29.9 ha	15,1%	6,7%	9,7%	2,1%	2,5%	1,7%	17,6%	4,4%	3,8%
From 30 to 49.9 ha	20,1%	10,0%	12,8%	1,6%	1,9%	1,5%	21,7%	3,9%	3,2%
From 50 to 99.9 ha	19,4%	19,8%	17,7%	0,8%	1,7%	1,3%	14,6%	3,0%	3,0%
100 ha or over	8,5%	20,7%	22,4%	0,2%	0,9%	1,6%	3,4%	1,5%	2,7%

Table 1c. The structure of farms by size – continued

Farm size	LU	LV	NL	PL	PT	RO	SE	SI	SK
Less than 2 ha	9,6%	22,9%	12,8%	23,3%	46,4%	73,2%	1,9%	25,5%	31,5%
From 2 to 4.9 ha	6,7%	19,7%	14,6%	31,1%	25,9%	19,0%	9,5%	34,3%	27,4%
From 5 to 9.9 ha	9,1%	19,7%	13,9%	21,6%	11,8%	5,3%	23,5%	23,8%	12,1%
From 10 to 19.9 ha	8,2%	19,3%	14,9%	14,6%	6,9%	1,4%	20,3%	11,3%	9,4%
From 20 to 29.9 ha	5,8%	6,5%	10,2%	4,3%	2,6%	0,3%	9,9%	2,8%	3,3%
From 30 to 49.9 ha	10,1%	5,1%	16,3%	2,8%	2,3%	0,2%	10,8%	1,5%	3,1%
From 50 to 99.9 ha	28,8%	3,3%	13,8%	1,4%	1,8%	0,2%	12,2%	0,6%	3,4%
100 ha or over	21,6%	3,5%	3,5%	0,8%	2,3%	0,4%	12,0%	0,2%	9,8%

* the data for Malta are not available yet and that is why not all the twenty-eight EU countries have been studied in this paper

The following codes of countries were used: AT – Austria, BE – Belgium, BG – Bulgaria, CY – Cyprus, CZ – Czech Republic, DE – Germany, DK – Denmark, EE – Estonia, ES – Spain, FI – Finland, FR – France, GB – United Kingdom, GR – Greece, HR – Croatia, HU – Hungary, IE – Ireland, IT – Italy, LT – Lithuania, LU – Luxembourg, LV – Latvia, NL – Netherlands, PL – Poland, PT – Portugal, RO – Romania, SE – Sweden, SI – Slovenia, SK – Slovakia.

Source: own computation based on Eurostat database (date of access: 27.03.2017).

The data in Table 1 indicate that there is an enormous variation in farm structures across the EU countries. Hence, the purpose of the study is to examine which of the Member States are similar in respect of farm sizes.

2. METHODOLOGY

In the study conducted in this paper the author has used an original conglomerate of statistical tools, namely, the maximum absolute value of the difference between cumulative distribution functions and the dendrite method. The dendrite method is admittedly well known method of classification, but in this study it has been applied in an innovative way.

The considered variable is the farm size. The cumulative distribution function *F* fully defines the distribution of the variable in a given population (Kot *et al.*, 2007, p. 267). Hence, the comparison of distributions of the variable in two populations can be reduced to the comparison of values of cumulative distribution functions in these populations, and if two populations have the same distribution, the values of their cumulative distribution functions have to be identical in all points (Razali, Wah, 2011, p. 23).

Let the first population contain n_1 elements, and the other n_2 elements. Then F_1 and F_2 stand for cumulative distribution functions regarding the first and the second population, respectively. The scale of differences between the values of these functions is the subject of the further analysis. The values of the cumulative distribution functions had to be calculated for each *i*-th class interval according to the formulas (Witkowski, 2010, p. 92):

$$F_{1,i} = \frac{n_{1cum,i}}{n_{1,i}} \qquad F_{2,i} = \frac{n_{2cum,i}}{n_{2,i}}, \tag{1}$$

where $n_{1cum,i}$ and $n_{2cum,i}$ denote the cumulative frequencies computed for the first and the second population, respectively.

In the next step for each *i*-th class interval the absolute value of the difference between the cumulative distribution functions was determined and the largest absolute value of the difference between $F_{1,i}$ and $F_{2,i}$ was indicated. It was labelled as $D_{1,2}$. Thus, the measure $D_{1,2}$ was defined as (Taylor, Emerson, 2011, p. 34):

$$D_{1,2} = \max_i \left| F_{1,i} - F_{2,i} \right|. \tag{2}$$

Thanks to the classification procedure the set of twenty seven countries can be divided into a given number of subsets that are relatively uniform with respect to the adopted criterion. Such a division is desirable, in which the value of *D* statistic calculated for any pair of countries belonging to the same group is less than the value of the statistic for any pair of countries belonging to different groups (Turczak, Zwiech, 2015b, p. 26). To make this division the dendrite method was used. The procedure was carried out in the following stages (Dziechciarz, 2002, p. 273):

Stage 1. On the basis of the values of *D* statistic for each country the country most similar was found. Then the dendrite was built composed of vertices and lines. The construction of the dendrite was started by joining each country with the most similar one. As a result of such a joining procedure a graph consisting of first order clusters was created in which countries were connected to one another by lines in a direct or indirect way. At that stage more than one first order cluster was obtained and therefore it was necessary to carry out the second stage (Turczak, Zwiech, 2015a, p. 93).

Stage 2. At that stage for each first order cluster the most similar one had to be found. As the value of the *D* statistic referring to a pair of clusters, the minimum value of this statistic calculated for countries belonging to these two clusters was assumed (Młodak, 2006, p. 77). Consequently, by joining each first order cluster with the most similar one, the second order clusters were formed. The described procedure was repeated until all clusters were connected.

Stage 3. The graph has already been connected. Thus, it is now ready to make its appropriate division. If the final classification is to distinguish *k* disjoint groups, the *k*-1 longest lines have to be removed from the dendrite.

3. GROUPS OF COUNTRIES SIMILAR AS REGARDS FARM SIZE DISTRIBUTION

As already mentioned, the purpose of the study is to compare the distributions of farm size constructed for the EU countries. The similarity of those distributions is to be measured using the *D* statistic. Two distributions are more similar if *D* is smaller. Table 2 presents the values of *D* statistic calculated for each pair of countries covered by the study.

Table 2a. The values of *D* statistic obtained for each pair of countries (in percentage points)

D	**AT**	**BE**	**BG**	**CY**	**CZ**	**DE**	**DK**	**EE**	**ES**	**FI**	**FR**	**GB**	**GR**	**HR**
AT	0.0	23.8	65.0	64.0	19.0	26.4	27.6	**7.5**	21.8	32.7	32.4	34.4	46.1	38.7
BE	23.8	0.0	72.4	75.3	11.9	**6.9**	14.8	26.1	39.4	11.0	17.3	17.0	62.2	57.4
BG	65.0	72.4	0.0	3.7	68.3	78.2	81.4	64.5	47.5	81.5	63.2	80.0	24.5	37.2
CY	64.0	75.3	3.7	0.0	71.3	81.2	84.4	63.5	46.6	84.4	65.2	83.0	23.6	36.2
CZ	19.0	11.9	68.3	71.3	0.0	13.1	13.1	16.4	33.9	20.6	14.4	17.6	58.2	50.8
DE	26.4	**6.9**	78.2	81.2	13.1	0.0	8.3	29.5	43.9	8.1	16.0	10.2	68.1	60.8
DK	27.6	14.8	81.4	84.4	13.1	8.3	0.0	28.1	47.1	12.1	19.2	**6.9**	71.3	64.0
EE	**7.5**	26.1	64.5	63.5	16.4	29.5	28.1	0.0	19.4	37.0	29.0	33.9	43.7	36.3
ES	21.8	39.4	47.5	46.6	33.9	43.9	47.1	19.4	0.0	50.3	35.7	45.6	24.2	18.0
FI	32.7	11.0	81.5	84.4	20.6	**8.1**	12.1	37.0	50.3	0.0	19.2	13.9	72.2	68.3
FR	32.4	17.3	63.2	65.2	14.4	16.0	19.2	29.0	35.7	19.2	0.0	17.8	55.6	51.7
GB	34.4	17.0	80.0	83.0	17.6	10.2	**6.9**	33.9	45.6	13.9	17.8	0.0	69.9	63.5
GR	46.1	62.2	24.5	23.6	58.2	68.1	71.3	43.7	24.2	72.2	55.6	69.9	0.0	12.7
HR	38.7	57.4	37.2	36.2	50.8	60.8	64.0	36.3	18.0	68.3	51.7	63.5	12.7	0.0
HU	65.0	70.6	**2.3**	5.3	66.0	76.0	79.1	64.4	47.5	79.2	63.2	77.7	24.5	37.1
IE	29.9	**9.5**	79.9	82.8	19.2	12.0	17.2	35.6	48.9	9.9	22.4	22.1	70.7	66.9
IT	28.0	48.1	48.3	47.4	40.1	51.5	53.2	25.6	8.7	59.0	44.3	54.2	23.8	11.2
LT	27.5	47.9	61.8	60.8	38.2	51.3	49.9	21.8	14.3	58.9	44.5	54.0	37.3	24.6
LU	42.4	27.4	70.5	73.5	24.5	20.5	15.8	39.1	44.9	22.6	**10.1**	10.4	63.4	59.6
LV	14.2	35.8	53.1	52.1	26.6	38.0	38.0	11.4	**9.9**	45.6	38.8	44.3	34.1	26.8
NL	15.1	**13.6**	63.2	62.5	14.1	18.8	22.0	15.0	25.8	24.6	23.1	22.8	49.3	43.8
PL	27.9	48.3	52.6	51.7	38.6	51.7	50.3	22.2	12.1	59.3	47.8	54.4	28.1	15.4
PT	41.6	57.8	29.5	28.6	53.7	63.7	66.9	39.2	19.8	67.4	50.8	65.4	**5.0**	7.6
RO	62.2	77.7	6.4	**2.7**	73.7	83.6	86.8	61.7	44.8	86.8	67.6	85.4	21.7	34.4
SE	19.2	**9.4**	75.4	78.4	9.5	10.7	11.6	21.6	41.0	18.3	16.3	18.1	65.2	57.9
SI	35.6	55.9	50.4	49.5	46.3	59.4	58.0	29.9	16.6	66.9	52.1	62.0	25.9	13.3
SK	28.2	44.4	44.4	43.5	40.4	50.3	53.5	25.8	**6.4**	54.3	37.7	52.1	19.9	14.0

Table 2b. The values of *D* statistic obtained for each pair of countries (in p.p.) – continued

D	**HU**	**IE**	**IT**	**LT**	**LU**	**LV**	**NL**	**PL**	**PT**	**RO**	**SE**	**SI**	**SK**	**Min.**
AT	65.0	29.9	28.0	27.5	42.4	14.2	15.1	27.9	41.6	62.2	19.2	35.6	28.2	**7.5**
BE	70.6	9.5	48.1	47.9	27.4	35.8	13.6	48.3	57.8	77.7	9.4	55.9	44.4	**6.9**
BG	**2.3**	79.9	48.3	61.8	70.5	53.1	63.2	52.6	29.5	6.4	75.4	50.4	44.4	**2.3**
CY	5.3	82.8	47.4	60.8	73.5	52.1	62.5	51.7	28.6	**2.7**	78.4	49.5	43.5	**2.7**
CZ	66.0	19.2	40.1	38.2	24.5	26.6	14.1	38.6	53.7	73.7	**9.5**	46.3	40.4	**9.5**

DE	76.0	12.0	51.5	51.3	20.5	38.0	18.8	51.7	63.7	83.6	10.7	59.4	50.3	**6.9**
DK	79.1	17.2	53.2	49.9	15.8	38.0	22.0	50.3	66.9	86.8	11.6	58.0	53.5	**6.9**
EE	64.4	35.6	25.6	21.8	39.1	11.4	15.0	22.2	39.2	61.7	21.6	29.9	25.8	**7.5**
ES	47.5	48.9	8.7	14.3	44.9	9.9	25.8	12.1	19.8	44.8	41.0	16.6	**6.4**	**6.4**
FI	79.2	9.9	59.0	58.9	22.6	45.6	24.6	59.3	67.4	86.8	18.3	66.9	54.3	**8.1**
FR	63.2	22.4	44.3	44.5	**10.1**	38.8	23.1	47.8	50.8	67.6	16.3	52.1	37.7	**10.1**
GB	77.7	22.1	54.2	54.0	10.4	44.3	22.8	54.4	65.4	85.4	18.1	62.0	52.1	**6.9**
GR	24.5	70.7	23.8	37.3	63.4	34.1	49.3	28.1	**5.0**	21.7	65.2	25.9	19.9	**5.0**
HR	37.1	66.9	11.2	24.6	59.6	26.8	43.8	15.4	**7.6**	34.4	57.9	13.3	14.0	**7.6**
HU	0.0	77.6	48.3	61.8	68.2	53.0	63.1	52.6	29.5	7.8	74.0	50.4	44.4	**2.3**
IE	77.6	0.0	57.6	57.4	32.5	44.1	23.1	57.8	65.9	85.2	16.8	65.4	52.9	**9.5**
IT	48.3	57.6	0.0	13.4	53.5	16.1	34.5	**4.3**	18.8	45.6	47.2	7.9	8.7	**4.3**
LT	61.8	57.4	13.4	0.0	53.6	13.3	34.3	**9.2**	32.3	59.0	41.7	11.4	17.4	**9.2**
LU	68.2	32.5	53.5	53.6	0.0	48.7	33.2	57.0	58.7	75.9	26.4	61.3	46.8	**10.1**
LV	53.0	44.1	16.1	13.3	48.7	0.0	25.4	13.7	29.7	50.3	31.1	21.4	16.3	**9.9**
NL	63.1	23.1	34.5	34.3	33.2	25.4	0.0	34.7	44.9	64.8	15.9	42.3	31.5	**13.6**
PL	52.6	57.8	**4.3**	9.2	57.0	13.7	34.7	0.0	23.1	49.8	43.0	7.6	11.2	**4.3**
PT	29.5	65.9	18.8	32.3	58.7	29.7	44.9	23.1	0.0	26.8	60.8	20.9	14.4	**5.0**
RO	7.8	85.2	45.6	59.0	75.9	50.3	64.8	49.8	26.8	0.0	80.7	47.7	41.6	**2.7**
SE	74.0	16.8	47.2	41.7	26.4	31.1	15.9	43.0	60.8	80.7	0.0	48.7	47.4	**9.4**
SI	50.4	65.4	7.9	11.4	61.3	21.4	42.3	**7.6**	20.9	47.7	48.7	0.0	14.4	**7.6**
SK	44.4	52.9	8.7	17.4	46.8	16.3	31.5	11.2	14.4	41.6	47.4	14.4	0.0	**6.4**

Source: own computation based on Table 1.

The task is to divide a set of twenty seven countries into such disjoint and non-empty subsets that countries from the same group are the most similar to one another, and countries from different groups are the least similar. To achieve this purpose, the dendrite method procedure can be performed on the basis of the values of *D* statistic. In each row of Table 2 the smallest positive value of *D* is marked in bold. Based on the numbers in bold the adequate graph was drawn. The countries (i.e., vertices) are shown as circles in the graph. The completion of the first and the second stage of dendrite method led to formation of the connected graph presented in Figure 1.

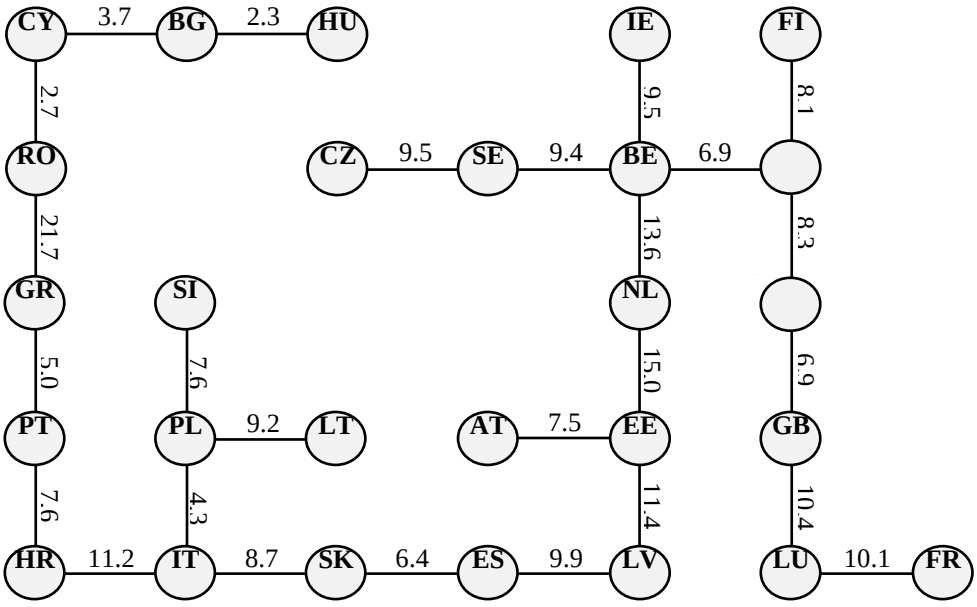


Figure 1.The connected graph
Source: own compilation based on Table 2

The following step is the appropriate division of the dendrite into separate groups. If the division into two relatively homogeneous subsets is needed, the line corresponding to the longest distance equal 21.7 p.p. should be removed from the graph. In that case one group would include BG, CY, HU and RO, and the other group – remaining twenty three countries. If it is necessary to isolate three groups, additionally the distance of length amounting for 15.0 p.p. should be eliminated. Then, the lines for distances 13.6 and 11.4 could also be deleted. It seems that in the case of twenty seven vertices of the graph, splitting it into more than five groups is not justified. Thus, as a result of accomplishing the procedure of dendrite method – innovatively performed on the basis of *D* statistic – five sets were created, which are depicted in Figure 2.

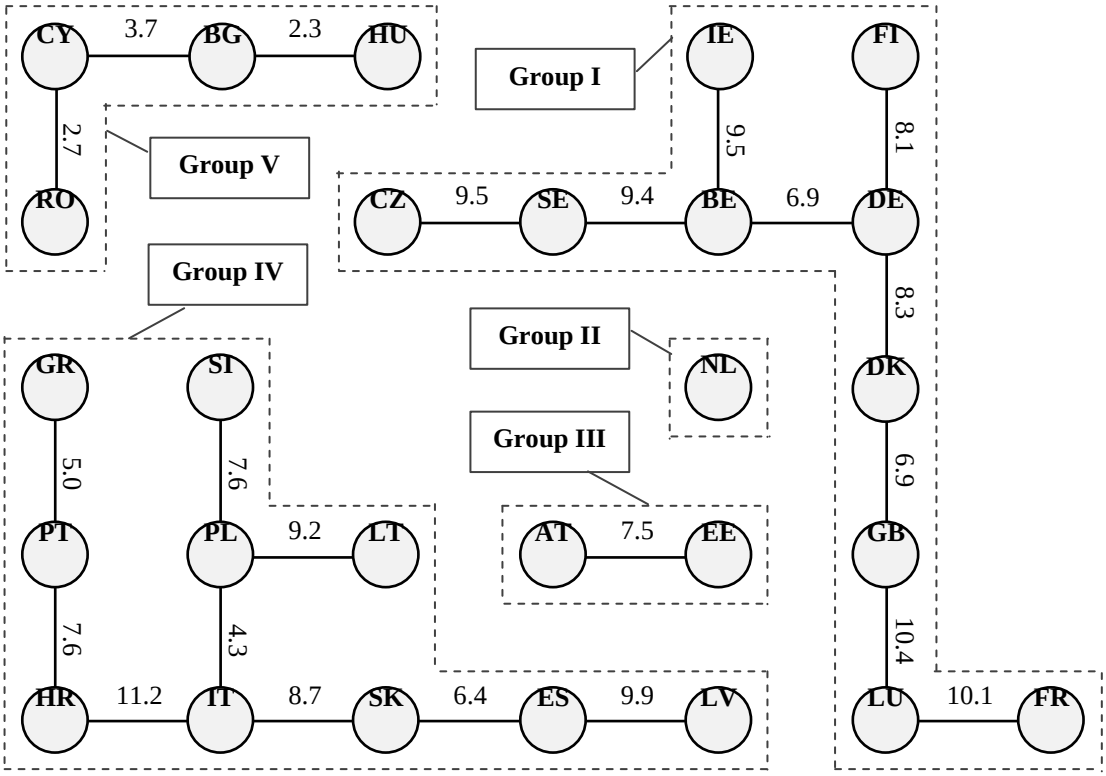


Figure 2. The dendrite divided into five separate groups *Source: own compilation based on Figure 1*

4. COMPARISON OF DISTRIBUTIONS IN THE FIVE FORMED GROUPS

Figures 3a–3e present information on the shapes of size distributions of farms in the five specified groups.

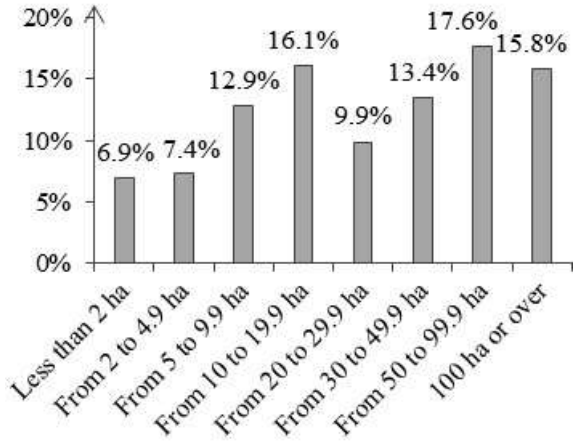


Figure 3a. Farm size distribution in gr. I

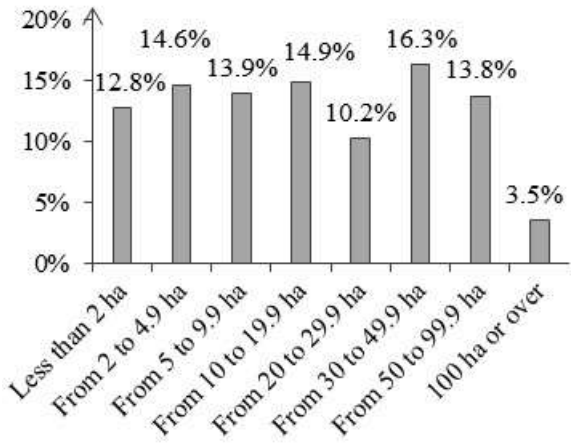


Figure 3b. Farm size distribution in gr. II

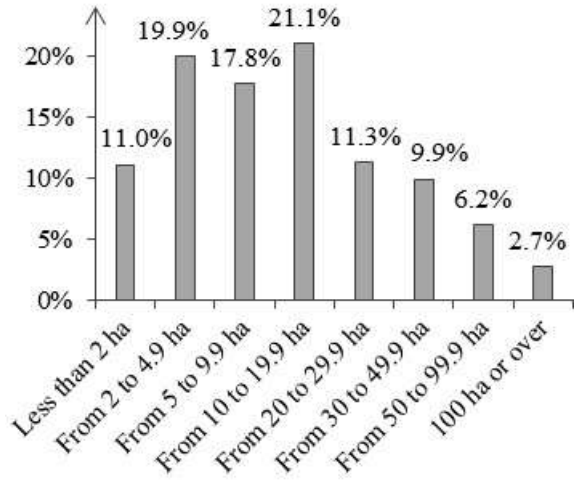


Figure 3c. Farm size distribution in gr. III

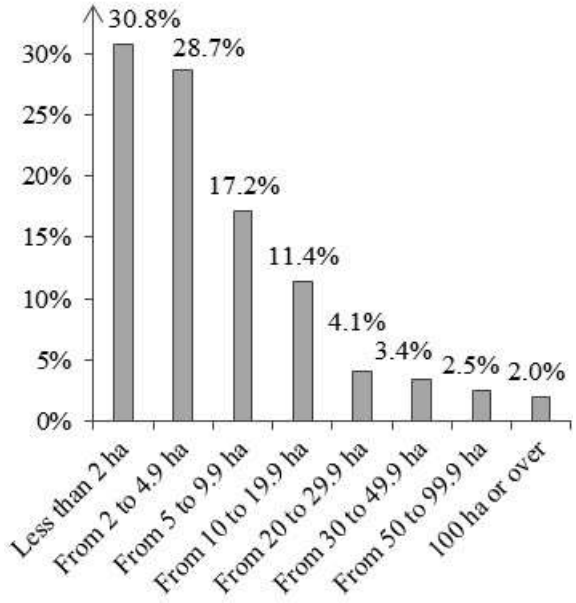
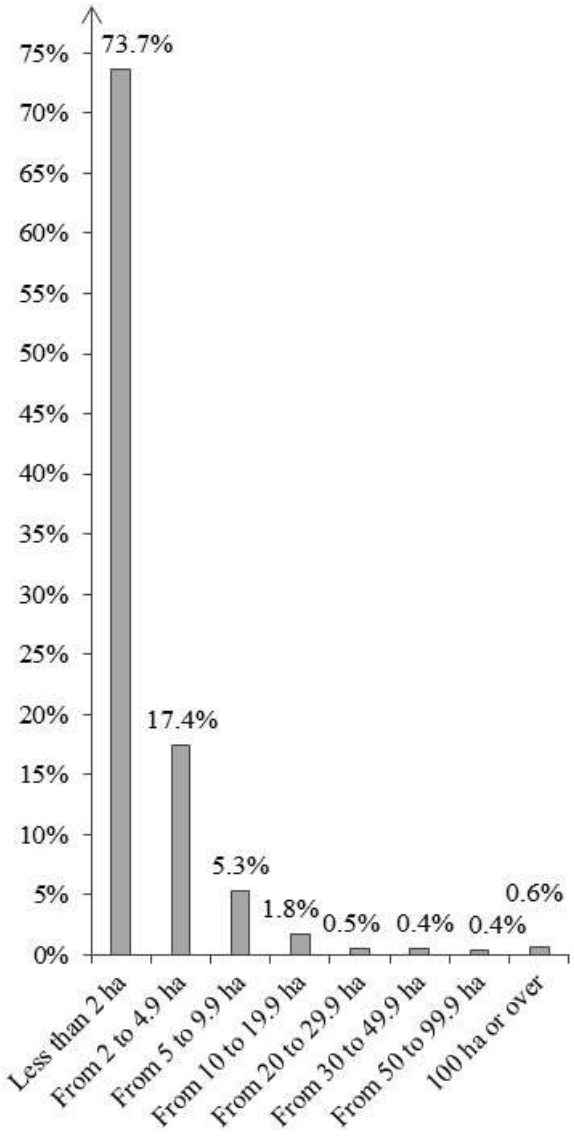


Figure 3d. Farm size distribution in gr. IV



NUMBERS OF HOLDINGS:

Group I (1,305,790):

Belgium (37,760), Czech Republic (26,240), Denmark (38,270), Finland (54,410), France (472,210), Germany (285,030), Ireland (139,590), Luxembourg (2,080), Sweden (67,150), United Kingdom (183,050)

Group II (67,480):

Netherlands (67,480)

Group III (159,600):

Austria (140,430), Estonia (19,170)

Group IV (4,885,190):

Croatia (157,430), Greece (709,510), Italy (1,010,310), Latvia (81,790), Lithuania (171,790), Poland (1,429,000), Portugal (264,420), Slovakia (23,560), Slovenia (72,370), Spain (965,010)

Group V (4,410,790):

Bulgaria (254,400), Cyprus (35,390), Hungary (491,340), Romania (3,629,660)

Figure 3e. Farm size distribution in gr. V

As Figures 3a–3e indicate, a great diversity of structural patterns between the five isolated groups of the European Union countries can be observed. The first group has encompassed 12.1% of the total number of EU holdings, gr. II – 0.6%, gr. III – 1.5%, gr. IV – 45.1%, and gr. V – 40.7% of the Member States holdings.

5. CONCLUSIONS

To analyse farm structures and compare them across different countries, regions, or over time, physical measures such as hectares of utilised agricultural area or the amount of labour input per farm can be used. However, it is important to remember that these measures are highly dependent on the type of farming and provide little information on the economic situation of a farm (*What is*…, 2011, p. 1).

In recent years, and in particular following the accession of Bulgaria and Romania to the European Union, small farms have received increased attention in the political debate, recognizing the role they play in

rural areas and the need to improve their economic and social conditions in times of structural change of the agricultural sector towards fewer and larger farms. The interesting issue is that although there is a broad statistical association between economic development and the average farm size, in many advanced countries the family remains the main source of farm labour (Eastwood *et al*., 2010, p. 3324).

The aim of the paper was to determine the degree of similarity between the European Union countries in terms of farm sizes and to single out countries most similar in that respect. The twenty seven countries were divided into five groups of alike distributions. In order to accomplish this task, for each pair of countries the maximum absolute value of the difference between cumulative distribution functions was computed and then the dendrite method was employed. All calculations were carried out based on Eurostat database.

Summarizing, the data about the number of hectares are certainly easy to collect and to use. Looking at the development over time of farm sizes in terms of utilised agricultural area can give an indication of structural change, especially when observing this development within a group of similar farms. However, patterns regarding family management, use of hired workforce, contribution of non-farm sources of income, technological level, age of the workforce, conservative vs. innovative behaviour, level of training, degree of specialisation and a wide range of other characteristics could be used in future analyses for a better understanding of the nature of small, medium and large farms (*What is*…, 2011, p. 2).

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