

STRUCTURE AND DYNAMICS OF MAJOR CROPS SOWN IN THE EUROPEAN UNION

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ABSTRACT

This article contains a comparison of the EU countries in terms of similarity of the structure of sown main crops: wheat, rye, barley, potatoes, and sugar beet. Based on the fuzzy classification method, countries with a similar structure of specified crops sown were grouped together. Then, we compared the direction and pace of change in the sowing area of these crops in different countries in the period 2006-2012 according to separate typological groups.

Key words: crop structure, country groups, European Union, comparison, crops.

INTRODUCTION

The sowing structures in Poland and Romania are dominated by cereals. In Poland wheat is the leading crop, while in Romania it is wheat and maize.

In 2012, in Poland, the share of basic cereals in the overall sowing area was nearly 74%, of which the area of wheat accounted for 27%. Rye, barley and oats, as well as potatoes and sugar beet have always played an important role in Poland's crop production. In recent years, there have been large changes in Poland taking place in the area occupied by particular crops, which also causes significant changes in the structure of sowing. The area of potato cultivation decreased from 803,000 ha in 2002 to 359,000 ha in 2012. The cultivation area of rye and oats has decreased at a very fast rate, and their place was taken by wheat, cereal mixes and triticale. A rapid growth of the area of corn harvested for grain is also taking place, which is conditioned by breeding progress and certain climate changes (Kuś and Krasowicz et al., 2009). It can be generally stated that the acreage sown with species of cereal of a higher economic value has increased at the expense of the less valuable species.

In Romania, the share of cereals in the total sowing area was more than 65% in 2012. From the total cereals' area, wheat and maize accounted for 35% and 50%, respectively. Other important crops are sunflower, barley, potatoes and oats. The most significant changes between 2002 and 2012 are decreases of 55% in the area occupied by rye, 35.7% for sugar beet, 26.8% for barley and 21.6% for potatoes. Only the area occupied by sunflower increased, by 17.8%. In the same period, the total area allocated to cereals decreased by almost 10%.

The aim of this study is to compare Poland and Romania with other EU countries in terms of the sowing structure of the main following agricultural crops: wheat, rye, barley, potatoes, and sugar beet. The study was conducted based on the data contained in the Statistical Yearbook of Agriculture (2014) concerning the sowing area of selected agricultural products in the EU in 2012. Based on the fuzzy classification method, countries similar in terms of examined structure were grouped together. Then, the dynamics of changes in the sowing area of the above mentioned crops in the particular countries in the period 2006-2012 was compared within separate typological groups.

Examination method

The grouping of the countries by crop structure similarity was based on fuzzy classification that was then converted into classic **categorization**. In contrast to classical categorization, where the inclusion of the objects in a given class is described using a binary variable, the inclusion of the object in the class in fuzzy classification is described by means of a continuous variable. These are so-called membership functions that take values from the range (0,1).

The definition of fuzzy classification can be formulated as follows.

It is assumed that the given Ω set, numbering n objects (in this case, countries):

$$P_1, P_2, \dots, P_n.$$

These objects are circumscribed by the r values of the variables. X_1, X_2, \dots, X_r (in the work X_i designates the share of the area of l -th crop (agricultural product) in the total area of selected crops (agricultural products) in the particular country). It is necessary to determine the family of fuzzy classifications on the Ω set:

S_1, S_2, \dots, S_K ($1 < K < n$), in order to meet the following conditions:

$$1. 0 \leq f_{S_j}(P_i) \leq 1 \quad (i=1, \dots, n; j=1, \dots, K)$$

where $f_{S_j}(P_i)$ designates a degree of membership of P_i to the S_j class.

$$2. \sum_{j=1}^K f_{S_j}(P_i) = 1 \quad (i=1, \dots, n),$$

3. The objects for which the degrees of membership in the same class are large are very similar, while the objects for which the degrees of membership to different classes are large – are not very similar.

Creating a fuzzy classification is thus based on designating for each object $P_i \in \Omega$ such a vector $f(P_i) = (f_{S_1}(P_i), f_{S_2}(P_i), \dots, f_{S_K}(P_i))$, that the conditions 1-3 are fulfilled.

There are several methods for creating fuzzy classification (Jajuga, 1984). An iterative method using the concept of a fuzzy gravity center was used in the work. In this method the degree of objects' membership in particular classes is being changed in

subsequent iterations. The procedure is continued until these values no longer change in a meaningful manner.

Fuzzy classification obtained this way was then transformed into classical categorization, assuming that the object P_i belongs to the S_j class (typological group), when $f_{S_j}(P_i) = \max_i f_{S_i}(P_i)$

Findings

On the basis of data presenting the sowing area of selected agricultural products in the EU countries in 2012 (Statistical Yearbook of Agriculture, 2014), the structure of main agricultural crops was appointed (Table 1). In the case of four countries (Cyprus, Estonia, Luxembourg, Malta), the data was incomplete, thus these countries were not taken into account in further studies. The resulting structure is characterized by strong differentiation. Wheat cultivation area makes up from 17.3% in Portugal up to 61.8% in Bulgaria; the shares of barley range from 5.3% in Portugal to 59.4% in Ireland. Smaller differences relate to the shares of rye, potatoes and sugar beets.

Based on the research method presented above, classification of the countries was carried out in terms of similarity of sowing structure of the aforementioned crops. Calculations were made using a proprietary computer program that fjk iuhg or a given set of multidimensional objects defines the centers of gravity of the clusters, and calculates values of the membership function of particular objects in these clusters.

The following groups were obtained:

- 1st group: Bulgaria, France, Greece, Lithuania, Slovakia, Italy.
- 2nd group: Austria, Croatia, **Poland**, Portugal, **Romania**, Slovenia, Hungary.
- 3rd group: Czech Republic, Latvia, Germany, UK.
- 4th group: Denmark, Finland, Spain, Ireland, Sweden.

Two countries, Belgium and the Netherlands, deviate with their structures from the separated groups and form one-element groups.

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Table 1. Structure of the major crops sown in the EU in 2012 (as percentage of total)

No.	Country	Wheat	Rye	Barley	Other crops	Potatoes	Sugar beet
		%					
1	EU (28)	41.7	4	20.5	28.2	3	2.7
2	Austria	34.1	5.5	16.7	35.8	2.4	5.4
3	Belgium	46.4	0.1	9.8	16.6	13.9	13.2
4	Bulgaria	61.8	0.5	10	26.8	0.9	0
5	Croatia	30.1	0.8	9.2	54.5	1.6	3.9
6	Czech Republic	52.9	2	24.8	14.9	1.6	4
7	Denmark	38.8	4.1	45.6	6.4	2.5	2.6
8	Finland	21.2	2	42.2	31.5	2	1.1
9	France	53.1	0.3	16.9	24.2	1.5	3.9
10	Germany	42.8	9.9	23.5	14.8	3.3	5.6
11	United Kingdom	58.4	0.2	29.4	4.1	4.4	3.5
12	Greece	55	1.5	11.2	29.1	2.3	0.8
13	Hungary	38.1	1.3	9.9	49.3	0.8	0.6
14	Ireland	30.2	0.1	59.4	7.6	2.8	0
15	Italy	51.5	0.1	7	38.5	1.7	1.3
16	Latvia	59.9	6.1	14.3	15	4.7	0
17	Lithuania	51.7	4.6	17.9	21.5	2.6	1.7
18	Netherlands	35.8	0.4	7.1	4.5	35.3	16.9
19	Poland	25.1	12.6	14	41.4	4.3	2.6
20	Portugal	17.3	6.3	5.3	62.5	8.5	0.1
21	Romania	35	0.2	7.4	52.9	4	0.5
22	Slovakia	47.2	1.9	18	29.4	1.1	2.4
23	Slovenia	33.5	0.9	17.2	45.1	3.3	0
24	Spain	30.2	3.6	45.9	18.5	1.3	0.7
25	Sweden	34.8	2.1	35	22.1	2.4	3.7

Source: own calculations based on The Statistical Yearbook 2014 (Central Statistical Office GUS, Warsaw) and Eurostat.

The characteristics of the resulting groups are presented below (Table 2).

In the countries of the 1st group wheat amounts on average to 53.4% of sown area of

the main crops, while the other cereals make 28.2%, followed by barley (13.5%). Rye, potatoes and sugar beet present a small percentage: respectively 1.5%, 1.7% and 1.7%.

Table 2. Characteristics of the groups of countries with similar structures of the main agricultural

Group	Characteristics	Wheat	Rye	Barley	Potatoes	Sugar beet	Other crops	Total
1 st	Average (%)	53.4	1.5	13.5	1.7	1.7	28.2	100
	s(x)	4.5	1.5	4.3	0.6	1.2	5.3	
	V(x)	0.08	1.02	0.32	0.37	0.75	0.19	
2 nd	Average (%)	30.5	4.4	11.8	3.9	1.5	47.8	100
	s(x)	7.1	4.3	4.5	2.4	1.9	8.5	
	V(x)	0.23	0.97	0.38	0.61	1.27	0.18	
3 rd	Average (%)	53.5	4.5	23	3.5	3.3	12.2	100
	s(x)	6.7	3.8	5.5	1.2	2	4.7	
	V(x)	0.13	0.83	0.24	0.35	0.63	0.38	
4 th	Average (%)	31	2.4	45.6	2.2	1.6	17.2	100
	s(x)	5.9	1.4	7.9	0.5	1.3	9.4	
	V(x)	0.19	0.6	0.17	0.24	0.83	0.54	
5 th	Belgium	46.4	0.1	9.8	13.9	13.2	16.6	100
6 th	Netherlands	35.8	0.4	7.1	35.3	16.9	4.5	100

Source: own calculations.

In the countries of the 2nd group, shares of wheat and barley are lower than in the 1st group, and they are respectively 30.5% and 11.8%. Other cereals dominate here, which constitute 47.8%. Shares of rye, potatoes and sugar beet are at a comparable level as in the 1st group. It should be noted that Poland differs from the other countries in this group with high shares of rye (12.6%), and these are the highest shares of rye among all EU countries.

The 3rd group differs from the first two groups with higher shares of barley (23%), while the shares of other cereals are the lowest among the typological groups of the countries and amount to 12.2%. The first place in terms of sowing area (53.5%) is taken by wheat.

The 4th group is characterized by the highest shares of barley among all groups (on average 43.3%), while wheat has the lowest shares (31%). Other cereals represent on average 17.2%.

Belgium and the Netherlands diverge from the separated groups with the highest shares of potatoes (accordingly 14% and 35%) and sugar beet (13% and 17%). The largest part of crops in those countries is wheat (46% and 36%), while barley shares are the lowest among the typological groups and are below 10%.

In the period 2006-2012, in all EU countries there were changes in the sowing area. The dynamics of these changes have been analyzed (Tables 3-7) for the following crops: cereals in general, wheat, rye, barley, potatoes, sugar beet (wherein "total cereals" include only grain cereals, such as wheat, rye, barley, oats, maize, millet, buckwheat, feed cereals, etc.). (Statistical Yearbook of Agriculture, 2014)

In all the countries of the 1st group, except Italy, the cereal cultivation area increased, from 4% in France and Greece, to 23% in Bulgaria. Similar tendencies in this group also applied to rye and potatoes. Rye cultivation area increased in all countries of this group, although the rate of these changes was different: from 10% in Lithuania to 79% in Italy.

Potato cultivation acreage declined at a rate from 3% in France to 51% in Slovakia. In the case of wheat, barley and sugar beet, direction and rate of changes were different. In Bulgaria, Slovakia and Lithuania the area of wheat sowing increased significantly (22%, 11% and 82% respectively), while in other countries changes were relatively moderate. The area of barley cultivation increased by 53% in Greece, while in Lithuania it decreased by 43% (Table 3).

Table 3. Dynamics of selected crops sown area in the 1st group during 2006-2012

Country	Year	Cereals								Potatoes		Sugar beet	
		Total		Wheat		Rye		Barley		(1,000 ha)	2006=1	(1,000 ha)	2006=1
		(1,000 ha)	2006=1	(1,000 ha)	2006=1	(1,000 ha)	2006=1	(1,000 ha)	2006=1				
EU (27)	2012	57,583	1	25,472	1.03	2,415	1.04	12,498	0.91	1,819	0.81	1,660	0.87
	2006	57,384		24,807		2,333		13,793		2,258		1,917	
Bulgaria	2012	1,900	1.23	1,185	1.22	10	1.35	191	1.03	17	0.71	0	0
	2006	1,548		970		7		186		24		1	
France	2012	9,434	1.04	5,303	1.01	32	1.19	1,684	0.99	154	0.97	390	1.03
	2006	9,106		5,247		27		1,693		158		379	
Greece	2012	991	1.04	563	0.92	15	1.15	115	1.53	24	0.67	8	0.2
	2006	956		610		13		75		36		40	
Italy	2012	3,545	0.93	1,880	0.98	5	1.79	255	0.77	61	0.85	46	0.5
	2006	3,803		1,926		2.8		331		72		92	
Lithuania	2012	1,160	1.2	627	1.82	56	1.1	217	0.57	32	0.55	20	1.05
	2006	515		215		43		154		45		13	
Slovakia	2012	794	1.08	388	1.11	16	1.23	148	0.8	8.9	0.49	20	0.74
	2006	733		349		13		185		18		27	

Source: own calculations based on The Statistical Yearbook, 2014, Central Statistical Office GUS, Warsaw, 2014.

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In the countries of the 2nd group, moderate changes occurred in the sowing area of crops in total. In Poland and Hungary, a slight decrease took place (by 8% and 5%, respectively), while in Romania and Austria the area increased by 7% and in Slovenia by 5%. Only Portugal experienced a significant decrease, of 12% (Table 4). Inconsiderable

changes (0-9%), however in different directions, also applied to wheat crops. In this case, again in Portugal, there was a relatively big change (drop by 51%). With the sole exception of Austria, the areas for potato and sugar beet cultivation were diminished (with a rate between 4% in Hungary to 42% in Slovenia, for potato).

Table 4. Dynamics of selected crops sown area in the 2nd group during 2006-2012

Country	Year	Cereals								Potatoes		Sugar beet	
		Total		Wheat		Rye		Barley		(1,000 ha)	2006=1	(1,000 ha)	2006=1
		(1,000 ha)	2006=1	(1,000 ha)	2006=1	(1,000 ha)	2006=1	(1,000 ha)	2006=1				
EU (27)	2012	57,583	1	25,472	1.03	2,415	1.04	12,498	0.91	1,819	0.81	1,660	0.87
	2006	57,384		24,807		2,333		13,793		2,258		1,917	
Austria	2012	832	1.07	308	1.08	50	1.85	151	0.73	22	1	49	1.26
	2006	777		285		27		206		22		39	
Hungary	2012	2,748	0.95	1,063	0.99	35	0.9	276	0.94	22	0.96	17	0.34
	2006	2,880		1,078		39		294		23		50	
Poland	2012	7,704	0.92	2,077	0.95	1,042	0.79	1,161	0.95	359	0.6	212	0.81
	2006	8,381		2,176		1,318		1,221		597		262	
Portugal	2012	291	0.82	55	0.49	20	0.91	17	0.38	27	0.66	0.3	0.08
	2006	357		112		22		45		41		4	
Romania	2012	5,430	1.07	1,992	1	8.7	0.51	423	1.3	229	0.81	27	0.69
	2006	5,080		1,992		17		326		283		39	
Slovenia	2012	101	1.05	35	1.09	0.9	1.13	18	1.06	3.4	0.58	0	0.00
	2006	96		32		0.8		17		5.9		6.7	

Source: own calculations based on The Statistical Yearbook, 2014, Central Statistical Office GUS, Warsaw, 2014.

In three countries of the 3rd group, just as in the 1st and 2nd group, the changes occurring in the areas of total cereals and wheat were relatively small. The area of

total cereals increased in Latvia and UK by 10%, and declined in the Czech Republic and Germany by 5% and 3%, respectively (Table 5).

Table 5. Dynamics of selected crops sown area in the 3rd group during 2006-2012

Country	Year	Cereals								Potatoes		Sugar beet	
		Total		Wheat		Rye		Barley		(1,000 ha)	2006=1	(1,000 ha)	2006=1
		(1,000 ha)	2006=1	(1,000 ha)	2006=1	(1,000 ha)	2006=1	(1,000 ha)	2006=1				
EU (27)	2012	57,583	1	25,472	1.03	2,415	1.04	12,498	0.91	1,819	0.81	1,660	0.87
	2006	57,384		24,807		2,333		13,793		2,258		1,917	
Czech Republic	2012	1,457	0.95	815	1.04	31	1.41	382	0.72	24	0.8	61	1
	2006	1,535		782		22		528		30		61	
Germany	2012	6,513	0.97	3,061	0.98	710	1.32	1,683	0.83	238	0.87	402	1.12
	2006	6,702		3,115		539		2,025		274		358	
Latvia	2012	565	1.1	355	1.65	36	0.84	85	0.55	28	0.62	0	0
	2006	515		215		43		154		45		13	
UK	2012	3,141	1.1	1,992	1.09	6	0.86	1,002	1.14	149	1.06	120	0.92
	2006	2,859		1,833		7		881		141		131	

Source: own calculations based on The Statistical Yearbook, 2014, Central Statistical Office GUS, Warsaw, 2014.

Wheat acreage changed in the countries of this group within the limits of 2-9%, except Latvia, where the increase was much larger (65%). Latvia distinguishes itself among the countries of this group by the (relatively) largest changes, while the United Kingdom by dissimilar direction of changes in the case of potatoes and barley. In both cases, in the UK, the area increased (potatoes by 6% and barley by 14%), while in the other countries of this group barley cultivation area declined by 17-45%, and potatoes cultivation area declined by 13-38%. For rye, there were relatively significant growths recorded in Germany (32%) and Czech Republic (41%),

while in Latvia and UK the areas declined, by 16% and 14%, respectively.

In the countries of the 4th group, potatoes and sugar beet experienced similar direction of changes: in both cases crop area declined. The sole exception is Denmark, where the acreage of these crops hardly changed, while the area of rye cultivation increased by more than twice, with a growth rate of 132%. Similarly high increase in rye cultivation area took place in Spain, by 110%. In the case of wheat and total cereals, the changes that took place in the countries of this group were within the range of 2%-18%, in different directions (Table 6).

Table 6. Dynamics of selected crops sown area in the 4th group during 2006-2012

Country	Year	Cereals								Potatoes		Sugar beet	
		Total		Wheat		Rye		Barley		(1,000 ha)	2006=1	(1,000 ha)	2006=1
		(1,000 ha)	2006=1	(1,000 ha)	2006=1	(1,000 ha)	2006=1	(1,000 ha)	2006=1				
EU (27)	2012	57,583	1	25,472	1.03	2,415	1.04	12,498	0.91	1,819	0.81	1,660	0.87
	2006	57,384		24,807		2,333		13,793		2,258		1,917	
Denmark	2012	1,503	1	614	0.9	65	2.32	723	1.06	40	1.03	41	1
	2006	1,498		686		28		679		39		41	
Finland	2012	1,133	0.98	216	1.13	16	0.73	562	1	26	0.93	15	0.63
	2006	1,151		192		22		564		28		24	
Ireland	2012	316	1.13	98	1.11	0.2	1	193	1.15	9	0.82	0	0
	2006	279		88		0.2		168		11		32	
Spain	2012	5,721	0.91	1,759	0.9	208	2.1	2,676	0.83	74	0.85	39	0.45
	2006	6,291		1,958		99		3,227		87		87	
Sweden	2012	992	1.02	367	1	22	0.92	370	1.21	25	0.89	39	0.89
	2006	969		366		24		307		28		44	

Source: own calculations based on The Statistical Yearbook, 2014, Central Statistical Office GUS, Warsaw, 2014.

In Belgium and the Netherlands, the area of wheat increased by 10% and 8%, respectively (Table 7). On the other hand, the acreage of beet cultivation decreased by

25% and 14%, respectively, while of rye by 6% and 33%. The acreage of potato cultivation slightly declined (3-4%).

Table 7. Dynamics of selected crops sown area in the 2nd group during 2006-2012

Country	Year	Cereals								Potatoes		Sugar beet	
		Total		Wheat		Rye		Barley		(1,000 ha)	2006=1	(1,000 ha)	2006=1
		(1,000 ha)	2006=1	(1,000 ha)	2006=1	(1,000 ha)	2006=1	(1,000 ha)	2006=1				
EU (27)	2012	57,583	1	25,472	1.03	2,415	1.04	12,498	0.91	1,819	0.81	1,660	0.87
	2006	57,384		24,807		2,333		13,793		2,258		1,917	
Belgium	2009	341	1.07	217	1.1	0.5	0.83	46	0.94	65	0.97	62	0.75
	2006	318		198		1		49		67		83	
Netherlands	2009	203	0.94	152	1.08	1.9	0.73	30	0.67	150	0.96	72	0.86
	2006	215		141		2.6		45		156		84	

Source: own calculations based on The Statistical Yearbook, 2014, Central Statistical Office GUS, Warsaw, 2014.

CONCLUSIONS

EU countries are strongly diversified in terms of sowing structures of main crops: wheat, rye, barley, other cereals, potatoes and sugar beets. The area of wheat makes up from 17.3% of total area of the aforementioned crops in Portugal up to 61.8% in Bulgaria; the shares of barley range from 5.3% in Portugal to 59.4% in Ireland, while the shares of potatoes range from 0.8% in Hungary to 35.3% in the Netherlands. Smaller divergences relate to the shares of rye (from 0.1% to 12.6%) and sugar beet (from 0% to 16.9%).

It is possible to separate 4 groups of countries with similar structures of main crop cultivation. In the countries of the first group (Bulgaria, France, Greece, Italy, Lithuania, Slovakia) wheat represents an average of 53.4% of the sowing area of main crops, with the remaining crops in the second place (28.2%), then barley (13.5%). Rye, potatoes and sugar beet represent a small percentage, 1.5%, 1.7% and 1.7% accordingly. In the countries of the second group (Austria, Hungary, Poland, Portugal, Romania, Slovenia), the shares of wheat are on average 30.5%, of remaining cereals 47.8% and of rye 11.8%, while the shares of other crops are at comparable levels as in the first group. The third group (Germany, Czech Republic, Latvia, UK) differs from the first two groups with higher shares of barley (23%), while the shares of other crops are among the lowest in the surveyed countries, at 12.2%. Wheat takes the first place here, with 53.5%. The 4th group (Denmark, Finland, Ireland, Spain, Sweden) is characterized by the highest shares of barley from among all groups (45.6% on average) and by the lowest shares of wheat (31% on average). The other cereals represent on average 17.2%. Belgium and the Netherlands differ from the other groups with the highest shares of potatoes (14% and 35%, respectively) and sugar beet (13% and 17%, respectively). The largest part of the

crops here is taken by wheat (46% and 36%, respectively), while barley and other cereals make less than 10%. During 2006-2012, the area of cereal cultivation increased in 11 countries of the EU within the range of 4-10%; higher growths (around 20%) were recorded in Bulgaria and Lithuania. In 8 countries a decline was recorded, ranging from 3% to 10%, while in Portugal the decline reached the highest level, of 18%. Wheat crops increased in most of the countries by 1-11%, or slightly decreased in some (from 1% to 5%). The exceptions are Bulgaria, Lithuania and Latvia, where the increases were significantly larger (22%, 82%, and 65%, respectively) and Portugal, where the drop reached 51%. The area of rye increased rapidly in most countries of the 1st, 3rd and 4th groups. The increase occurred in a total of 12 countries. An opposite trend applies to barley, the area of which decreased in 15 countries, with a rate between 5% and 62%. Potato cultivation visibly declined in 16 countries by 15-51%, while in the other countries it didn't change much.

During 2006-2012, the trends of changes in sowing areas were similar in most countries: total cereal area increased, including wheat and rye, while the area of barley decreased. The area of potatoes and sugar beet cultivation also diminished, and in the case of the latter in many countries it was possible to notice a very dynamic decline.

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