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Development of clusters and international competitiveness of the agro-food sectors in the EU countries

Figiel S.[1], Kuberska D.[2] and Kufel J.[1]

1 Institute of Agricultural and Food Economics – National Research Institute, Warsaw, Poland
2 University of Warmia and Mazury, Faculty of Economic Sciences, Olsztyn, Poland

sfigiel@gmail.com

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Abstract

It is quite widely believed that well developed clusters are vehicles for competitiveness and innovation. In the paper we test a hypothesis that occurrence of strong clusters in a country's agro-food sector is positively related to its international competitiveness. Using the European Cluster Observatory dataset on cluster mapping and WTO data on international trade we have looked for correlation between relative strength of the clusters in the EU countries agro-food sectors and international trade measures of competiveness such as RCA, RMA and RC indices. We found that the EU countries differ in terms of both occurrence and relative strength of the agro-food clusters and levels of comparative advantage in agriculture commodities and food products. However, statistical evidence for relationships between variables under consideration appeared to be weak what leads to some suggestions regarding cluster mapping methodology and further studies in this area which could allow to formulate useful policy recommendations.

Keywords: clusters, competitiveness, agro-food sector, international trade

JEL classification: Q17

1. INTRODUCTION

Calls for action to increase competitiveness of the EU economy have been present in many policy agendas including recent Europe 2020 growth strategy for the coming decade (e.g. European Commission, 2010). The issue of competitiveness is also a subject of the debate on future directions of the CAP, particularly on its second pillar, which is supposed to be focusing more on competitiveness and innovation. This seems to be fully justified considering the fact that the EU is the largest world exporter and importer of food products (even excluding intra-trade) and yet the overall competitiveness of the European food industry is rather weak, particularly compared to the US and Canada. Labour productivity and growth in value added are higher in these countries, and in many sub-sectors Brazil also outperforms the EU by gaining market share (Wijnands et al., 2006).

The role of business clusters in building competitive advantage of national economies and their particular sectors is a subject of numerous discussions. As pointed out in one of the communications from the EU Commission a very important way to improve competitiveness should be development of "world-class clusters" (European Commission, 2008). Such recommendation stems from a widely spread view that not companies themselves but strong clusters are vehicles for competitiveness and innovations.

Ever since Marshall's considerations on "thickly peopled industrial districts" (Marshall, 1920) location and concentration have played a significant role in economic thought. The works of Italian scientists on *distretti industriali* (Becattini, 1979, Becattini, 1991) have also contributed to today's relevance of spatial economics theory and practice among scientists and policymakers. The paper is based on the currently most accepted concept of clusters defined as geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (for example universities, standards agencies, and trade associations) in particular fields that compete but also cooperate.

Spatial distribution of economic activity stems from uneven distribution of human population, among other reasons. Certain industries choose specific locations due to the existence of various factors, e.g. the existence of natural endowments. Industrial concentration occurs in certain regions and is explored by many authors (Krugman, 1991, Ellison et al., 1997, Porter, 1998). In some cases geographic concentration of companies results in forming clusters. Clusters can be part of every economy, irrespective of its stage of development, and are formed by and in numerous industries. Their role in innovation and economic development is under great scrutiny. The concept is also frequently brought into the debate on gaining and sustaining competitiveness at country, industry and microeconomic levels. Externalities play a significant role in cluster performance as they link its elements (Porter, 2003). Hence, one of the main characteristics of this concept is the importance of intercompany relations – a particular trait that differentiates clusters from other types of agglomerations and puts stress on related as well as supporting activities.

Clusters are present throughout Europe. Some have developed over centuries, others are a result of rapid changes in contemporary times. European clusters vary among each other in many dimensions, such as geographic scope or number of industries that form them. The disparities that occur result from differences among particular regions and countries (Ketels and Sölvell, 2006). One of the first steps of cluster analysis is the identification of their existence which consists of separating cluster-type interdependencies among industries.

Fundamental dimension of a cluster occurrence is level of employment in certain sectors or types of economic activities being noticeably higher than in other parts of a national or regional economy. This can also be seen as sign of economic specialization resulting from comparative advantage. Therefore, if clusters are supposed to be important for building competitiveness their development should eventually translate into observable economic effects, for instance, such as strong competitive position in international trade. Having considered this assumption implausible would seriously undermine rationale of policies aimed at development of clusters. In this context the paper objectives are to identify distribution and relative strength of the agro-food clusters in the EU member countries and compare with the competitiveness of their agro-food sectors reflected by international trade specialization. The key research question is whether the existence of strong agro-food traded clusters is positively related to the trade measures of competiveness of a country's agro-food sector. If so, a hypothesis that development of clusters contributes to improvement of competitiveness would be empirically supported.

2. DATA AND METHODS

In this paper we use dataset including results of cluster mapping provided by the European Cluster Observatory. Among many other advantages it allows to discern agro-food types of clusters. Identification of the clusters is based on employment data for all EU member states used to estimate values of such variables as cluster size, focus and specialization (location quotient). As relative economic importance of agro-sectors in national economies may play a role in development of the considered type of clusters in order to highlight this issue we also use data on employment, gross value added and output in agro-food sectors extracted from the Eurostat Database. Due to the data availability and the EU most significant recent enlargement 2004-2009 was the period considered in the analysis. Because the data covered the years prior to 2008, the NACE Rev. 1.1 statistical classification of economic activities was applied. Referring to the agro-food sector, the data regarding three branches (i.e. Agriculture, hunting and forestry; Fishing; Manufacture of food products, beverages and tobacco) were used for calculations of average values for the period. The analysis included the data for the EU27 member countries.

In the next step of our analysis selected trade measures of competitiveness were calculated using the WTO database on exports and imports. A starting point was to calculate values of revealed comparative advantage index (RCA), which was first formulated by Balassa (1965) and later modified by Vollrath (1991). The RCA, often called the Balassa index, for *i*-th country and *j*-th commodity can be defined as follows:

$$\mathrm{RCA}_{ij} = \mathrm{RXA}_{ij} = (X_{ij}/X_{ik})/X_{nj}/X_{nk})$$

where X are exports, *k* denotes all commodities other than *j* and *n* denotes all countries other than *i*. Another, similar in nature to RXA, as proposed by Vollrath (1991), measure of comparative advantage included in the analysis was the RMA index calculated according to the following formula:

$$\mathrm{RMA}_{ij} = (M_{ij}/M_{ik})/M_{nj}/M_{nk})$$

where M are imports instead of exports. Based on these two indices as discussed by Latruffe (2010) so-called revealed competiveness index (RC) was then computed as follows:

$$\mathrm{RC}_{ij} = \ln(\mathrm{RXA}_{ij}) - \ln(\mathrm{RMA}_{ij})$$

As RC index is the difference between RXA and RMA indices in logarithmic form the RXA and RMA are symmetric at the origin (Latruffe, 2010, Laursen, 1998). The RCA, RMA and RC indices were calculated for two types of trade categories i.e. agricultural products and food as defined in the WTO database. The RXA and RMA and consequently the RC values used in the analysis were calculated as averages for the period of 2006-2010.

Finally, using correlation and linear regression analysis as well as Chi-square test for independence and logistic regression analysis we looked for a relationships between relative strength of the agro-food type of clusters based on an aggregated assessment of their characteristics (cluster size, focus and specialization) and the RC values. This approach was motivated by assumption that if the most important from the international competitiveness point of view so-called traded clusters are present in the agro-food sectors this should be reflected in the revealed competitiveness level of a country in respective trade categories.

3. RESULTS AND DISCUSSION

3.1. Occurrence of the agro-food clusters in the EU countries

One of the first cluster mapping studies in Europe was conducted by Ketels and Sölvell (2006) and focused on 10 new member states of the European Union. 38 cluster categories were formulated prior to this study among which Processed Food and Agricultural Products represented the agro-food sector. Each category comprised of industries which were proven empirically to co-locate. The study identified 367 clusters that met at least one of three conditions expected from strong regional clusters. The authors stipulated that specialization ratio, absolute size of a cluster as well as its dominance i.e. regional importance are the features that distinguish strong clusters. The employed methodology resulted in Processed Food cluster being the largest of all cluster categories in the EU10 countries when taking overall employment into consideration whereas the Agricultural Products cluster was the 22nd cluster category.

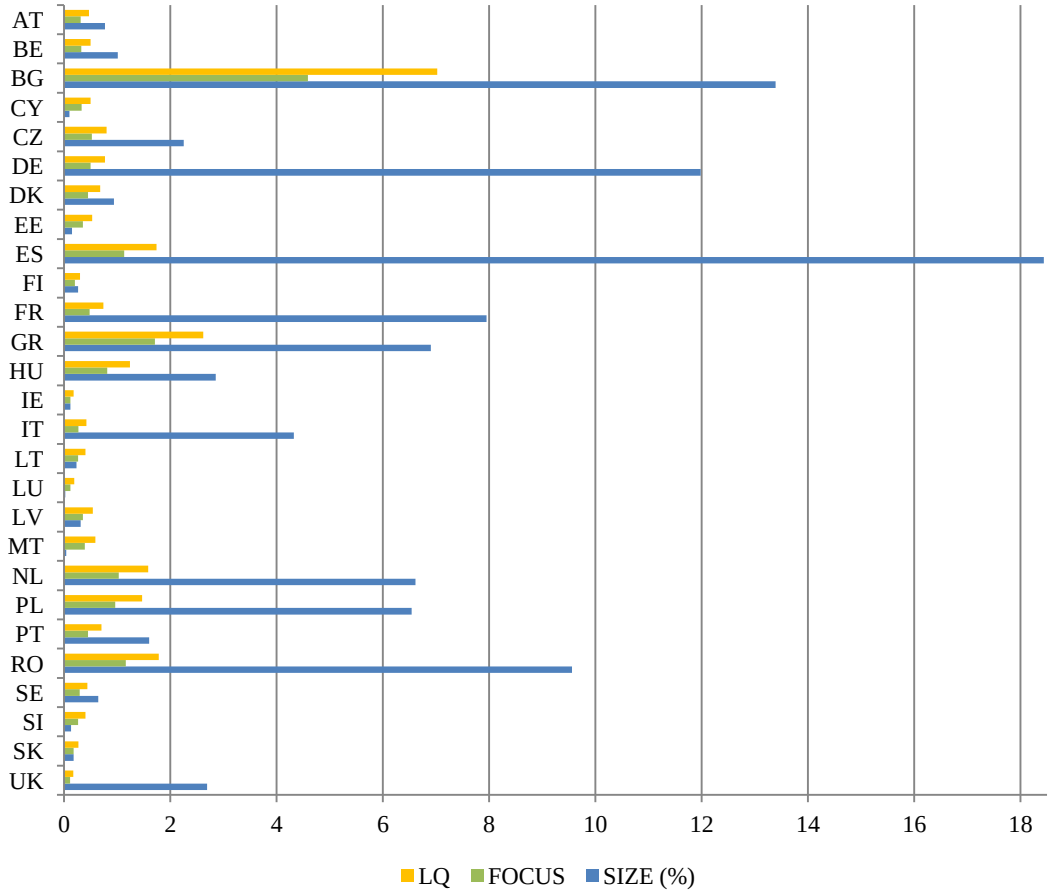
As a comparison the authors presented results for two other economies: United States and Sweden. The two agro-food cluster categories were ranked 9th and 30th in the U.S. and 7th and 28th in Sweden respectively. The highest rates of employment in the United States and Sweden belonged mostly to service-type categories (Business Services, Financial Services and Hospitality and Tourism in the U.S. and Transportation and Logistics, Heavy Construction Services and Metal Manufacturing in Sweden). Interestingly, five top regional clusters within the Processed Food category and four out of five top regional clusters within the Agricultural Products category by total employment were located in Poland. Only 21 clusters met all three conditions for strong clusters and were given the highest ranking. Among these only one cluster was considered an agro-food cluster (Processed Food) and was located in Hungary (Szeged) (Ketels and Sölvell, 2006).

Another study that identifies clusters has been carried out by Center for Strategy and Competitiveness at Stockholm School of Economics under its project – European Cluster Observatory (ECO). In this paper we employ openly available data published by researchers from the ECO where three agro-food cluster categories are distinguished: Agricultural Products, Farming and Animal Husbandry and Processed Food. Those cluster categories were determined using employment data (full-time equivalents or total number of people employed) mostly at 4-digit level of the NACE Rev. 2 classification. Agricultural Products clusters are mainly represented by support activities to agricultural production, manufacture of oils and fats, spirits, wines and non-distilled fermented beverages. Farming and Animal Husbandry clusters category include crop and animal production activities as well as renting and leasing of agricultural machinery and equipment. Processed Food clusters comprise manufacture of food products, beer, malt and supply of production factors activities related to food processing (European Cluster Observatory). The methodology used by the ECO aggregates 4-digit industries into 41 standard-type industry clusters (with four knowledge-intensive business services clusters and three life-science clusters) and eight creative and cultural industry clusters. Cluster strength is then measured using three dimensions (i.e. specialization, focus and size) and for each of them a

cluster may receive a recognition in form of a star that identifies the strongest ones (as a result up to three stars may a cluster be rewarded).

A large span of values can be observed among all agro-food cluster categories concerning the measures mentioned above. A closer comparison of their strength shows that within the Agricultural Products category location quotient for EU countries only Bulgaria (7.02) and Greece (2.62) reached the level above 2. The median value for all countries considered is 0.54 and the lowest score 0.17 belongs to the UK. The highest share of employment in Europe (size) within this cluster category is observed in Spain (18.44%), Bulgaria (13.39%), and Germany (11.98%). Figure 1 presents all three cluster dimensions, namely location quotient, focus and size for the EU27 countries.

Figure 1. Characteristics of the Agricultural Products clusters in EU27



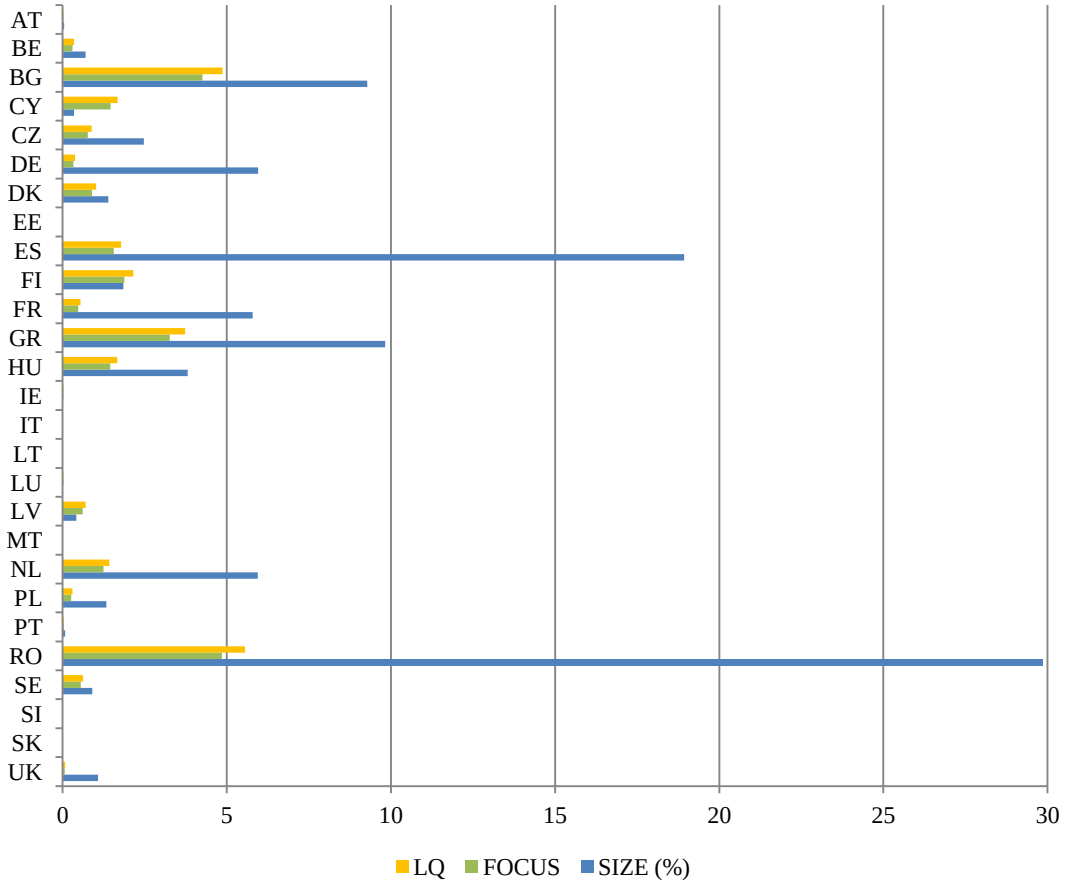
Source: own calculations on the basis of data from the European Cluster Observatory

Specialization is based on location quotient as its measure (clusters with location quotient of 2 and more receive a star), focus compares employment in a cluster category and compares it to overall employment within a given region (10% of clusters with the largest share in a region's employment are considered star-worthy), whereas size compares employment in each

cluster category to overall employment within that category in Europe (10% of the largest clusters within a given category in Europe are considered star-worthy). European Union's employment data suggests that most clusters that received three stars are located in Germany (30 clusters), United Kingdom (17 clusters) and Romania (14 clusters). Cyprus, Denmark, Estonia, Luxembourg, Latvia, Malta and the Netherlands have no three-star clusters according to the ECO methodology.

Farming and Animal Husbandry clusters, presented in Figure 2, have a location quotient median value of 0.38. The highest share of European employment lies within the borders of Romania (29.85%), Spain (18.93%), and Greece (9.82%), whereas the highest location quotient is observed in Romania (5.55) and Bulgaria (4.87).

Figure 2. Characteristics of the Farming and Animal Husbandry clusters in EU27

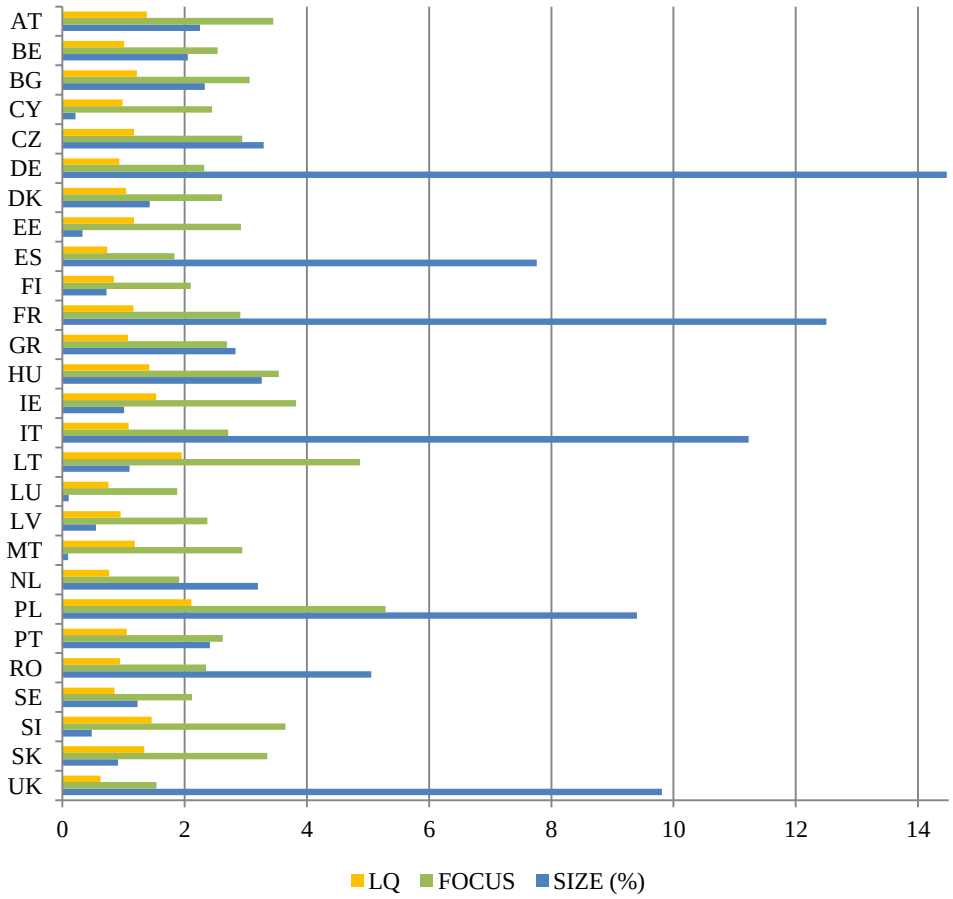


Source: own calculations on the basis of data from the European Cluster Observatory

Processed Food cluster category (see Figure 3) is characterized by location quotient median value of 1.07 and the span between the lowest and highest location quotient of 1.49 points (2.11 for Poland and 0.62 for UK). The highest share of employment within the given

cluster category belongs to Germany, France and Italy and equals 14.47%, 12.5%, and 11.23% respectively.

Figure 3. Characteristics of the Processed Food Clusters in EU27



Source: own calculations on the basis of data from the European Cluster Observatory

The data presented above depict the location and strength of agro-food clusters in EU countries. Further study in this matter is highly recommended as a range of differences occur at more detailed geographic levels.

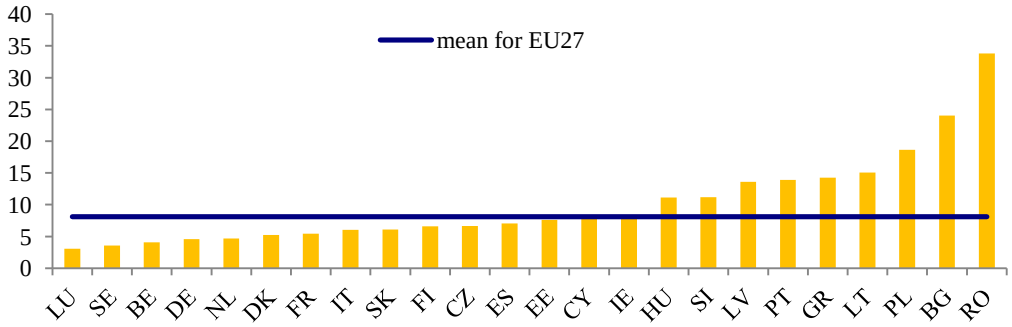
3.2. International competitiveness of the agro-food sectors in the EU countries

It seems reasonable to assume that international competitiveness of a sector may stem from its importance for economy as a whole. Economic importance of a sector can be considered in various dimensions, however empirical cross-country analyses are constrained by availability of consistent data needed for meaningful comparisons. To illustrate economic importance of the agro-food sectors in the EU countries, which potentially may be related to existence of the agro-food clusters, we use three following indicators: share of agro-food sector employment in total employment, share of gross value added (GVA) created in agro-food sector

in total GVA created in national economy and share of the sector output in the total output of all NACE activities.

Figure 4 presents the average share of employment in those three agro-food branches in the total employment in all NACE activities for each of the EU27 member countries for the period 2004-2009. For the EU27 countries the average share of employment in agro-food sector in total employment for this period was 8.1%. For Malta, the UK and Austria there were unfortunately no data available in Eurostat database.

Figure 4. Average share of employment in agro-food sector in total employment in the EU countries for the period 2004-2009 [%]

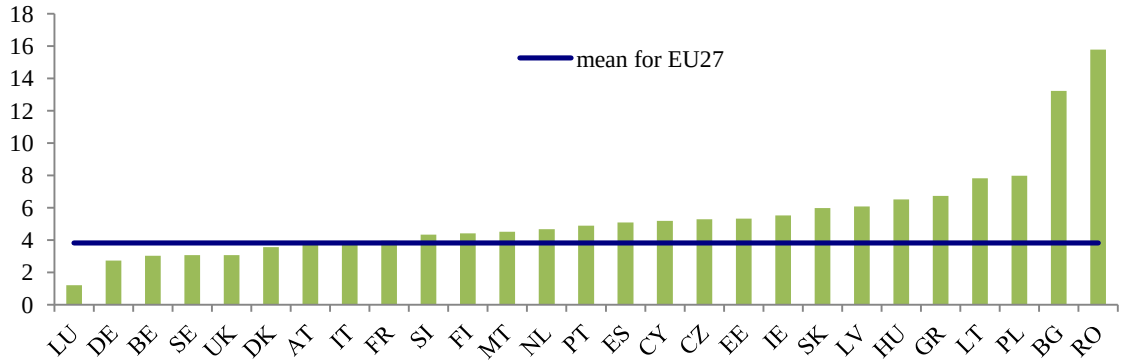


Source: own calculations on the basis of data from the Eurostat database

Regarding employment indicators, European agro-food sectors accounted for 3.1-33.8% of the total employment in particular EU countries. Among all the EU member countries the agro-food sector is the least important (less than 5.4% of total employment) in Luxemburg, Sweden, Belgium, Germany, the Netherlands, and Belgium, and the most important (above 13.7% of total employment) in Romania, Bulgaria, Poland, Lithuania, Greece, and Portugal. The median value of indicators for 27 EU countries is 7.3%.

Figure 5 presents the average share of GVA in total GVA for each of the EU27 member countries for the period 2004-2009. For the all EU27 the average share of agro-food sector in total GVA for the analyzed period was 3.8%.

Figure 5. Average share of GVA in agro-food sector in total GVA in the EU countries for the period 2004-2009 [%]

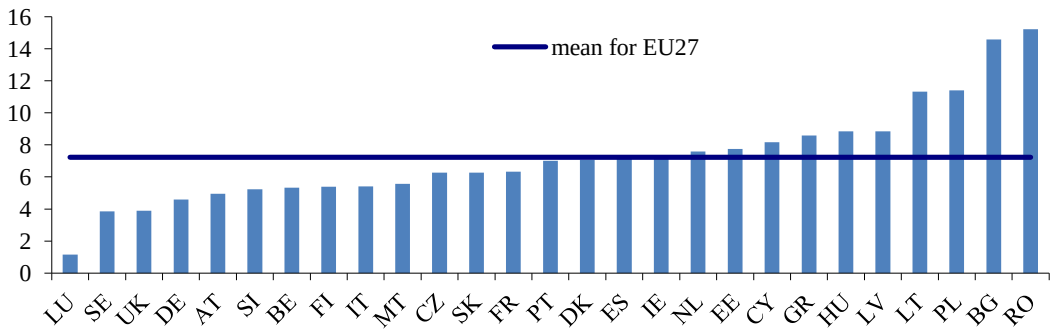


Source: own calculations on the basis of data from the Eurostat database

Regarding GVA indicators, European agro-food sectors accounted for 1.2-15.8% of the total GVA in particular EU countries. Among all the EU member countries the agro-food sector is economically the least important in Luxembourg, Germany, Belgium, Sweden, United Kingdom, Denmark, and Austria (less than 3.84% of total GVA), and the most important (above 6.0% of total GVA) in Romania, Bulgaria, Poland, Lithuania, Greece, and Hungary. The median value of indicators for the EU27 countries is 4.9%.

Figure 6 presents the average share of output of the agro-food sector in total output of all NACE activities for each of 27 EU members for the period 2004-2009 (in case of not available data shorter time series were used to calculate the mean). For the EU27 the average share of agro-food sector in total output for the analyzed period was 7.2%.

Figure 6. Average share of output in agro-food sector to total output in the EU countries for the period 2004-2009 [%]



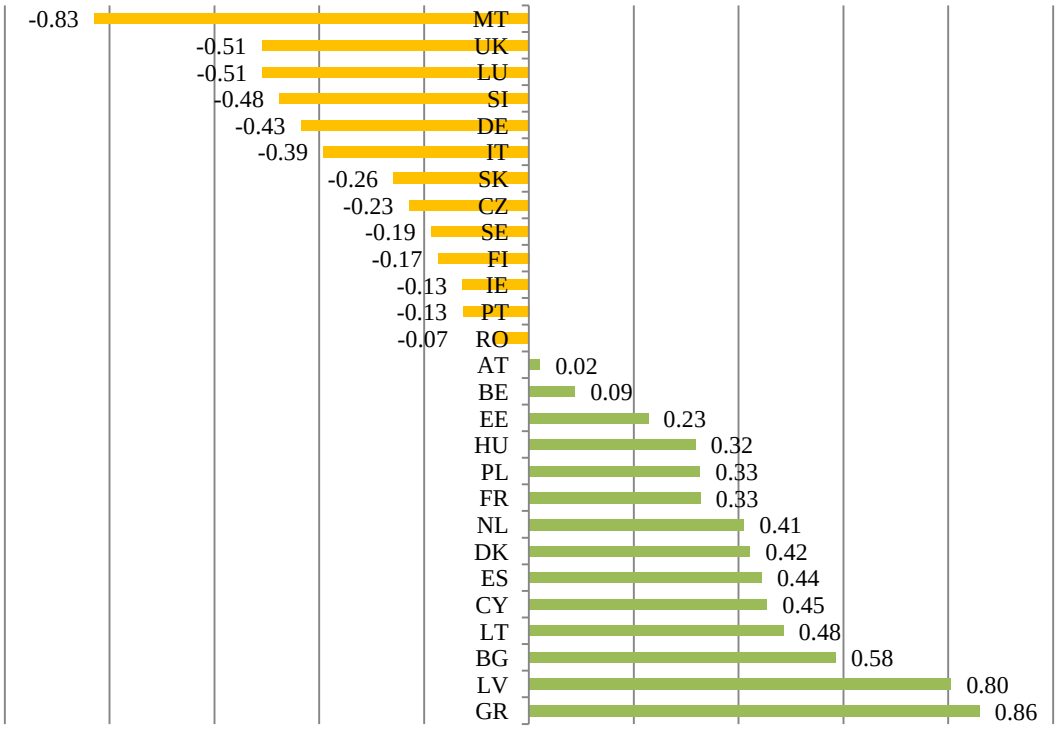
Source: own calculations on the basis of data from the Eurostat database

Regarding output indicators, European agro-food sectors accounted for 1.2-15.2% of the total output in particular EU countries. Among all the EU member countries the agro-food sector is economically the least important in Luxembourg, Sweden, United Kingdom, Germany, Austria, Slovenia, and Belgium (less than 5.4% of total output) and the most important (above 8.4% of total output) in Romania, Bulgaria, Poland, Lithuania, Latvia, Hungary, and Greece. The median value of indicators for 27 EU countries is 7.0%.

Summarizing, the economic importance of the agro-food sector in the EU member countries is rather low. It contributes more to total employment and total output than to total GVA. Moreover, in 10 out of 27 EU countries the agro-food sector's share in employment is lower than its share in output (especially in the Netherlands, Denmark, Belgium, France, and Sweden) and only in Luxembourg, Romania, and Slovenia it's more than two times higher. It suggests that productivity and efficiency of the agro-food sectors in the EU27 differ greatly across the countries. Its share in GVA is on average only 3.8%, what means that other sectors and clusters related to them are much more important for the EU economies. It should also be noticed that for each country the share in GVA is lower than the share in employment.

Figures 7 and 8 contain values of the revealed competiveness index (RC) for agricultural products and food trade categories ordered from the lowest to the highest by country.

Figure 7. Values of the revealed competiveness index (RC) for the agricultural products trade category in the EU member countries

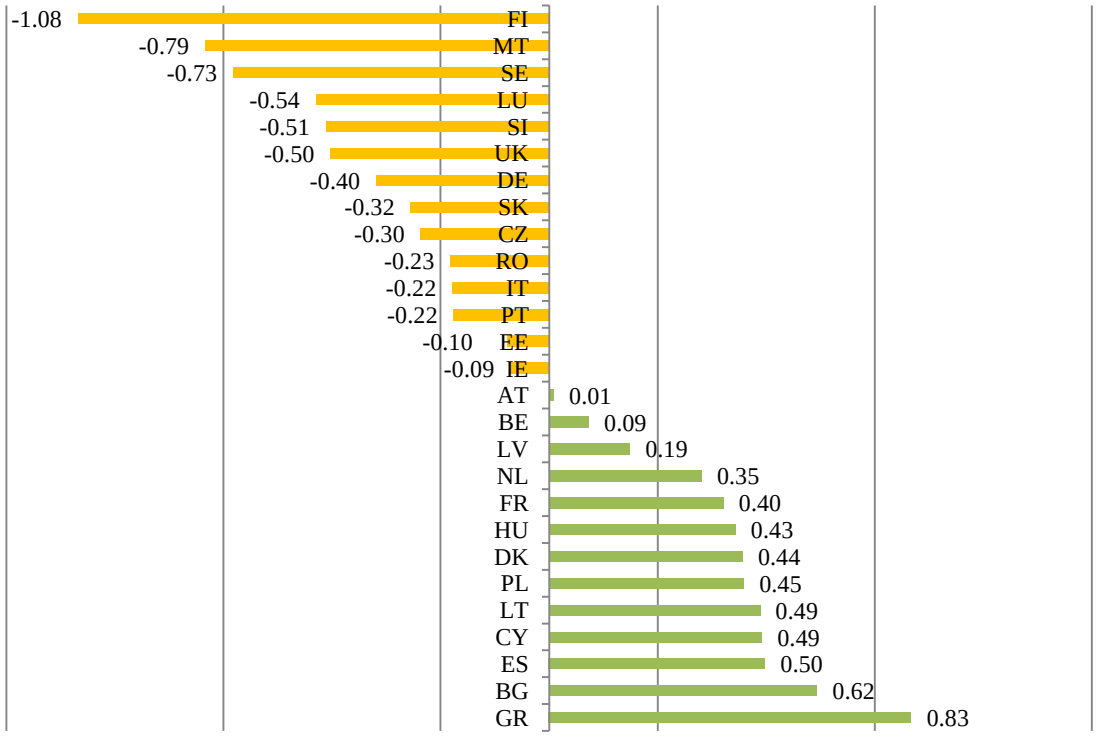


Source: Own calculations based on data from the WTO database

As it can be noticed the RC for agricultural products trade category is ranging from as low as -0.83 for Malta to as high as 0.86 for Greece. The RC values are negative for 13 countries and positive for 14 of them with positive mean value equal to 0.05 and standard deviation amounting to 0.44.

A similar picture emerges when the RC for the food trade category is considered. The RC values are negative for 14 countries and positive for 13 of them. The country ranking is not much different than in case of the RC for the agricultural products category. The only country which switched from the positive to the negative RC is Estonia. In fact, the RC values for agricultural products and food trade categories are rather strongly correlated (correlation coefficient equals 0.87 and is statistically significant at $\alpha \leq 0.01$). However, it should be noticed that the range of values is wider, namely from -1.08 for Finland to 0.83 for Greece with negative value of -0.03 and slightly higher standard deviation of 0.49. Also the distribution is more skewed to negative values. This implies that revealed competiveness in food trade category for the EU27 as a whole is rather weaker than in agricultural products category. It is also worth to mention that among countries with positive values of both the RC for agricultural products and food trade categories are mainly those countries where the agro-sector is more important from the economic standpoint.

Figure 8. Values of the revealed competiveness index (RC) for the food trade category in the EU member countries



Source: Own calculations based on data from the WTO database

3.3. Relationships between occurrence and strengths of the clusters and revealed competitiveness for the agro-food sectors of the EU countries

Should development of clusters have a positive impact on the analyzed country agro-food sectors international competiveness it is reasonable to expect high variations observed in characteristics of the agro-food type of clusters and revealed competitiveness (RC) of the agro-food sectors in the EU member countries to be somehow related. When analyzing the correlations between values for cluster size, focus and specialization and values of RXA, RMA and RC indices it appeared that last one was best correlated with the all three cluster characteristics, so it was chosen as the most promising variable in testing for existence of the presumed relationship.

In general, the correlations between cluster characteristics and the RC levels appeared to be weaker than expected. As reported in Table 1 the highest correlation coefficients were obtained for the type of clusters defined by the ECO as Agricultural Products clusters. Apart from the one calculated for relationship between cluster size and the RC in agricultural products trade category all of them are also statistically significant. Weaker and statistically less significant are respective correlation coefficients for the Farming and Animal Husbandry

clusters. In case of the Processed Food clusters, what is somewhat surprising, there are no statistically significant correlations.

Table 1. Correlation coefficients between cluster characteristics and revealed competitiveness (RC) of the agro-food sectors in the EU member countries

Type of clusters	Cluster size		Cluster focus		Cluster specialization	
	RC_{AG}	RC_{AGFO}	RC_{AG}	RC_{AGFO}	RC_{AG}	RC_{AGFO}
Agricultural products	0.28	0.40**	0.44**	0.48**	0.44**	0.48**
Farming and husbandry	0.23	0.24	0.42**	0.32*	0.42**	0.32*
Processed food	-0.10	0.10	0.16	0.30	0.15	0.29

RC_{AG} and RC_{AGFO} denote revealed competitiveness indices for agricultural products and food trade categories respectively as defined in the WTO database
**, * – statistical significance at the levels of $\alpha \leq 0.05$ and $\alpha \leq 0.1$ respectively
Source: own calculations on the basis of the European Cluster Observatory and WTO data

In order to test for relationships between relative strength of the agro-food types of clusters reflected by the average number of stars granted according to the ECO methodology and the RC values levels a multiple regression model was estimated. The results included in Table 2 show that only in case of the RC calculated for food trade category the relationship can be considered as existing, however, coefficient for the Farming and Animal Husbandry type of clusters is statistically insignificant, and moreover has unexpected negative sign.

Table 2. Parameters of linear regression models of revealed competitiveness (RC) values on the average number of stars granted to agro-food clusters at a country level

Item	RC_{AG}		RC_{AGFO}	
	β (SE)	t	β (SE)	t
Constant (β_0)	-0.10 (0.15)	-0,69	-0.35 (0.15)	-2.31**
Variables (average number of stars granted to cluster):				
Agricultural products (β_1)	0.37 (0.25)	1.45	0.63 (0.26)	2.46**
Farming and husbandry (β_2)	-0.05 (0.20)	-0.23	-0.21 (0.20)	-1.03
Processed food (β_3)	0.06 (0.14)	0.41	0.24 (0.14)	1.72*
R^2	0.26		0.40	
F	2.72		5.11***	

RC_{AG} and RC_{AGFO} denote revealed competitiveness indices for agricultural products and food trade categories respectively as defined in the WTO database
β – coefficient, SE – standard error, t – value f t statistic
***, **, * – statistical significance at the levels of $\alpha \leq 0.01$, $\alpha \leq 0.05$ and $\alpha \leq 0.1$ respectively
Source: own calculations on the basis of the European Cluster Observatory and WTO data

Having in mind that number of stars granted to a cluster is a nominal variable we also applied nonparametric testing for interdependence. Contingency tables built for the types of clusters under considerations included four groups for the average number of stars and six groups for the RC levels. Results of the Chi-square test for independence are contained in Table

3. Based on them it can be claimed that only occurrence of strong Agricultural Products clusters is related to the revealed competiveness both in agriculture products and food trade categories.

Table 3. Results of the Chi-square test for independence between levels of countries revealed competiveness (RC) and relative strength of the agro-food clusters

Type of clusters	RC_{AG}		RC_{AGFO}	
	Value of the χ^2 statistic	p-value	Value of the χ^2statistic	p-value
Agricultural products	23.86	0.068	34,25	0.003
Farming and husbandry	14.66	0.476	19,91	0.176
Processed food	9.06	0.526	10.44	0.402
All types clusters aggregated	20.11	0.168	22,54	0.094

RC_{AG} and RC_{AGFO} denote revealed competitiveness indices for agricultural products and food trade categories respectively as defined in the WTO database
Source: own calculations on the basis of the European Cluster Observatory and WTO data

Another way of testing for relationships between variables in question was logistic regression analysis. In this case dependent variable (RC) was treated as binary one taking value of 0 for RC ≤ 0 and 1 for RC > 1. Table 4 includes the results. Once again, it turned out that only occurrence of strong Agricultural Products clusters can be seen as potentially increasing the probability of gaining a comparative advantage in agricultural products and food trade.

Table 4. Parameters of logistic regression models of revealed competitiveness (RC) on the average number of stars granted to agro-food clusters at a country level

Item	RC_{AG}		RC_{AGFO}	
	β (SE)	p-value	β (SE)	p-value
Constant (β_0)	-0.87 (0.82)	0,303	-1.05 (0.85)	0.229
Variables (average number of stars granted to cluster):				
Agricultural products (β_1)	4.6 (2.76)	0.109	4.82 (2.83)	0.102
Farming and husbandry (β_2)	-1.97 (1.53)	0.212	-1.98 (1.57)	0.219
Processed food (β_3)	0.64 (0.76)	0.405	0.59 (0.76)	0.448
χ^2	6.92		7.61	
P-value	0.074		0.054	

RC_{AG} and RC_{AGFO} denote revealed competitiveness binary values (0 for RC ≤ 0 and 1 for RC > 1) for agricultural products and food trade categories respectively as defined in the WTO database
β – coefficient, SE – asymptotic standard error
Source: own calculations on the basis of the European Cluster Observatory and WTO data

4. CONCLUSION

The relationships between existence and relative strengths of the agro-food types of clusters and the international competitiveness of the EU member states agro-food sectors is not that obvious as it could be expected. The results of testing the hypothesis that existence of strong clusters in a country agro-food sector may have a positive impacts on its position in the

international agricultural trade are mixed with regard to the types of clusters and their potential role in building trade competitive advantage. It appeared that mainly characteristics of the Agricultural Products clusters, which include mainly service and likely export oriented type of activities were positively related to the revealed competitiveness of the country agro-food sectors. However, it has to be stressed that our analysis is not free from caveats. First of all the classification of clusters used in the analysis can be considered debatable as the employment data may be inadequate to properly identify existence of clusters and assess their strength. Other economic variables and qualitative factors like cooperation within the clusters and level of social capital, which may play important role are simply omitted. Also not all agro-food sector related clusters, even being relatively strong, have to be traded clusters. Finally, the connection between existence of clusters in agro-food sectors and their international competitiveness may not be direct, therefore, when designing policies aimed at supporting cluster development all potentially important linkages should be examined with great scrutiny.

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