Potential for clustering in the agricultural sector assessment: the case of Slovakia

Abstract. Agricultural activity has a long tradition in Slovakia. One of the ways to contribute to the development and enhance the competitiveness of this sector is to involve various agricultural interests in cluster cooperation. In the world, there are several known cases of clusters in the agricultural sector, which significantly contribute to regional competitiveness. In that context, the main aim of this paper is to assess the current state of conditions necessary for the emergence of clusters in the agricultural sector in Slovakia and identify key regions eligible for the establishment of agricultural clusters. The methods used are: Data Envelopment Analysis (DEA) and Localization Coefficient (LQ). The results obtained were transformed into a BCG matrix. DEA was used to assess regional efficiency and LQ - to assess regional potential for clustering. Using of these methods created the base for the cluster potential identification in the most efficient region from the point of view of agriculture.

The uniqueness of this paper is the focus on a new area of clustering, which could contribute to increased regional competitiveness in the Slovak Republic. From the point of view of the Slovak agricultural efficiency assessment, the most important regions for clustering are Nitra and Trnava. From the point of view of the cluster potential assessment, the appropriate regions are Nitra and Prešov. Based on the results of the applied methods, basic preconditions for clustering have been created mainly in the Nitra region.

Keywords: Agriculture; Efficiency; Cluster; Clustering; Competitiveness; Region; Regional Actors

JEL Classification: O13; O18; Q19; R30

Acknowledgements: The article is related to the VEGA project No. 1/0953/16 «The evaluation of clusters’ impact measurement on regional development of the Slovak Republic». This article was created with the support of the Grant Agency of the University of South Bohemia in České Budějovice: project GAJU 074/2017/S «Development of the South Bohemian Region - the potential for the application of the European Commission’s initiative - Smart Region».

DOI: https://doi.org/10.21003/ea.V167-05
1. Introduction

Current economic activity is characterized by the forces of globalization, technology, deregulation and democratization, collectively creating an extremely complex operating environment for companies and policy-makers. (Gorzen-Mitka, Okreglicka, 2015). In this current globalized world, economic subjects established in various regions are looking for different opportunities for cooperation, which would bring an increase in regional competitiveness and economic growth. One of them is the clustering of cooperation. Clustering is an effective tool of networking of the involved, mainly regional, stakeholders from different sectors, which together share the benefits of participation. Thereby, their competitiveness is increased and also by their progress they affect the overall level of competitiveness and economic growth of particular regions (see also Perez-Aleman, 2015, Chen et al., 2013). As shown by many studies, the agricultural field also gets to the forefront of interest for the evaluation of efficiency, the method known as Data Envelopment Analysis (DEA) and its process of application will be used in accordance with Jablonský & Dlouhý (2004). DEA is a non-parametric method, which was designed to assess the efficiency of Decision Making Units (DMUs) and is considered as one of the most appropriate tools for efficiency measurement (Bojin & Latruffe, 2013; Grmanová, 2010). DEA models can be input oriented (I - input) or output oriented (output - O). In this study we used Banker-Charnes-Cooper’s Input model (BCC - I). For details about the other DEA models (the alternatives and the modified ones) see Grmanová (2010).

In the second part of this article, we performed a sectoral analysis of the Slovak regions, with a focus on the field of agriculture (A) and a sub-sector of industrial production (10) Food processing. These economic sectors belong to important areas for clustering in many economies and the data about food production has been included in this research also, because agricultural production is the basis for food and
drink production at a much greater intensity than it used to be in the past. For the sectoral analysis we used the static values of the Localization Coefficient \( LQ \) within the two compared periods and for the needs of clustering we also assessed the dynamics of \( LQ \) values. The resulting values are incorporated into the BCG matrix, based on which we have identified significant regions for agricultural clusters’ establishment.

Localization coefficient \( LQ \) shows the relation:

\[
LQ = \left( \frac{LF_{X,N}}{LQ} \right) \left( \frac{LF_{X,N}}{LF_{X,N}} \right)
\]

where: \( LQ \) is the Localization Coefficient for the region in the selected economic sector; \( LF \) is the number of employees in the economic sector in the region; \( e \) is the number of employees in the economic sector at the national level, \( e \) is the total number of employees at the national level, \( e \) is the number of employees in the region, \( N \) is the number of employees, \( X \) is the economic sector, \( LQ \) is the national level, \( LQ \) is the total number of employees at the national level, \( e \) is the number of employees, \( X \) is the economic sector.

3. Purpose

The possibility of using various methods has determined the purpose of this research. Theoretical and methodological aspects of the cluster theory, official statistical publications, expert opinions and our own calculations form the basis of this study. The requirements for agricultural development affect other factors that need to be taken into account at present. These include: the economic potential of raw materials and food production at the local level with lower import dependence, the necessity and economics of food transport and their impact on the economy, climate, etc., the impacts on soil, the impacts on public health, etc. In this context, the focus on issues of clustering is at the forefront. Clustering could contribute to the development of agriculture not only by increasing production but also by the increase of interest in additional research, development and innovation, which finally could contribute to the overall competitiveness of regions and the whole economy of a country.

4. Results

The main indicator for the detection of cluster potential in Slovak regions in this study is the number of employees. The regions of Western Slovakia (Trnava, Trenčín and Nitra) have the largest share of total employment in the agriculture sector. That is why these regions are in the focus of this study.

For analyzing the degree of efficiency of agricultural units we examined four indicators in 23 districts (listed in Table 3) of Western Slovakia for the year 2016. Each of the districts (\( DMU_1, ..., DMU_23 \)) is characterized by four data: \( i \) is the share of agricultural land compared to the total area (ha), \( j \) is a census of the areas sown with crops (ha), \( O_1 \) is hectare yields of selected crops (t/ha), \( O_2 \) is production of selected crops (t).

Nine models were compiled from these inputs and we compared both Technical Efficiency and Super Efficiency. As we considered the necessity of including all inputs and outputs, we analyzed in more detail the model with two inputs and two outputs. The efficiency analysis of selected areas of Slovak agriculture was carried out by using a BCC - 1 model. The optimization problem has \( n = 23 \) production units (districts), \( m = 2 \) inputs, \( r = 2 \) outputs. For each input and output parameter, the descriptive statistics were calculated. An overview is given in Table 1.

A correlation analysis was conducted to describe the degree of connection between analyzed parameters. Table 2 shows the results.

None of the analyzed parameter pairs showed statistically significant negative correlation. A negative correlation means that an increase in input results in a reduction of output and this is considered to be unacceptable.
In the next part of this study, we have calculated the technical efficiency for each DMU. Table 3 presents the results of the BCC-I model. The stated optimization task has 28 input variables and 5 restrictive conditions. In this model the unit rate of efficiency is assigned to effective DMUs. It means that there could be a greater number of effective DMUs. From this reasoning, Super Efficiency was calculated (column 4). This allows the classification of effective units (DMUs) from the most to the least significant. The most effective districts are Galanta, Trnava and Nové Zámky. Twelve DMUs were marked as ineffective. The least efficient DMU, which is the worst to recover its input, is the district of Myjava. At the same time, the coefficients of the linear combination of the original inputs for effectiveness achievement are calculated in columns 5-8. The results of the DEA's calculation confirm that evaluated regions belong to efficient agricultural regions, which are also determined by their long agricultural history and the natural conditions of the evaluated regions.

Due to the lower number of monitored indicators, it was pointless to subject the data to a PCA analysis. By the cluster analysis, using the procedure of agglomerative hierarchical clustering, Ward’s method (the highest Cophenetic Coefficient and the lowest Delta criterion) and Euclidean distance rates, five clusters were identified (C1: D. Streda, Komárno, Trnava, Nitra; C2: Galanta, Prieštany, Topoľčany, Levice, Nové Zámky; C3: Hlohovec, Zlaté Moravce, Senica, Nové Mesto n. Váh, Šaľa; C4: Škála, Bánovce n. Bebravou, Partizánske, Trenčín; C5: Ilava, Myjava, Púchov, Považská Bystrica) - see Figure 1.

As shown in many studies in the Slovak Republic devoted to the mapping and the impact of existing clusters on regional development their importance is growing, especially in industry, ICT, key enabling technologies and tourism (Vojtovic, 2015). In the analysis of Slovak clusters carried out in the frame of the VEGA project No. 1/0953/16 in 2016 we found out that there are more than 30 clusters in eight self-governing Slovak regions (Bratislava - BA, Trnava - TT, Trenčín - TN, Nitra - NR, Zilina - ZA, Banská Bystrica - BB, Prešov - PO and Košice - KE). It is possible to find several agro-food clusters in the official Register of Association of Legal Entities (Bioeconomy cluster, Agroenvironmental Cluster - Association of Legal Entities and Food Cluster, which are registered in the Nitra region and Cluster Agriculture and Rural areas in the Trnava region), but only one of them (the Bioeconomy cluster) is carrying out its activities. However, its activities correspond more with the focusing of Key enabling technologies clusters.

The next part of this study is focused on the calculation of the Localization Coefficients (Table 5) for eight Slovak self-governing regions.

Observered periods were the years 2009 and 2016. The data from the databases of the Statistical Office of the Slovak republic about the average registered number of employees in the agricultural sector (A) and sub-sectors of industrial production (10) Food processing according to SK NACE Rev. 2 were used for the calculation.

The results showed that the basic preconditions for cluster cooperation establishment in the sector of agriculture are met in all Slovak regions except Bratislava, Zilina, Trenčín and Košice regions. In the year 2016, we can observe a significant level of $LQ (> 1.2)$ in Nitra, Trnava, Banská Bystrica and Prešov regions. From the point of view of clustering, it is important to follow the changes in the observed period. The positive results in the sector of agriculture were achieved only in the case of the Nitra and Prešov regions, if we take into account the result of an $LQ$ higher than 1,00. From the created BCG matrix for the agricultural sector (Figure 2), it is clear that the key regions for clustering are Nitra and Prešov. Both regions belong to the group of regions which often stay behind in overall economic assessment. That is why it is possible to use their potential and develop the agricultural sector through the involvement of related interests in the cluster. Although the Trnava region belongs to regions with effective agriculture, in the case of $LQ$ calculation it achieved a high level of $LQ$, but with a decreasing tendency, thus these regions are placed in the BCG matrix among mature regions.

### Tab. 2: Pearson coefficient of correlation of analyzed indicators (p < .05000)

| Correlation (Input data) | $I_1$ | $I_2$ | $O_3$ | $O_2$ |
|--------------------------|-------|-------|-------|-------|
| $I_1$ | 1.000000 | 0.736805 | 0.555426 | 0.775055 |
| $I_2$ | 0.736805 | 1.000000 | 0.290990 | 0.970620 |
| $O_3$ | 0.555426 | 0.290990 | 1.000000 | 0.447410 |
| $O_2$ | 0.775055 | 0.970620 | 0.447410 | 1.000000 |

Source: Own calculation based on the data of the Statistical Office of the Slovak Republic, elaborated in the programme Statistica

### Tab. 3: The Results of BCC-I model

| DMU | ES | Super - Efficiency | $V1_1$ | $V1_2$ | $V1_3$ | $V1_4$ | $V1_5$ | $V1_6$ | $V1_7$ | $V1_8$ | $V2_1$ | $V2_2$ | $V2_3$ | $V2_4$ | $V2_5$ | $V2_6$ | $V2_7$ | $V2_8$ |
|-----|----|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1   | Dunašska Streda | 0.86 | 86.13% | 0.65 | 0.35 | 0.00 | 0.62 |
| 2   | Galanta | 1.00 | 100.00% | 0.00 | 1.00 | 6313546 | 0.02 |
| 3   | Hlohovec | 1.00 | 176.02% | 0.00 | 1.00 | 17.2 | 0.00 |
| 4   | Prieštany | 1.00 | 133.54% | 0.00 | 1.00 | 231 | 1.38 |
| 5   | Senica | 0.71 | 71.10% | 0.61 | 0.19 | 0.07 | 0.30 |
| 6   | Škála | 0.69 | 69.34% | 0.00 | 1.00 | 1.02 | 0.36 |
| 7   | Trnava | 1.00 | 100.00% | 0.00 | 1.00 | 2066/69 | 4.82E-68 |
| 8   | Bánovce n. Bebravou | 1.00 | 146.94% | 0.97 | 0.97 | 4.22 | 0.00 |
| 9   | Ilava | 1.00 | 100.00% | 0.43 | 0.57 | 2.9 | 0.00 |
| 10  | Myjava | 0.50 | 50.48% | 0.92 | 0.08 | 0.06 |
| 11  | Nové Mesto n. Váhom | 0.89 | 89.27% | 0.79 | 0.21 | 0.23 | 0.39 |
| 12  | Pattažské | 0.91 | 90.67% | 0.34 | 0.66 | 0.83 | 0.39 |
| 13  | Považská Bystrica | 1.00 | 129.33% | 1.00 | 0.00 | 0.00 |
| 14  | Prievidza | 1.00 | 101.83% | 0.89 | 0.11 | 0.30 | 0.28 |
| 15  | Púchov | 1.00 | 121.72% | 0.00 | 1.00 | 272 | 0.37 |
| 16  | Trenčín | 0.86 | 86.83% | 1.00 | 0.00 | 0.00 | 0.52 | 0.11 |
| 17  | Komárno | 0.94 | 82.99% | 0.66 | 0.34 | 0.00 | 0.59 |
| 18  | Levice | 0.98 | 98.98% | 1.00 | 0.00 | 0.00 | 0.60 |
| 19  | Nitra | 0.88 | 89.92% | 0.61 | 0.00 | 0.775055 | 0.63 |
| 20  | Nové Zámky | 1.00 | 100.00% | 0.06 | 0.94 | 18823426 | 25841006 |
| 21  | Šaľa | 0.66 | 66.37% | 0.78 | 0.22 | 0.00 | 0.40 |
| 22  | Topoľčany | 0.97 | 97.47% | 0.71 | 0.29 | 0.09 | 0.62 |
| 23  | Zlaté Moravce | 0.82 | 82.33% | 0.76 | 0.24 | 0.00 | 0.39 |

Notes: ES - Technical efficiency, VI - Virtual input, VO - Virtual output

Source: Own calculation based on the data of the Statistical Office of the Slovak Republic, elaborated in the programme DEAP
In the case of the (10) Food processing sector (in 2016), the basic precondition for clustering is not fulfilled in the Bratislava, Žilina, Trenčín, Banská Bystrica and Košice regions. The results of the BCG matrix (Figure 3) showed the same situation as in the case of sector (A) for agriculture.

5. Conclusion
Efficiency, spatial proximity and relatedness of similar economic activities, which we verified by using the DEA model and BCG matrix, represent the first step towards finding a potential for clustering in the agricultural sector in Slovak regions. Establishment and further development of clusters need to fulfill other conditions. Their formation is affected not only by the presence of corresponding factors of production in the region, but also by the presence of various stakeholders (i.e. companies, universities, foreign investors, local government institutions, secondary vocational schools, agencies and governmental bodies), which economic, and competitive), research on the level of cluster policy and cluster conception at the nation-wide and regional levels, the investigation of the level of R&D and further financial support for clusters, etc.. The results in this study showed that the preliminary precondition for clustering in the agricultural sector are fulfilled mainly in the Nitra region.

References
1. Gorzeń-Mitka, I., & Okręglicka, M. (2015). Managing Complexity: A Discussion of Current Strategies and Approaches. Procedia Economics and Finance, 27, 438-444. doi: https://doi.org/10.1016/j.proeфи.2015.08.017
2. Perez-Aleman, P. (2005). CLUSTER formation, institutions and learning: The emergence of clusters and development in Chile. Industrial and Corporate Change, 14(4), 867-897. doi: https://doi.org/10.1093/icc/14.4.867
3. Chien, Ch.-P., Chien, Ch.-F., & La, Ch.-T. (2013). Cluster policies and industry development in the Hsinchu Science Park: A retrospective review after 30 years. Innovation: Management, Policy & Practice, 15(4), 416-436. Retrieved from http://search.informit.com.au/documentSummary;dn=22528439117503;res=IELBUS
4. Jablonski, J., & Dlouhý, M. (2004). Efficiency models of production units. Prague: Professional publishing (in Czech).
5. Bojnec, Š., & Latruffe, L. (2013). Farm size, agricultural subsidies and farm performance in Slovenia. Land Use Policy, 32, 207-217. doi: https://doi.org/10.1016/j.landusepol.2012.09.016
6. Grmanová, E. (2010). The effectiveness of commercial insurance companies and banks evaluation by models of Data envelopment analysis. Trenčianska Univerzita Alexandra Dubčeka (in Czech).
7. Mura, L., & Sleziak, J. (2014). Innovation and Entrepreneurship Network. In 5th Central European Conference in Regional Science (CERS) Proceedings, (pp. 643-651). Košice: Technical University Košice. Retrieved from http://www3.ekf.tuke.sk/cers/files/2014/PDF/Mura,%20Sleziak.pdf
8. Kordos, M., Krajnakova, E., & Karbach, R. (2016). Cluster policies implementation in Slovakia. Actual Problems of Economics, 181(7), 90-96.
9. Todorova, L. (2017). Cluster development as a factor in improving the competitiveness of the agro-industrial complex of the Republic of Moldova. Scientific Papers Series - Series Management, Economic Engineering in Agriculture and Rural Development, 17(2), 375-379. Retrieved from http://managementjournal.usamv.ro/pdf/vol.17_2/Art52.pdf
10. Zen, A. C, Fensterseifer, J. E., & Prévot, F. (2014). The impact of export performance resources of companies belonging to clusters: a study in the French food industry. RBGN-Revista Brasileira De Gestao De Negocios, 16(S2), 374-391. doi: https://doi.org/10.7819/rbgn.v16s2.1523
11. Murray, W. E, & Overton, J. (2016). Fictive clusters: Crafty strategies in the New Zealand beer industry. BMJ Open Access, 22528439117503;res=IELBUS
12. Maya-Ambía, C. J. (2011). Constructing agro-industrial clusters or disembedding of the territory? Lessons from Sinaloa as the leading horticultural export-oriented region of Mexico. Open Geography Journal, 4, 29-44. doi: https://doi.org/10.2174/17497351109010929
13. Beciu, S., Ursu, A., Popa, D., & Nistor, S. (2011). Study on development of an experimental model of integrated regional cluster, as support for increasing the competitiveness of regional enterprises with an agro-industrial profile. In Creating Global Competitive Economies: A 360-Degree Approach - Proceedings of the 17th International Business Information Management Association Conference, Volume 4 (pp. 1299-1304).
14. Borsavasta, Z. N., Tolyšaybev, B., & Iulcov, A. (2015). Potential opportunities of creating a sectoral cluster in an agro-industrial region. Actual Problems of Economics, 169(2), 214-221.
15. Ivanova, O. P., Antonov, G. D., Shabashev, V. A., Zobova, L. L., & Nesterov A. Y. (2017). Formation of an agro-industrial cluster on the priority social and economic development area of a mono-industry town. Foods and Raw Materials, 5(1), 192-204. Retrieved from http://www.researchgate.net/publication/318605077_Formation_of_agro-industrial_cluster_on_the_priority_social_and_economic_development_area_of_the_mono-industry_town
16. Vojtovic, S. (2015). Future for regional creative industry. In International Scientific Conference on Knowledge for Market Use - Women in Business in the Past and Present Proceedings, (pp. 1093-1099). Olomouc: Palacký University.

Received 23.08.2017