Equilibrium. Quarterly Journal of Economics and Economic Policy
Volume 15 Issue 3 September 2020
p-ISSN 1689-765X, e-ISSN 2353-3293
www.economic-policy.pl

ORIGINAL ARTICLE

Citation: Bartova, L., & Fandel, P. (2020). Membership in agricultural producer organizations and farm technical efficiency in Slovakia. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *15*(3), 489–509. doi: 10.24136/eq.2020.022

Contact to corresponding author: lubica.bartova@uniag.sk; Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Department of Statistics and Operations Research, tr. A. Hlinku 2, 949 76 Nitra, Slovakia

Received: 5.01.2020; Revised: 21.05.2019; Accepted: 20.06.2020; Published online: 15.09.2020

Lubica Bartova
Slovak University of Agriculture in Nitra, Slovakia
orcid.org/0000-0002-6620-8379

Peter Fandel
Slovak University of Agriculture in Nitra, Slovakia
orcid.org/0000-0003-4285-6811

Membership in agricultural producer organizations and farm technical efficiency in Slovakia

JEL Classification: *L25; C12; D24; Q12; Q18*

Keywords: *farms; producer organizations; technical efficiency; metafrontier; RDP support*

Abstract

Research background: EU National Rural Development Programs (RDPs) support food chain organization, including the establishment of agricultural producer organizations (APOs) to assist the cooperation among small- and medium-sized farms and improve their performance.
Purpose of the article: We assessed how membership in an APO affects technical efficiency in a sample of Slovak farms. We break down our results by the type of membership (non-members, long-term members, and members of newly established APOs, benefitting from the RDP support) and production specialization of farms (crops, livestock, unspecialized). We expected a positive effect of membership on farm performance, although with differences by production specialization.
Methods: We analyzed cross-sectional data of 645 farms in Slovakia in 2014, when the 2007–2013 RDP support was over. We applied a DEA-based two-stage metafrontier approach. During the first stage, we estimated group-specific efficiency and calculated adjusted (target) values of inputs, given the outputs. During the second stage, we estimated the meta-technical efficiency of farms relative to the metafrontier derived from pooled adjusted inputs and outputs of farm groups by their membership within production specialization. The meta-efficiency indicates farm efficiency associated with membership in a producer organization. We examined the differences between meta-efficiency by membership groups by the Kruskal-Wallis and post hoc Dunn's tests.

Findings & Value added: Members of APOs were mainly large farms. Membership in newly established APOs, benefitting from of the RDP support, contributed significantly to higher technical efficiency of livestock and crop farms. Their performance was, however, affected by managerial and scale inefficiencies. Well-performing farms with good farm management had joined APOs already before the year 2007. However, the long-term APO membership did not improve farm technical efficiency significantly. Public support of farm cooperation should be designed to improve the governance, sustainability of the APO activities, and performance of their members.

Introduction

A significant part of the budgets of the EU Common Agricultural Policy (CAP) and national agricultural policies is targeted towards rural development through various programs and funds, including those directed to the enhancement of competitiveness of the agricultural sector. Viability, competitiveness, food chain organization and risk management belong to the priorities of rural development policy (European Network for Rural Development, 2017).

Taking into account the CAP objectives (e.g. increasing productivity of agricultural production, a fair standard of living for agricultural communities, stabilizing markets, assuring supplies and ensuring reasonable prices for the consumer), the standard competition rules are modified when applied to agricultural products. Specific competition rules are determined for farmers, their associations, producer organizations, and interbranch organizations in so far as they produce or trade in agricultural products (Velázquez & Buffaria, 2017; European Commission, 2019).

Agricultural Producer Organizations (APOs) could play an important role in strengthening the position of agricultural producers in the food supply chain by carrying out a wide range of activities on behalf of their members. APOs could achieve economies of scale and synergies to process and market the products of their members (European Commission, 2020a).

The financial support of the new producer organizations in the EU generated growing research on the factors of their establishment, success, and structure. There are only a few studies that analyze the APO effects on their members' productivity, e.g. Duvaleix-Tréguer and Gaigné (2015). Some studies analyze the technical efficiency of the APO members in developing countries (e.g. Abate *et al*., 2014). In the EU, most empirical studies assess the differences in technical efficiency and economies of scale either among selected APOs, between APOs and individual farms, or between an APO and investor-owned firms. Due to lack of microdata, available studies usually rely on case studies of selected APOs and countries, and there are only a few studies assessing the impact of membership in an APO on their members' productivity. These studies, however, do not distinguish farm performance by the type of membership and farm production specialization. Lack of such analyses is related to the limited availability of microdata. The net effect of the RDP support to newly established APOs on their members has recently been studied by using counterfactual methods at the national level of a few EU Member States, including Slovakia (Michalek *et al*. 2018, MoA SR, 2016). The net effect of the RDP policies on conventional performance indicators does, however, not consider farm production specialization.

The objective of our study is to assess farm technical efficiency based on microdata of the Slovak farms, taking into account their heterogeneity by considering production specialization and membership in the APOs. The key question we ask is: to what extent does membership in an APO improve the technical efficiency of their members?

We consider the membership in an APO and farm specialization as different farm technologies. Farm efficiency has also been affected by different levels of managerial and scale inefficiencies. Therefore, a comparison of technical efficiencies among farms by their membership and production specialization cannot be performed using conventional Data envelopment analysis (DEA). To account for different production technologies, we apply a metafrontier approach, which can measure farm efficiencies associated with distinctive and heterogeneous technologies and eliminates all other sources of inefficiency.

The structure of this paper is as follows: section 2 presents a literature review on the empirical evidence of the APOs establishment, performance, and the performance of their members. Section 3 describes the data used and explains the methodology. In section 4, we present our results; in section 5, we discuss them; and in section 6, we present the conclusions and policy recommendations.

Literature review

Fałkowski and Ciaian (2016) identified factors supporting the development of producer organizations in the EU. Among the most important belong the expansion of super- and hyper-markets, increasing concentration in the processing industry, and the rise in food quality and safety standards. The benefits of membership in an APO could be monetary (e.g., competitive producer price, attractive capital investments, taxation gains) and tangible (e.g., access to services, selling all production, proximity of the markets) (Alho, 2015).

Most literature recommends small farms to join APOs and gain benefits from the membership (e.g. Bijman *et al*., 2012, Cechin *et al*., 2013,). As pointed by Alho (2015) in her study of Finnish agricultural producers, large farms can also benefit from the APO membership. She found that both large and small producers appreciated a complex cooperative structure and the market channel, but the reduced uncertainty brought by a cooperative buyer was particularly valuable to agricultural producers investing in expansion. Also Duvaleix-Tréguer and Gaigné (2015) found that large farms, due to economies of scale, can be more able to benefit from the APO.

Country studies analyzing APOs in the EU look at the functioning, size, role, and factors of the establishment of APOs. For instance, Banaszak and Beckmann, (2010), Matczak (2012), and Chlebicka and Pietrzak (2018) analyzed the functioning and establishment of APOs in Poland and reached diverse conclusions. Ratinger *et al*. (2012) found that APOs of dairy farms in the Czech Republic were relatively successful in gaining higher bargaining power. Ribašauskiene *et al.* (2019) analyzed the drivers and obstacles of lagging cooperation in agriculture in Lithuania.

In analyzing the effect of the RDP support on the establishment of APOs in the Czech Republic and Slovakia, Kotyza *et al*. (2018) found differences in the design and implementation of the APO support policies. They assess the Slovak policy as more successful.

Effects of the membership in an APO on farm performance

The Ministry of Agriculture of the Slovak Republic (MoA SR, 2018) and Michalek *et al*. (2018) estimated the effects of the RDP SR support of newly established APOs on target indicators of their members, using methods of counterfactual approach. As proxies to assess the performance of members of APOs, they used four outcome variables: farm gross value added, farm profits, farm employment, and gross value added per annual work unit. They found that membership in APOs improved farm performance. Hoken and Su (2015) investigated the treatment effect of participation in a rice-producing cooperative in suburban China. Their results show no significant difference between participants and non-participants of a cooperative in terms of net income from rice production when controlling for the difference in farmers' rice incomes before the treatment. There is a gap in the literature concerning the effects of membership in APOs on farm performance, farm efficiency, and productivity (Van Herck, 2014).

Soboh *et al.* (2009) identified five performance measures: profitability, leverage, solvency, liquidity, and efficiency. Performance measures typically used in studies on performance and efficiency of APOs are based on accountancy information.

The effect of the APO membership on farm technical efficiency, productivity and their income was studied mainly in developing countries (e.g. Abate *et al*., 2014). Studies conducted in the developed countries assessed, for example, the effects of APOs on economies of scale. A correlation between the size of APOs and their performance was studied by Guzmán *et al*. (2009), Arcas *et al*. (2011). As a proxy for the size of cooperatives they used sales, total assets, material fixed assets, handling surface and the number of permanent and temporary employees. They found a positive influence of the APO size on the efficiency of agricultural cooperatives. Large APOs, however, were less flexible, more complex, and associated with lower performance.

APOs and their efficiency

Ferrier and Porter (1991) assessed the relative productive efficiency of the US cooperative and non-cooperative fluid-milk processors, using a nonparametric frontier production model. They found that the US milk processing cooperatives were less efficient than their proprietary counterparts.

Guzmán and Arcas (2008), Guzmán *et al.* (2009) and Arcas *et al*. (2011) examined the performance of fruit and vegetable producer organizations in Spain and Italy using DEA and complemented it with traditional economic and financial ratio analysis. They found that, on average, the Spanish APOs exhibited relatively high efficiency and that there could be a positive effect of the APO size on their performance, which indicates that size is associated with cost reduction through economies of scale and differentiation through innovation.

Skevas and Grashuis (2019) investigated and confirmed the role of spatial spillovers in the technical efficiency of farmer neighboring grain marketing cooperatives in the Midwest region of the United States. They measured the technical efficiency of cooperatives using a DEA model and used a bootstrap truncated regression to identify the effect of spatial spillovers and cooperative firm-level characteristics on technical efficiency. They found that technical efficiency is also influenced by several cooperative firm-level characteristics, for example, age, liquidity, differentiation, and the number of cooperative members.

Van Herck (2014) compared efficiency generated by carrying out some of the activities of agricultural producers jointly in producer organizations and individually. She conducted case studies from the beef and veal sector in Poland and the arable crop sector in Romania. Based on survey evidence she found that investigated APOs in both countries were not involved in downstream integrated activities.

A conventional approach to evaluating the efficiency of firms is to use production frontiers. However, the analysis of efficiency differences when firms operate under alternative technology conditions (or programs) needs a different approach. Charnes *et al.* (1981) estimated the efficiency of participants and non-participants of a program. They introduced the term managerial efficiency as the efficiency of a decision-making unit (DMU) relative to the frontier of its own group, and program efficiency as the efficiency of a DMU relative to the pooled frontier constructed from DMUs of both groups — program participants and non-participants, after all units have been made managerially efficient.

Battese and Rao (2002) introduced the concept of metafrontier as a frontier that consists of an unrestricted technology set, while group-frontier consists of a restricted technology set. Battese *et al.* (2004) applied the concept of metafrontier within stochastic frontier analysis (SFA) framework and Battese *et al.* (2008) in a DEA setting. Their DEA-based metafrontier analysis works with two types of frontiers: a metafrontier — a frontier enveloping the observations from a number of groups — and the group frontier enveloping the observations belonging to the group. Efficiency is then calculated relative both to the metafrontier and the group frontier. The ratio of these two efficiency scores, referred to as the metatechnology ratio (or technology gap ratio, or best-practice gap), indicates the distance between the group frontier and the metafrontier, from the point of view of the observation under analysis. It is identical with the program efficiency score of Charnes *et al.* (1981).

Based on the characteristics of the data sample, the metafrontier analysis allows us to distinguish farm groups by three production specialisations and three types of membership in an APO. We can also compare the gap in performance among farms with different technologies.

Research methodology and data

DEA-based two-stage metafrontier approach

We assume a positive effect of the newly established APOs on the technical efficiency of their members. We verify a hypothesis that in 2014 the technical efficiency of members of the newly established APOs was significantly higher than the efficiency of non-members or long-term members. The financial support from the RDP 2007–2013 programming period to newly established APOs ended in 2013. Therefore, we assess the farm performance in the first year without support from the old RDP, when the new RDP measures of the 2014–2020 programming period were already under the preparation.

We assume that efficiency differences between farms are due to the three major reasons: (1) farm management, (2) suboptimal farm scale size, and (3) different approaches of farms to membership in producers' organizations. In addition, there are efficiency differences resulting from farm production specialization.

To measure the net effect of membership in an APO on farm technical efficiency (TE), we apply a DEA-based two-stage metafrontier approach suggested by Charnes *et al.* (1981). During the first stage, we distribute farms into three groups by prevailing production specialization (crops, livestock, and unspecialized). For each specialization, we distinguished three groups of APO membership: 0 — non-members, 1 — long-term members, and 2 — members of the newly established APO (beneficiaries of the RDP support). Then, we estimate group-specific technical efficiency employing a Charnes, Cooper and Rhodes (1978) (CCR) DEA model and assuming constant returns to scale. Charnes *et al.* (1981) denote the estimated measures of technical efficiency ($TE \in [0; 1]$) as managerial efficiency and interpret them as the extent to which inefficient farms have to adjust (reduce) their inputs to become managerially and scale efficient, given the values of outputs. To eliminate the managerial and scale inefficiency of farms in each APO membership group, we calculate adjusted (target) values of inputs as a product of group-specific TE and observed values of inputs.

During the second stage, we pool the adjusted farm data of all membership groups, creating metadata to run the CCR DEA model, separately for each specialization. Farm technical efficiency is now measured relative to the metafrontier and is denoted as meta-technical efficiency. Metafrontier is represented by the best practicing farms of all three APO membership groups, and meta-technical efficiency now reflects the effect of a farm's membership in an APO.

A comparison of the distributions of the meta-efficiency scores between the three membership groups is required to assess which APO membership is superior.

To test the normality of the meta-efficiency scores by farm groups, we applied Shapiro-Francia W' and Shapiro-Wilk W tests. The Levene's test was carried out to test the homogeneity of variances.

For the normally distributed meta-efficiency scores with unequal variances, we applied the Welch's test. This test assumes that groups of data are sampled from populations that follow a normal distribution, but it does not assume that the populations have the same variance.

We examined the group differences of non-normally distributed meta-efficiency scores as suggested by Brockett and Golany (1996) and Sueyoshi and Aoki (2001), using the nonparametric Kruskal-Wallis rank test (Kruskal & Wallis, 1952) and post hoc Dunn's test. Limitations of the use of the two abovementioned approaches in special cases are discussed in Simpson (2007). The tests were conducted using STATA 16 software.

Data

We used a sample of cross-sectional data of 645 farms in 2014, extracted from the Slovak Ministry of Agriculture database (IL MoA SR, 2018).

We divided farms into three groups. Farms were considered specialized in crop (livestock) production if more than 60% of their sales come from the crop (livestock) production. Unspecialized farms are those where neither crop nor livestock production dominate.

Only one call (in 2008) was launched in Slovakia for the new APOs projects submissions under the 2007–2013 RDP. The selected newly established APOs with successful projects then obtained financial transfer over the next five years. Therefore, we assess the farm technical efficiency in 2014 — the first year after the 2007–2013 RDP programming period.

We use one output variable — total sales, and four input variables — material and energy costs, land rent paid, wages paid, and total fixed assets (all variables measured in thousands of euros). For the farm sample description, we also employ utilized agricultural area (in hectares) from the Land parcel identification system. Table 1 presents descriptive statistics of the variables. Out of 645 farms in the sample, 38% were not a member of an APO, 17% were long-term members, and 45% newly established members. Farms specializing in crop production dominate in our sample as well as in the groups of non-members and members of the newly established APOs. Most long-term members specialized in livestock.

Results

An average farm in our sample cultivated 1,338 hectares of land, an area corresponding to large farms in Slovakia. Long-term members of APOs cultivated on average 1,636 hectares, and unspecialized farms were even larger with 1,867 hectares on average. The 2007–2013 RDP support in Slovakia was officially intended for small and medium farms. Nevertheless, most members of the supported APOs were large farms (MoA SR, 2016).

Group-specific technical efficiency

The average group-specific TEs (GTEs) are not comparable since farms' TEs were estimated relative to frontiers representing mutually exclusive technologies. However, they can be interpreted as the indicators of the potential feasible productivity improvement within APO membership groups, and following Charnes *et al.* (1981), we call them managerial efficiencies.

Table 2 shows that long-term APO members, regardless of their production specialization, are on average, the most managerially efficient (GTE crop 0.745, livestock 0.666, and unspecialized 0.886); that is, they are closer to their group-specific frontier than are new members or non-members. Together with relatively low variability (standard deviation) of GTE score (Table 2) it indicates that long-term members of APOs, are successfully competing with the best practicing farms in the groups by all three types of production specialization.

A comparison of managerial efficiency across production specializations showed the best results for unspecialized farms (GTE = 0.674), followed by crop farms (GTE = 0.5118).

In 2014, specialized farms who were members of newly established APOs, showed the lowest average managerial efficiency (GTE crop 0.465; livestock 0.314) with higher variability (standard deviation for crop 0.215; livestock 0.252) in their performance and low competition.

The average TE is affected by all sources of inefficiencies, not only by inefficiency due to the APO membership. We conclude that the unobserved variables, for example, managerial (in)ability, contributed to the low level of average TE of the specialized farms that were also members of the newly established APOs in contrary to non-members or long-term members of the APOs.

Meta-technical efficiency

At the second stage of the estimation of the efficiency measures, we calculated within each production specialization the meta-technical efficiency of farms relative to the best practicing farms on the common metafrontier. After the elimination of essential sources of inefficiencies — managerial and scale ones — the farm technical efficiency reflects the residual and can be attributed to the effects of its membership in the APO (Table 2). Meta-technical efficiency expresses how efficient farms with alternative APO membership would perform under the current best technology. The average farm meta-efficiencies are now comparable within the production specialization, and we can observe the effect of alternative membership in the APO on farm performance.

Farms specialized in crops exhibited on average the highest meta-technical efficiency (meta-TE = 0.869), followed by unspecialized farms (0.808) and livestock farms (0.6365) (Table 2).

We also tested the significance of the meta-efficiency scores differences between the three membership groups. Meta technical efficiency data by APOs membership were not normally distributed at the significance level less than 0.05 (Shapiro-Francia) (Table 2). Based on the Shapiro-Wilk test, however, we did not reject the hypothesis that meta-TE score of unspecialized farms, members of newly established APOs, are normally distributed. The Levene's robust test statistic rejected the hypothesis of homoscedasticity across meta technical efficiency of crop, livestock specialized and unspecialized farm groups. Since data on meta-TE unspecialized farms, members of newly established APOs were normally distributed, but not homoscedastic, for testing of differences in average meta TE of unspecialized farms we applied both Welch's t-test and Kruskal-Wallis, followed by the Dunn's test. Meta TE differences of crop and livestock specialized groups were tested using non-parametric Kruskal-Wallis test (Table 2).

The Kruskal-Wallis test reveals significant differences (p-value less than 0.01) in average meta-technical efficiencies of at least one pair of farm groups by their APO membership, for all three production specializations (Table 2). Dunn's pairwise comparison test indicates significant differences in meta-TE scores among new members, long-term members, and non-members for crop farms as well as unspecialized farms. The Dunn's test results for meta-TE score of unspecialized farm groups are consistent with the results obtained by Welch's test (p-value less than 0.01). In the group of livestock farms, we did not find any significant differences between meta-TE of non-members and long-term members; this indicates an insignificant effect of long-term membership in an APO for livestock farms on their technical efficiency, compared to non-member livestock farms.

We found a significantly higher average meta-TE for the members of the newly established APO in both crop (meta-TE = 0.980, GTE = 0.465) and livestock (meta-TE = 0.999, GTE = 0.314) farms. The highest average meta-technical efficiency can be attributed to membership in the APOs, established under the RDP financial support. Despite the positive APO effect, the technical efficiency of these farms was reduced by managerial and scale inefficiencies (GTE).

In our sample of crop farms, the newly established APO members dominate with meta-TE = 0.980. Their technical efficiency related to the APO membership is on average 12 percentage points (p.p.) better than the efficiency of non-members and almost 47 p.p. better than of the long-term members. These results are even more pronounced for livestock farms where members of an APO have technical efficiency 57 p.p. higher than non-members and 58 p.p. higher than long-term members.

Most of 59 approved APO projects under the 2007–2013 RDP SR were oriented on crop commodities (38), 15 APO on raw milk, 4 APO on hog, 1 APO on poultry and 1 on livestock production (MoA SR, 2016).

The livestock and crop farms benefited the most from their membership in newly established APOs, receiving financial support from the RDP. This finding confirms the importance of effective market agencies, producers' organizations, inter-branch organizations and contract farming, to assure stable markets for the viability of specialized farms as highlighted Roest *et al.* (2018)

Some APOs were active in Slovakia already before 2007. We found that membership of livestock farms in those APOs had no significant effect on their average technical efficiency in 2014 compared to non-members.

Generally, in 2014, long-term membership in an APO improved the technical efficiency of farms (regardless of specialization) only a little. Nevertheless, these farms exhibited the highest group-specific technical efficiency when managerial and scale efficiencies are taken into account (GTE crop 0.745; livestock 0.666; unspecialized 0.886) (Table 2). This result suggests that mostly farms with good management and appropriate production scale size chose to be long-term APO members, but the APO activities did not contribute to further improvement of their performance.

There were significant statistical differences in meta-TE of unspecialized farms. The highest average technical efficiency was achieved by non-members (meta-TE = 0.957). This farm group performed 35 p.p better than long-term APO members and 16 p.p. better than newly established APOs.

The unspecialized farms that were not members of APOs had the highest meta-technical efficiency. Since the managerial and scale inefficiencies were eliminated from the meta-TE score, this finding highlights that the main source of improvement of the performance of unspecialized farms lies in managerial and scale efficiencies.

Discussion

We consider the membership in an APO and farm specialization as different, mutually exclusive, farm technologies. The estimation of technical efficiency of farm APO membership groups by production specialization based on pooled data could bias estimates. Duvaleix-Tréguer and Gaigné (2015) discussed how different forms of producer organizations could affect farmers' economic performance. To account for different production technologies, we apply a metafrontier approach, which can measure farm efficiencies associated with distinctive and heterogeneous technologies and eliminate all other sources of inefficiency.

The average group-specific TEs (GTEs) indicate managerial efficiencies as potential feasible farm productivity improvement within particular APO membership group (Charnes *et al*., 1981). Managerial efficiencies across farm production specializations showed the best results for unspecialized farms. This result is in line with the findings of De Roest *et al.* (2018) that farms rediscover diversification as one way of reducing market risks, as well as improving the efficiency of the farm's organization and resource use. Specialization allows farmers to be technically efficient, acquire highly specific production skills, and apply the latest production techniques. Specialized farms are, however, also highly dependent on the commodity markets in which they operate, which increases their economic vulnerability.

Leckner *et al*. (2017), however, emphasized the importance of cross-country studies, since the effects of diversification, particularly on efficiency, are different across countries. They show that diversification negatively affects the technical efficiency of a farm in Germany and Switzerland, but in Austria diversification contributes to higher efficiency.

After the elimination of managerial inefficiencies, we found a significantly higher average meta-TE that can be attributed to membership in the APOs established under the RDP financial support in both crop and livestock farms.

Studies assessing farm specialization as a factor of the farm efficiency in the EU yield mixed results. The farms, members of APOs in the EU, reported higher productivity and economic efficiency based on price for the products they sell through the APOs (European Commission, 2019b). Bojnec *et al*. (2014) found a positive relation of farm specialization and farm technical efficiency in the new EU Member States. Zhu and Lansink (2010) observed a negative effect of crop farm specialization on technical efficiency in Germany, while it was positive in the Netherlands and Sweden. The positive change in technical efficiency in Germany and Sweden was attributable to farm size.

Most of 59 approved APOs projects under the 2007–2013 RDP SR were oriented on crop commodities (38), 15 APOs on raw milk, 4 APOs on hog, 1 APO on poultry and 1 on livestock production (MoA SR, 2016).

We found that livestock and crop farms benefited the most from their membership in newly established APOs. Michalek *et al.* (2018) also found a positive effect of the RDP support to newly established APOs in Slovakia on their members' profitability, added value and employment in 2015. Our finding is also in line with the observation that among newly established APOs, the most successful in growing farm revenue and APOs sustainability in Slovakia were the APOs of dairy producers (MoA SR, 2016).

According to an ex-post evaluation of the Slovak Ministry of Agriculture, the policy and criteria of granted support for newly established APOs, did generally not improve selected partial financial indicators (MoA SR, 2016). Another negative consequence of the insufficiently designed policy was a 58% closure rate of the supported APOs by the end of June 2016.

Production technology of farm may depend not only on APO membership, but also on the type of this organization. The Slovak APOs mainly focus on bargaining activities (MoA SR, 2016), they do not own assets and bargain with processors, input suppliers and other actors of the food supply chain. These types of APOs generated the highest marginal cost to their members in France hog production and were the least successful in the facilitation of their members among other types of producers' organizations investigated by Duvaleix-Tréguer and Gaigné (2015).

The participation criteria of the RDP support to newly established APO in Slovakia were not designed to maintain the viability of the new APOs. Francesconi and Wouterse (2015) demonstrated that setting participation criteria in the supporting program may lead to the formation of APOs for the sole purpose of benefitting from program incentives, and lack an economic justification.

The members of analyzed APOs were mostly large farms. Most studies on agricultural producers' cooperation, however, concentrate on how small or family farms can benefit from membership in APOs and factors of APO survival, e.g. EC (2019b); Chlebicka and Pietrzak (2018).

Giagnocavo *et al.* (2018) showed that companies with a cooperative structure for marketing, financing, processing and other collective services, are an effective organizational coordination mechanism for small-scale farmers. They found longevity and high ability of the cooperatives, relying on collective collaboration, to meet the needs and challenges of both members and the community. Chlebicka and Pietrzak (2018) found the relevance of the size of the membership of newly-established APOs to their survival in Poland.

Our results on the positive effect of large farm membership in APOs on their performance correspond with findings of Duvaleix-Treguer and Gaigne (2015), Duvaleix-Treguer, (2018) and Michalek *et al*. (2018) on the benefit of large farms or APOs from economies of scale.

According to our results, mostly farms with good management and appropriate production scale size chose to be long-term APO members, but the APO activities did not contribute to further improvement of their performance. According to the theory of cooperative life cycle, the well-established, longer-term functioning APOs might be able to generate benefits for their members (Cook, 1995; Cook, 2018), which was observed in empirical studies (e.g. Francesconi & Wouterse, 2015; Michalek *et al*., 2018). The significantly lower effect of long-term membership in the APOs of the specialized farms could be related to the inability of the established APOs to act in unstable agricultural markets and poor functioning of the APOs in Slovakia. The dominant position of large farms and the importance of management was highlighted by Cechin *et al*. (2013) in maintaining the commitment of large APOs, with the heterogeneity of membership, both to collective action and a customer-oriented strategy. The low contribution of long-term APO membership to farm performance deserves further investigation.

The cross-sectional microdata allowed us to estimate technical efficiency differences by farm groups in the year following the termination of the RDP financial support flow. A potential limitation of our study, however, is that farm technical efficiency development over the RDP programming period cannot be analyzed. The availability of panel data, or at least from the year before the RDP started, would allow for assessment of technical efficiency changes over time. These micro-data would allow applications of approaches accounting for self-selection and selection biases and analyses of causal relationships.

Conclusions

Using a DEA-based metafrontier approach, we assessed the technical efficiency of 645 of Slovak farms in 2014 by their production specialization and the APO membership. The newly established APOs received financial support from the 2007–2013 RDP to enhance their bargaining power in the supply chain and to improve value added and economic viability. We, therefore, expected a positive effect of the membership in an APO on farm performance, although with differences with regard to farms' specialization.

Our results show that membership in newly established APOs contributed significantly to higher technical efficiency of farms in comparison to the performance of members of APOs existing already before 2007.

Members of newly established APOs mostly specialized in crop production and livestock to some extent. When taking into account managerial and scale inefficiencies, the same members exhibited low technical efficiency, however. The results show the high potential of those farms to improve their performance by improving farm management.

On the other hand, the highest level of group-specific technical efficiency was found for long-term members of APOs. When managerial and scale inefficiencies were eliminated, we found a minor contribution of long-term membership in an APO on the farm technical efficiency. This could indicate that well-performing farms with good management and appropriate production scale joined APOs already before the year 2007. However, the membership did not improve their technical efficiency significantly.

Slovak agriculture is characterized by a dual farm structure, with a high proportion (80%) of small farms, while only 10% of agricultural direct payment claimants cultivate 90% of agricultural land. (European Commission, 2020b). The farms in our sample are primarily large commercial units. Our study contributes to the previous literature that shows that large farms on average could also benefit from their membership in APOs. We leave the estimation of the effects of APO membership on small agricultural producers for future research. Similarly, left for the future is the investigation of the effect of farm membership in APOs on the farm performance by commodities using a microdata panel. Another important question we did not address in this paper relates to the persistence and factors of farm membership in APOs related to the negative experience with the supported APO disintegration, once the support was over.

Our findings contribute to the literature on the effects of membership of large farms in APOs on technical efficiency for different production specialization. The lagging performance of farm associated in long-existing

APOs also has a policy implication — public support of farm cooperation should be designed to improve the governance of APOs, introduce professional management, and improve the sustainability of the APO activities and performance of their members. Our findings thus contribute to redesigning of agricultural policy in Slovakia, its better targeting, and use of public funds.

References

Abate, G. T, Francesconi, G. N., & Getnet, K. (2014). Impact of agricultural cooperatives on smallholders' technical efficiency: empirical evidence from Ethiopia. *Annals of Public and Cooperative Economics, 85*(2). doi: 10.1111/apce.12035.

Alho, E. (2015). Farmers' self-reported value of cooperative membership: evidence from heterogeneous business and organization structures. *Agricultural and Food Economics, 3*. doi: 10.1186/s40100-015-0041-6.

Arcas, N., García, D., & Guzmán, I. (2011). Effect of size on performance of Spanish agricultural cooperatives. *Outlook on Agriculture*, *40*(3). doi: 10.5367/oa.2011.0051.

Banaszak, I., & Beckmann, V. (2010). Compliance with rules and sanctions in producer groups in Poland. *Journal of Rural Cooperation, 38*(1).

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science, 30*(9). doi: 10.1287/mnsc.30.9.1078.

Battese, G. E., & Rao, D. S. P. (2002), Technology gap, efficiency and a stochastic metafrontier function. *International Journal of Business and Economics, 1*(2).

Battese, G. E., Rao, D. S. P., & O'Donnell, C. J. (2004). A metafrontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies. *Journal of Productivity Analysis, 21*. doi: 10.1023/B:PROD.0000012454.06094.29.

Battese, G. E., Rao, D. S. P., & O'Donnell, C. J. (2008). Metafrontier frameworks for the study of firm-level efficiencies and technology ratios. *Empirical Economics, 34*. doi: 10.1007/s00181-007-0119-4.

Bijman, J., Iliopoulos, C., Poppe, K., Gijselinckx, C., Hagedorn, K., Hanisch, M., Hendrikse, G. W. J., Kühl, R., Ollila, P., Pyykkönen, P., & Van Der Sangen, G. (2012). *Support for farmers' cooperatives*. Report prepared for the European Commission. Wageningen UR. Retrieved from https://library.wur.nl/WebQuery/wurpubs/fulltext/245008.

Bojnec, Š., Fertő, I, Jámbor, A., & Tóth, J. (2014). Determinants of technical efficiency in agriculture in new EU Member States from Central and Eastern Europe. *Acta Oeconomica, 64*(2). doi: 10.1556/AOecon.64.2014.2.4.

Brockett, P. L., & Golany, B. (1996) Using rank statistics for determining programmatic efficiency differences in data envelopment analysis. *Management Science 42*(3). doi: 10.1287/mnsc.42.3.466.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2*. doi: 10.1016/0377-2217(78)90138-8.

Charnes, A., Cooper, W. W., & Rhodes, E. (1981). Evaluating program and managerial efficiency: an application of data envelopment analysis to program follow through. *Management Science*, *27*(6). doi: 10.1287/mnsc.27.6.668.

Cechin, A., Bijman, J., Pascucci, S., & Omta, O. (2013). Decomposing the member relationship in agricultural cooperatives: implications for commitment. *Agribusiness*, *29*(1). doi: 10.1002/agr.21321.

Chlebicka, A., & Pietrzak, M. (2018). Size of membership and survival patterns of producers' organizations in agriculture. Social aspects based on evidence from Poland. *Sustainability*, *10*(7). doi: 10.3390/su10072293.

Cook, M. L. (1995). The future of US agricultural cooperatives: a neo-institutional approach. *American Journal of Agricultural Economics, 77*. doi: 10.2307/124 3338.

Cook, M. L. (2018). A life cycle explanation of cooperative longevity. *Sustainability, 10,* 1586. doi: 10.3390/su10051586.

De Roest, K. Ferrari, P., & Knickel, K. (2018). Specialisation and economies of scale or diversification and economies of scope? Assessing different agricultural development pathways. *Journal of Rural Studies, 59*. doi: 10.1016/j.jrurstud. 2017.04.013.

Duvaleix-Tréguer, S., & Gaigné, C. (2015). Producer organizations and members performance in hog production. In *Agricultural and Applied Economics Association and Western Agricultural Economics Association annual meeting*. San Francisco, CA. doi: 10.22004/ag.econ.205494.

Duvaleix-Tréguer, S. (2018). *Producer organisations in the meat sector. The contribution of producer organisations to an efficient agri-food supply chain*. Belgium: European Commission, Bruxelles.

European Commission (2019a). *Competition.* https://ec.europa.eu/competition/ sectors/agriculture/overview_en.html

European Commission (2019b). *Study of the best ways for producer organisations to be formed, carry out their activities and be supported*. Final Report. doi: 10.2762/034412.

European Commission (2020a). *Producer and interbranch organisations.* https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultu ral-policy/market-measures/agri-food-supply-chain/producer-and-interbranch-o rganisations_en.

European Commission (2020b). *Factsheet on 2014-2020 Rural Development Programme for Slovakia*.

European Network for Rural Development (2017). *Policy Framework*. https://enrd.ec.europa.eu/policy-in-action/policy-framework.

Fałkowski, J., & Ciaian, P. (2016). *Factors supporting the development of producer organizations and their impacts in the light of ongoing changes in food supply chains.* JRC Technical Report No. EUR 27929 EN, Joint Research Centre, European Commission. doi: 10.2791/21346.

Ferrier, G. D., & Porter, P. K. (1991). The productive efficiency of US milk processing cooperatives, *Journal of Agricultural Economics, 42*(2). doi: 10.1111/j.1477-9552.1991.tb00344.x.

Giagnocavo, C., Galdeano-Gómez, E, & Pérez-Mesa, J. C. (2018). Cooperative longevity and sustainable development in a family farming system. *Sustainability*, *10*(7). doi:10.3390/su10072198.

Guzmán, I., & Arcas, N. (2008). The usefulness of accounting information in the measurement of technical efficiency in agricultural cooperatives. *Annals of Public and Cooperative Economics*, *79*(1). doi: 10.1111/j.1467-8292.2007.00354.x.

Hoken, H., & Su, Q. (2015). *Measuring the effect of agricultural cooperatives on household income using PSM-DID: a case study of a rice-producing cooperative in China*. Institute of Developing Economies, Japan External Trade Organization (JETRO). Retrieved from https://ideas.repec.org/p/jet/dpaper/dpaper539.html.

IL MoA SR. (2018). *Database information sheets of the Ministry of Agriculture and Rural Development of the Slovak Republics.*

Kotyza, P., Tomsik, K., Elisova, K., & Hornowski, A. (2018). Supporting producer groups–increasing producer's value added? *Scientia Agriculturae Bohemica, 49*(2). doi: 10.2478/sab-2018-0020.

Kruskal, W. H., & Wallis, W. A. (1952). Use of ranks in one criterion variance analysis. *Journal of the American Statistical Association*, *47*(260).

Lakner, S., Kirchweger, S. Hoop, D., Brümmer, B., & Kantelhardt, J. (2018). The effects of diversification activities on the technical efficiency of organic farms in Switzerland, Austria, and southern Germany. *Sustainability, 10*(4). doi: 10.3390/su10041304.

Matczak, P. (2012). *Support for farmers` cooperatives; case study report: performance and sustainability of new emerging cooperatives in Poland.* Wageningen: Wageningen UR. Retrieved from http://edepot.wur.nl/244933.

Michalek, J., Ciaian, P., & Pokrivcak, J. (2018). The impact of producer organizations on farm performance: the case study of large farms from Slovakia. *Food Policy, 75*. doi: 10.1016/j.foodpol.2017.12.009.

MoA SR. (2016). *Ex post hodnotenie PRV SR 2007 – 2013.* Final Report. Ministry of Agriculture and Rural Development of the Slovak Republic. Retrieved from http://www.mpsr.sk/index.php?navID=47&sID=43&navID2=318.

Skevas, T., & Grashuis, J. (2019). Technical efficiency and spatial spillovers: evidence from grain marketing cooperatives in the US Midwest. *Agribusiness. 2019*. doi: 10.1002/agr.21617.

Ratinger, T., Trdlicova, K., Abrahamova, M., Boskova, I., Souckova, I., Novotý, P., & Baudisova, H. (2012). *Support for farmer´s cooperatives.* Country report the Czech Republic. Retrieved from http://edepot.wur.nl/244817.

Ribašauskiene, E., Šumyle, D., Volkov, A. Baležentis, T, Streimikiene, D., & Morkunas, M. (2019). Evaluating public policy support for agricultural cooperatives. *Sustainability, 11*(3769). doi: 10.3390/su11143769.

Simpson, G. (2007). A cautionary note on methods of comparing programmatic efficiency between two or more groups of DMUs in data envelopment analysis. *Journal of Productivity Analysis, 28*. doi: 10.1007/s11123-007-0041-y.
Soboh, R. A. M. E., Lansink, A. O., Giesen, G., & Van Dijk, G. (2009). Performance measurement of the agricultural marketing cooperatives: the gap between theory and practice. *Applied Economic Perspectives and Policy, 31*(3). doi: 10.1111/j.1467-9353.2009.01448.x.
Sueyoshi, T., & Aoki, S. (2001). A use of a nonparametric statistic for DEA frontier shift: the Kruskal and Wallis rank test. *Omega. 29*(1). doi: 10.1016/S0305-0483(00)00024-4.
Van Herck, K. (2014*) Assessing efficiencies generated by agricultural producer organisations.* Brussels: European Commission. doi: 10.2763/76733.
Velázquez, B., & Buffaria, B. (2017). About farmers' bargaining power within the new CAP. *Agricultural and Food Economics, 5*(16). doi: 10.1186/s40100-017-0084-y.
Zhu, X., & Lansink, A. O. (2010). Impact of CAP subsidies on technical efficiency of crop farms in Germany, the Netherlands and Sweden. *Journal of Agricultural Economics, 61*(3). doi: 10.1111/j.1477-9552.2010.00254.x.

Acknowledgment

Authors acknowledge the financial support of the Slovak Scientific Grant Agency VEGA 1/0845/17.

Annex

Table 1. Descriptive statistics of a sample of Slovak farms in 2014 by their specialization and APO membership

Variable	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
	Non-members (245)				Specialized in crops (326)			
1	686	743	2	4.266	1.210	1.150	2	6.423
2	510	528	1	3.274	782	708	1	4.973
3	31	45	0	445	58	69	0	510
4	190	163	0	828	248	241	0	1.449
5	1.540	1.530	-3	8.728	2.350	2.690	-3	17.400
6	993	698	0	4.563	1.237	953	0	5.578
	New Members (111)				Specialized in livestock (211)			
1	1.070	845	19	4.011	1.040	2.300	2	24.500
2	783	594	34	2.584	813	1.500	12	15.600
3	39	35	0	127	25	47	0	452
4	308	270	14	1.745	289	333	0	1.922
5	2.870	2.610	0	12.300	2.830	4.710	0	56.100
6	1.323	891	0	4.703	1.223	931	13	5.234
	Long-term members (289)				Unspecialized (108)			
1	1.900	2.480	2	24.500	2.070	2.300	26	16.900
2	1.320	1.610	2	15.600	1.540	1.560	13	9.393
3	69	90	0	685	69	96	0	685
4	404	412	0	2.116	516	448	13	2.116
5	3.890	4.790	0	56.100	4.240	3.590	0	16.900
6	1.636	1.209	13	6.883	1.867	1.254	136	6.883

Note: Output variable: 1 total sales; Input variables: 2 material and energy costs, 3 land rent paid, 4 wages paid, 5 total fixed assets (variables 1-5 measured in thousands of euros), 6 utilized agricultural area (hectares). The number of farms in parentheses.

Source: own calculations based on IL MoA SR data.

Table 2. Group-specific and Meta-technical efficiency by APO membership for each production specialization in 2014

Spec APO Mem	Number of farms	Group-specific TE GTE		Meta-TE MTE				Shapiro-Wilk	Shapiro-Francia	Levene's	Kruskal-Wallis	Dunn's post-hoc (d) Welch's t-test (w) APO Membership	
		Aver.	Std. Dev.	Aver.	St. Dev.	Skew.	Kurt.	W	W'	W0	χ^2	0	1
Crop													
0	130	0.4872	0.2079	0.8606	0.0926	-1.762	8.3189	0.8255***	0.8379***	7.3195***	227.8***		
1	44	0.7452	0.2032	0.5118	0.0493	1.016	4.9828	0.9366**	0.9307**			5.8727 d***	
2	152	0.4653	0.2148	0.9802	0.0593	-5.769	46.5412	0.3283***	0.6379***			-11.2 d***	-13.8 d***
All	326	0.5118	0.2295	0.8693	0.1686	-1.364	3.6083	0.8511***	0.8672***				
Livestock													
0	85	0.5247	0.2615	0.4298	0.2012	1.271	3.8554	0.8617***	0.8635***	47.6822***	139.7***		
1	48	0.6660	0.2268	0.4122	0.1414	2.063	8.4538	0.8079***	0.7965***			-0.3245 d	
2	78	0.3140	0.2517	0.9996	0.0015	-5.511	36.4715	0.1930***	0.6839***			-11.1 d***	-9.1772 d***
All	211	0.4790	0.2847	0.6365	0.3137	.1300	1.2396	0.8893***	0.8756***				
Unspecialized													
0	30	0.5654	0.2961	0.9570	0.1166	-4.744	24.9140	0.1964***	0.3901***	3.2954***	56.9***		
1	19	0.8857	0.1706	0.6067	0.1404	1.275	4.2616	0.8684**	0.8594**			7.3297 d*** 9.0732 w***	
2	59	0.6615	0.2077	0.7967	0.0905	.638	2.9386	0.9674	0.9589 **			5.2963 d*** 6.5898 w***	-3.6447 d*** -5.5397 w***
All	108	0.6742	0.2518	0.8078	0.1579	-.558	2.6526	0.9462***	0.9687**				

Note: * p-value < 0.1; ** p-value < 0.05; *** p-value < 0.01; W – Shapiro-Wilk test; W' – Shapiro-Francia test; W0 – Levene's test; χ^2 – Kruskal-Wallis H test, 2 d.f.; APO Mem – farm APO membership: 0 – non-members, 1- long-term members; 2– newly established APO members. Spec – production specialization (crop, livestock, unspecialized); All – all farms of particular specialization in the sample.

Source: own calculations based on IL MoA SR data.