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Evaluation of technical efficiency of Hungarian and Croatian livestock sectors using DEA on FADN data

Procjena tehničke učinkovitosti mađarskih i hrvatskih stočarskih sektora primjenom DEA modela na FADN podacima

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ABSTRACT

The different sectors of the livestock industry play an important role in meeting the increasing demand for animal products in both Hungary and Croatia. The general objective of this study was to investigate and compare the efficiency of the livestock sectors in Croatia and Hungary using the Data Envelopment Analysis method. In this paper, the technical efficiency of the dairy, beef, broiler, sheep and goat, and pig sectors from 2014 to 2017 is investigated based on the Farm Accountancy Data Network database. This paper compared farms of different size classes based on the Standard Production Value for more detailed insights. Among the five main livestock sectors, Hungary performs better in terms of farm technical efficiency in the dairy and beef sectors, while Croatia has higher efficiency scores in the sheep sector. The performances in the pig and broiler sectors are almost the same in both countries. Moreover, in the Hungarian poultry, pig, sheep and goat sectors and the Croatian dairy, beef and pig sectors, the technical efficiency of small-sized farms is better than that of medium-sized farms.

Keywords: DEA, farm efficiency, livestock breeding, variable returns to scale

SAŽETAK

Različiti sektori stočarske industrije imaju važnu ulogu u zadovoljavanju sve veće potražnje za proizvodima životinjskog porijekla u Mađarskoj i Hrvatskoj. Glavni cilj ovog istraživanja bio je istražiti i usporediti učinkovitost sektora stočarstva u Hrvatskoj i Mađarskoj korištenjem metode Data Envelopment Analysis. U ovom radu istražuje se tehnička učinkovitost sektora mljekarstva, govedarstva, peradarstva, ovčarstva i kozarstva te svinjogojstva od 2014. do 2017. na temelju baze podataka Farm Accountancy Data Network. Za detaljniji uvid ovaj rad uspoređuje farme različitih veličina određenih na temelju Standardne proizvodne vrijednosti. Među pet glavnih sektora stočarstva, Mađarska ima bolje rezultate u pogledu tehničke učinkovitosti u mliječnom i govedarskom sektoru, dok Hrvatska ima bolje rezultate u sektoru ovčarstva. Učinci u sektorima svinjogojstva i peradarstva gotovo su isti u obje zemlje. Štoviše, u mađarskim sektorima peradarstva, svinjogojstva, ovčarstva i kozarstva te hrvatskim sektorima mljekarstva, govedarstva i svinjogojstva, tehnička učinkovitost malih farmi bolja je od onih srednjih farmi.

Ključne riječi: DEA, efikasnost farme, uzgoj stoke, model varijabilnih prinosa

INTRODUCTION

In terms of global food supply, it is essential to increase the efficiency of livestock production in the future to meet the increasing demand for meat and dairy products due to rapid population growth. From a social and economic point of view, increasing production efficiency in agriculture and food production, in general, is an important issue for the European Union and Hungary and Croatia as its members. Efficiency is a comprehensive term. Therefore, it is necessary to define precisely what we mean by it, what factors influence it, what evaluation indicators there are and what methods can be used to measure the efficiency of an individual farm. The issue of efficiency should be a priority for both Croatian and Hungarian livestock farms to ensure that even a single farm can produce competitively and efficiently for the national and global market, in an economically, socially and environmentally sustainable manner.

The current structure and organization, and thus the agriculture productivity, are partly due to historical development. Both Hungary and Croatia were socialist states until the late 1980s. Then the transformation to a democratic system and a market economy began, which was particularly difficult and lengthy in Croatia because, at the same time, the five-year of independence was taking place (i.e. Homeland War). Hungary joined the EU in 2004, becoming a stakeholder in the EU's Common Agricultural Policy (CAP), the implementation of which undoubtedly influences the agriculture of member states. Croatia joined the EU in 2013 and, as the youngest EU member, has the least experience in formulating, planning and implementing CAP.

In two studies conducted on farms in the ten new EU member states (Latruffe et al., 2004; Bojnec et al., 2014), the authors concluded that increasing technical efficiency in agriculture on the one hand, and developing employment and income in rural areas on the other hand, are seen as a strategy for raising living standards in agriculture and rural areas. Wei et al. (2016) integrated an ecological variable for grassland production capacity into the production function as a new step to conduct technical efficiency analysis in livestock grazing. They believe that understanding the relationship between technical efficiency and ecological performance would help balance local economic development and environmental protection.

Given the differences in historical development, the size and structure of the agricultural sector and the timing of EU accession, differences in efficiency between Croatian and Hungarian farms are expected. The method DEA, used in Croatia so far, mainly in the financial sector, is suitable for assessing technical efficiency (Jemrić and Vujčić, 2002; Sanjeev, 2006). Our intention to compare the efficiency of farms in the two countries and contribute to the research on the technical efficiency of farms using the method DEA led us to conduct this study. As far as we know, this is the first study to assess the technical efficiency of the Croatian livestock sector using the DEA method on a set of FADN data and then compare the results with another country.

The main objective of this research was to evaluate and compare the efficiency of livestock industries in Croatia and Hungary. We aimed to compare the efficiency of the entire livestock industry and the efficiency of individual sectors, and the class of farms concerning their size within a given sector. In doing so, we decided to apply the widely used method DEA to reveal hidden efficiency reserves in the respective countries, industries, sectors and classes.

MATERIAL AND METHODS

Efficiency is a widely used term in economic evaluations, for example in measuring performance at the farm level. Economic (or general) efficiency can be expressed as a combination of technical and allocative efficiency or price efficiency. Technical efficiency is the ability of the farmer to obtain the maximum output from a given set of inputs, while allocative efficiency measures the ability of the farmer to use inputs at an optimal ratio given input prices and technologies (Begum et al., 2009; Coelli et al., 2005). Several scientific methods are suitable for measuring efficiency. One of the most commonly used methods is Data Envelopment Analysis (DEA), including mathematical programming and econometric methods.

In this study, we used the input-oriented DEA model with VRS assumption to evaluate the technical efficiency of different livestock sectors in two countries. The DEA model with variable returns to scale (VRS) tightly encloses the data points and results in efficiency values higher than or equal to those of the model with constant returns to scale (CRS). The difference between the VRS model technical efficiency score and the CRS model represents the scale inefficiency. We used the radial approach to measure technical efficiency because the calculated technical efficiency values or scores are easy to interpret. They represent the maximum percentage reduction in inputs required to produce a given quantity of outputs or the maximum percentage expansion of outputs possible given inputs. The mathematical expression of the input-oriented model DEA VRS and the Directional Input Distance function is as follows (Serra et al., 2011):

$$\begin{aligned} &\underset{\beta,\lambda}{Max}\ \beta \\ &s.t.\quad -y_i + Y\lambda \geq 0 \\ &\qquad x_i - \beta g_x - X\lambda \geq 0 \\ &\qquad \lambda'1 = 1 \\ &\qquad \lambda \geq 0 \end{aligned}$$

where:

ß = Technical Inefficiency score;

gx = directional distance vector;

λ= vector of parameters (firm weights);

X and Y are matrixes with all outputs and inputs.

We used R software (ver. 3.6.1) with RStudio ver 1.2.1335 to calculate the efficiency indicators and Benchmarking packages version 0.27 (Bogetoft and Otto, 2011). The vrs technical efficiency indicator ranges from 0 to 1. The value 1 means that the farm is fully efficient, and there is no need for improvement. The distance from the estimated production frontier (1 or 100% efficient) represents the technical efficiency reserves or potential for improvement in that particular sector or farm size.

Statistical significance of differences in mean values of indicators of technical efficiency was tested by applying the t-test for samples with 30 or more data or the Wilcoxon test for smaller samples. MS Excel and R packages were used for descriptive data analysis and testing of mean differences.

For this study, we used data from the European Farm Accountancy Data Network (FADN) database provided by the Research Institute of Agricultural Economics (AKI, Hungary) and the Croatian Ministry of Agriculture (FADN Office). Data for dairy, beef, pig, poultry and sheep farms were extracted from the database for the period 2014-2017 for Hungary and Croatia. This research is in full compliance with all relevant codes of experimentation and legislation.

We used the corresponding FADN variables as outputs in our DEA models depending on the livestock sector. One output variable was used for all sectors, except for the dairy sector, where two output variables were used. The following variables were used as outputs in the model for each sector:

- Dairy sector: (1) Cow milk and milk products (in EUR, FADN code: SE216), and (2) Beef and veal (in EUR, FADN code: SE220);
- (Beef sector: Beef and veal (in EUR, FADN code: SE220);
- Pig sector: Pig meat (in EUR, FADN code: SE225);
- Poultry sector: Poultry meat (in EUR, FADN code: SE235);
- Sheep sector: Sheep and goats (in EUR, FADN code: SE230).

Following Kovács (2014) and Kovács (2016) for all the DEA farm models, the following five input variables from FADN database were used, namely:

- Total fixed assets (EUR): Buildings, land and other long term assets associated with agricultural activity. These assets do not wear out (land), or only slightly wear out during production (FADN code: SE441);
- Total current assets (EUR): The current assets comprise of non-breeding livestock and circulating capital (stocks of agricultural products + other circulating capital) (FADN code: SE465);
- Labour input: The total number of working hours (FADN code: SE011);
- Major cost items (EUR): The sum of the three biggest categories of costs, namely animal feed,

energy and other livestock specific costs. Usually, the highest among them are livestock feed costs, but other categories can also make a significant part. The third category is mainly made of the cost of veterinary services and includes other direct costs related to the farm. (FADN codes: SE310 +SE320+ SE330 + SE345).

The last input variables depend on the exact sector:

- Dairy cows: Number of female cattle that are held primarily for milk production, in livestock units (LSU) (FADN code: SE085);
- Sheep and goats: Number of sheep and goats of different categories, in LSU (FADN code: SE095);
- Pigs: Number of pigs, all categories, which are held for reproduction or for meat production, in LSU (FADN code: SE100);
- Poultry: Number of table chickens, laying hens and other poultry, in LSU (FADN code: SE105).

In line with the objectives set, the efficiency indicators were also analysed in terms of the economic size of the farm (farm size classes). For this purpose, farms were classified into three classes according to the value of the total Standard Output (TSO) of the farm: (1) small farms with a TSO of EUR 4,000 to EUR 25,000, (2) medium farms with a TSO of EUR 25,000 to EUR 500,000, and (3) large farms with a TSO of more than EUR 500,000.

In total, we constructed 160 marginal estimation models for the different time, country, farm type, and size dimensions. Table 1 shows the number of farms in the different DEA frontier models.

RESULTS AND DISCUSSION

This section describes the results of calculating technical efficiency under variable returns to scale (vrs) condition by year for different livestock sectors and farm size classes in Croatia and Hungary.

According to Eurostat, 61% of the 430,000 agricultural holdings in Hungary keep livestock, and within this subgroup, 43% specialise in one of five sectors: dairy cattle, cattle rearing and fattening, pigs, poultry, and sheep and goats and other grazing livestock. In Croatia, 68% of the 134,460 farms keep livestock, and the share of specialised farms is 23% (FSS 2016). Most specialised farms in Croatia are found in the sheep and goat and dairy cattle sectors, while in Hungary the most specialised are pig and poultry farms. Specialised farms in Croatia account for 63% of the total number of animals expressed in livestock units (LSU), while specialised livestock farms hold 66% of all LSU in Hungary. The number of animals per specialised farm (for all sectors) is 22.8 LSU in Croatia and 14.4 LSU in Hungary.

The above data are from the Eurostat Farm Structure Survey dataset, while our study is based on the Farm Accountancy Data Network (FADN) database. The total sample size for the FADN survey ranged from 1,290 to 1,337 farms in Croatia and from 1,965 to 2,146 farms in Hungary in 2014-2017 (Juračak et al., 2019).

There are international comparisons of technical efficiency for the Hungarian dairy sector but not for other major livestock sectors. For example, Latruffe et al. (2012), comparing Hungarian and French field crop and dairy farms, concluded that a significant difference in efficiency exists only for the former farm group, with French farms being more efficient on average. However, when using the metafrontier approach, Hungarian farms are more productive in both sectors. Bakucs et al. (2009) used the stochastic frontier analysis method to evaluate the technical efficiency of Hungarian farms before and after joining the European Union (EU). The results show that EU membership reversed the process of efficiency reduction before accession. On the other hand, the higher subsidies after accession contribute to the lower efficiency of Hungarian farmers. In 2020, Havliček et al. evaluated the technical efficiency of the pig sector in 16 countries by combining different DEA models and ranking the countries according to the score achieved. The Hungarian pig sector is ranked very low and is in the group of countries with the lowest, i.e. "sufficient" efficiency score. The technical and policy efficiency of farms in Croatia was assessed in 2020 to develop a national strategy for agricultural development (World Bank, 2020). Broken down by farm type, the highest technical efficiency (TE) was achieved by the clusters of

Table 1. The sample size by livestock sectors, country, farm size, and year

Dairy Sector Farms								
Year	Hungary				Croatia			
	All	Small	Medium	Large	All	Small	Medium	Large
2014	100	18	59	23	210	57	152	1
2015	112	18	67	27	209	53	155	1
2016	108	19	61	28	200	50	149	1
2017	109	18	63	28	209	53	155	0
Total:	429	73	250	106	828	213	611	3
Beef Sector Farms								
Year	Hungary				Croatia			
	All	Small	Medium	Large	All	Small	Medium	Large
2014	33	11	20	2	76	24	52	0
2015	33	9	23	1	81	22	59	0
2016	38	13	24	1	79	32	47	0
2017	37	15	21	1	76	29	47	0
Total:	141	48	88	5	312	107	205	0
Pig Sector Farms								
Year	Hungary				Croatia			
	All	Small	Medium	Large	All	Small	Medium	Large
2014	57	14	30	13	17	11	6	0
2015	60	17	28	15	23	13	10	0
2016	98	29	50	19	22	15	7	0
2017	87	27	42	18	21	10	10	0
Total:	302	87	150	65	83	49	33	0
Sheep Sector Farms								
Year	Hungary				Croatia			
	All	Small	Medium	Large	All	Small	Medium	Large
2014	30	11	19	0	74	56	16	0
2015	33	14	19	0	71	54	17	0
2016	34	15	19	0	61	48	13	0
2017	28	13	15	0	70	53	17	0
Total:	125	53	72	0	276	211	63	0
Poultry Sector Farms								
Year	Hungary				Croatia			
	All	Small	Medium	Large	All	Small	Medium	Large
2014	123	9	98	16	4	0	4	0
2015	121	9	97	15	16	1	15	0
2016	121	8	90	23	11	0	11	0
2017	115	9	83	23	19	0	17	0
Total:	480	35	368	77	50	1	47	0

Source: Hungary and Croatia national FADN databases specialists in granivores, horticulture, wine, and sheep and goats. Three livestock clusters are at the top of scale efficiency (SE): specialised dairy farms, specialised sheep and goat farms and specialist granivores. In general, Croatian farms are technically inefficient (mean bias-corrected TE = 0.30) but have very good scale efficiency (mean SE = 0.82).

A study that examined the effectiveness of agriculture in the European Union using DEA and Hellwig's taxonomic measure of development concluded that Croatian farms are technically efficient. At the same time, Hungary belongs to the group of countries with the lowest farm efficiency, together with Romania and Finland (Rusielik and Szczecińsk, 2020). In contrast, the authors who examined the economic efficiency of the farms of ten countries in Central and Eastern Europe using the technical and allocative efficiency, based on the DEA-COST approach, ranked Hungary as one of the most efficient countries. At the same time, Croatia belonged to the group of the most inefficient countries (Toma and Vlad, 2018).

Guth and Smedzik-Ambrozy (2020) used the DEA model to determine the relative differences in technical efficiency of different types of agricultural production in the regions of the EU. They found differences in factor endowments between groups of EU regions in agriculture, which translates into differences in the technical efficiency of farms in different sectors. A study in Serbia examined technical efficiency on a sample of 91 Serbian dairies using DEA. The results show that smaller farms suffer from input inefficiency and inadequate farm size, while the larger farms are overinvested (Popović and Panić, 2018). Another study on the dairy sector in different EU countries has shown that differences in local markets and firm characteristics lead to differences in the technology used and, consequently, the technical efficiency of dairy processing cooperatives (Rafat et al., 2014). Zhu et al. (2008) investigate the impact of CAP subsidies on the competitiveness of dairy farms in Germany, the Netherlands and Sweden. The results on technical efficiency show that coupled subsidies have adverse effects in Germany and the Netherlands but no significant effects in Sweden.

A study conducted in Poland analyses technical efficiency and its determinants for a panel of individual farms specialised in crop and livestock production in 2000. On average, livestock farms are more technically efficient than crop farms. The relationship between size and efficiency is positive for both specialisations, i.e. large farms are more efficient (Latruffe et al., 2004). Bojnec et al. (2014) analysed technical efficiency in agriculture in the ten new EU Member States.

Dairy sector

In the case of the dairy sector, we calculated the production frontier for each country and year and measured the average distance of farms from the frontier. The sample size ranged from 200 to 210 farms in Croatia and from 100 to 112 in Hungary depending on the year. Figure 1 shows the comparison between Croatian and Hungarian dairy farms by year. We see that Hungarian dairy farms' input-oriented VRS technical efficiency (vrsTE) is 8-13 percentage points higher than that of Croatian ones. The differences in average technical efficiency were significant in all four years studied (2014: t= -3.1587, P<0.01; 2015: t= -4.1679, P 0.01; 2016: t= -5.1612, P<0.01; 2017: t= -5.1103, P<0.01).

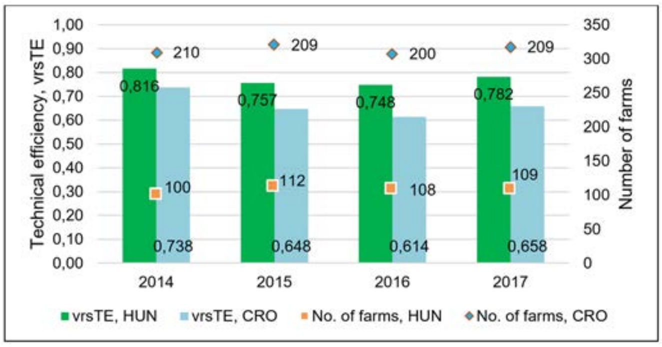

Figure 1. Technical efficiency indicators of the Hungarian and Croatian dairy sector 2014–2017

Figure 1 also shows that 2016 was the worst year for both countries in terms of the technical efficiency of individual farms. It was the first year after the abolition of the European milk quota system, which led to a significant decrease in raw milk prices.

The four-year average technical efficiency of small-sized dairy farms in Hungary is 91.5%, while the average efficiency of Croatian farms is 79.6%. At the same time, the efficiency of Croatian small-sized dairy farms varied greatly during the period studied: from 69.1% to 85.9% (Table 2). The technical efficiency of Hungarian small dairy farms was significantly higher than that of Croatian ones in 2014, 2015 and 2017 (2014: t= -4.1911, *P*<0.01; 2015: t= -4.0881, *P*<0.01; 2017: t= -2.6946, *P*<0.01).

As shown in Table 2, the indicators of technical efficiency of medium-sized dairy farms in Hungary and Croatia are close to each other. Only in 2014 was the difference large enough to be statistically significant, with Hungarian farms showing higher efficiency (t= -3.7463, *P*<0.0). The four-year efficiency average is 80.2% for Hungarian and 77.5% for Croatian farms.

Interestingly, the efficiency indicator for small-sized dairy farms in Hungary was significantly higher than for medium-sized farms in all years (*P*<0.01 in 2014 and 2017, *P*<0.05 in 2015-2016). In Croatia, small-sized farms had higher efficiency (*P*<0.01) than medium-sized farms in 2014 and 2017, and lower efficiency in 2015 (*P*<0.01). Although we can attribute this result to the relatively lower level of inputs on small farms, it suggests that efficiency needs to be improved in the class of medium-sized dairy farms.

There was only one large-sized Croatian dairy farm in the sample, so we did not compare two countries for this farm size group. The efficiency indicator for large Hungarian dairy farms is 94.5% for the period studied, which means that there is an untapped potential of 5.5% for these farms that can be exploited by (1) reducing the input to produce the same amount of output or (2) increasing the output level without changing the input used.

Beef sector

The Hungarian beef sector has a four-year average technical efficiency 22.8% higher than the Croatian does (Figure 2). The differences were the biggest and statistically significant in 2015 and 2017 (2015: t= -3.4435, *P*<0.01; 2017: t= -4.4071, *P*<0.01).

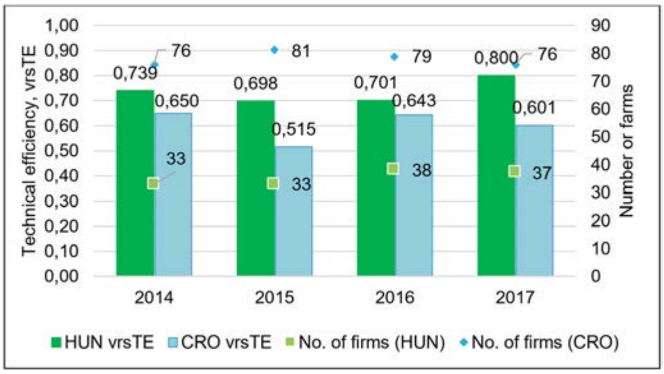

Figure 2. Technical efficiency of the Hungarian and Croatian beef sector, 2014-2017

Table 2. The technical efficiency of small-sized and medium-sized dairy farms in Hungary and Croatia 2014–2017

Year	Small-sized farms				Medium-sized farms			
	Technical efficiency scores (vrsTE1)		Mean difference test results		Technical efficiency scores (vrsTE1)		Mean difference test results	
	Croatia	Hungary	t	p-value	Croatia	Hungary	t	p-value
2014	0.859	0.971	-4.1911	0.000**	0.794	0.880	-3.7463	0.000**
2015	0.691	0.899	-4.0881	0.000**	0.808	0.793	0.54461	0.587
2016	0.794	0.861	-1.4523	0.155	0.749	0.768	-0.61544	0.540
2017	0.841	0.930	-2.6946	0.009**	0.748	0.768	-0.67754	0.500
Average	0.796	0.916			0.775	0.802		

[1] vrsTE = variable returns to scale technical efficiency score

** The mean difference is significant at the 0.01 level

Table 3. shows that the average efficiency of small-sized beef farms in Hungary (86.2%) is also higher than that of Croatian farms (74.4%). However, the difference was statistically significant only in 2017 (t= -4.0151, *P*<0.01).

The biggest difference in technical efficiency between beef farms in the two countries is in the medium-sized class. The Hungarian four-year average of technical efficiency is 84.2%, while the Croatian average is 63.3% (Table 3). Hungarian medium-sized beef farms had statistically higher technical efficiency than Croatian in all four years observed (Table 3).

The average technical efficiency of small-sized Croatian beef farms was significantly higher than of medium-sized farms in 2015 (t= -2.653, *P*<0.05; t= -2.320, *P*<0.05). We find a quite similar situation in Hungary, but the small-sized farms there had significantly higher efficiency only in 2017 (*P*<0.05. Analogously to the dairy sector, we can argue that this situation is due to the lower capital intensity in small farms compared to medium-sized farms. Small farms tend to use less paid inputs and aim to keep costs low, even if that means cutting back on production. The number of large-sized farms in the beef sector in the FADN sample is too small, so we did not perform the technical efficiency analysis for this size group.

Pig sector

The average indicator of technical efficiency over four years is 84.2% for the Hungarian and 84.3% for the Croatian pig farms (Figure 3). In no year in 2014-2017 is there a statistically significant difference in the average efficiency level of pig farms in the two countries.

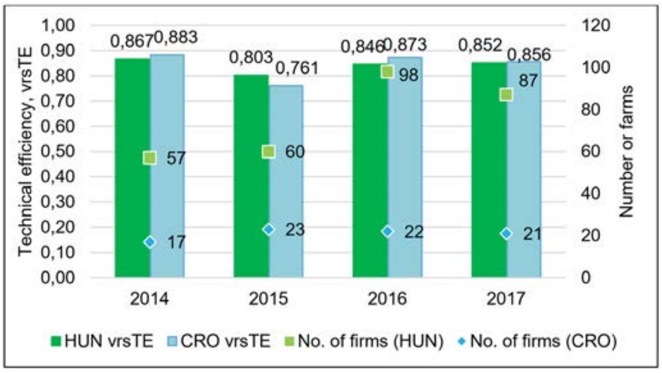

Figure 3. Technical efficiency of Hungarian and Croatian pig farms, 2014-2017

The four-year average efficiency indicator between the two countries for small-sized pig farms was not significant in the studied period (Table 4). The differences in the average efficiency for medium-sized farms are also slight and are not statistically significant.

Table 3. The technical efficiency of small-sized and medium-sized beef farms in Hungary and Croatia 2014–2017

Year	Small-sized farms				Medium-sized farms			
	Technical efficiency scores (vrsTE1)		Mean difference test results		Technical efficiency scores (vrsTE1)		Mean difference test results	
	Croatia	Hungary	t	p-value	Croatia	Hungary	t	p-value
2014	0.786	0.884	-1.3320	0.198	0.706	0.867	-2.9125	0.005**
2015	0.713	0.883	-1.8629	0.082	0.559	0.866	-6.4113	0.000**
2016	0.769	0.757	-1.2334	0.230	0.643	0.864	-4.1545	0.000**
2017	0.708	0.924	-4.0151	0.000**	0.623	0.722	-2.5238	0.015*
Average	0.744	0.887			0.633	0.842		

[1] vrsTE = variable returns to scale technical efficiency score

* The mean difference is significant at the .05 level

** The mean difference is significant at the .01 level

Table 4. The technical efficiency of small-sized and medium-sized pig farms in Hungary and Croatia 2014–2017

Year	Small-sized farms				Medium-sized farms			
	Technical efficiency scores (vrsTE1)		Mean difference test results		Technical efficiency scores (vrsTE1)		Mean difference test results	
	Croatia	Hungary	t	p-value	Croatia	Hungary	t	p-value
2014	0.945	0.938	0.13756	0.892	0.908	0.935	-0.2805	0.789
2015	0.875	0.961	-1.5829	0.133	0.888	0.894	-0.0774	0.940
2016	0.941	0.928	0.36637	0.717	0.960	0.893	1.6506	0.128
2017	0.976	0.967	0.32858	0.747	0.799	0.918	-1.4010	0.192
Average	0.934	0.948			0.889	0.910		

[1] vrsTE = variable returns to scale technical efficiency score

Regarding the differences between groups of pig farms by size, we found that although the average efficiency indicators are usually higher for small-sized farms, only in 2017 in Hungary the group of small-sized farms had higher technical efficiency than the group of medium-sized farms (W=148, *P*=0.0197).

Sheep sector

According to our results, the sheep sector is the only sector in which Croatian farms dominate according to the indicator of technical efficiency. The overall average technical efficiency of Croatian sheep farms in the studied period is 83.4% (Figure 4), while the efficiency of Hungarian sheep farms is ten percentage points lower (73.3%). However, the difference in means by year is significant only for 2017.

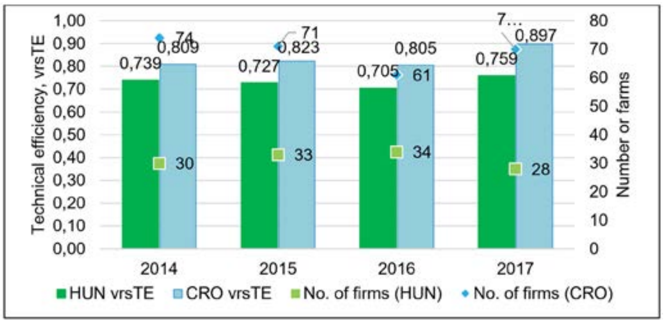

Figure 4. Technical efficiency of Hungarian and Croatian sheep farms, 2014-2017

Looking at the size of the farms, we find that the small-sized Hungarian sheep farms have a higher technical efficiency than the Croatian ones, while the medium-sized Croatian farms are more efficient than the farms of the same size category in Hungary. From 2014 to 2016, the technical efficiency of small sheep farms increased in Hungary, while it stagnated in Croatia, increasing the difference from 6.4 percentage points to 13.6 percentage points. However, in 2017, the indicator of technical efficiency of Hungarian farms decreased, while the same indicator for Croatian farms increased, bringing them in line. The difference in average efficiency in favour of small Hungarian farms was significant in 2015 (t= -2.0901, *P*=0.048) and especially in 2016 (t= -4.3549, *P*=0.000). The average technical efficiency of Hungarian farms is 80.0%, while Croatian sheep farms achieved higher efficiency in all four years, with a maximum of 95.3% in 2017. The difference between the mean values in favour of medium-sized Croatian farms is significant for 2015 (t=2.4537, *P*=0.019) and 2016 (t=3.4971, *P*=0.001).

In Hungary, the efficiency of small-sized sheep farms is significantly different from that of medium-sized farms only for 2016. (W = 76, *P*=0.0103). In Croatia, the efficiency of medium sheep farms was significantly higher than that of small-sized farms in 2015 and 2016 (t=2.2153, *P*=0.034; t=3.9159, *P*=0.000). Large-sized sheep farms are not included in the FADN, so we did not compare this size category.

Table 5. The technical efficiency of small-sized and medium-sized sheep farms in Hungary and Croatia 2014–2017

Year	Small-sized farms				Medium-sized farms			
	Technical efficiency scores (vrsTE1)		Mean difference test results		Technical efficiency scores (vrsTE1)		Mean difference test results	
	Croatia	Hungary	t	p-value	Croatia	Hungary	t	p-value
2014	0.848	0.912	-1.2080	0.246	0.865	0.792	0.9645	0.342
2015	0.841	0.939	-2.0901	0.048*	0.929	0.797	2.4537	0.019*
2016	0.840	0.976	-4.3549	0.000**	0.974	0.764	3.4971	0.001**
2017	0.916	0.921	-0.1339	0.895	0.953	0.853	1.7457	0.096
Average	0.861	0.937			0.930	0.799		

[1] vrsTE = variable returns to scale technical efficiency score
* The mean difference is significant at the .05 level
** The mean difference is significant at the .01 level

Poultry sector

The average efficiency of the poultry sector over the four years studied is almost the same for both countries (82.2% and 82.7%) (Figure 5). Here we think it is important to point out a large difference in the size of the country samples, which is about ten times larger in Hungary. We consider it a consequence of the polarisation of this sector in Croatia, where most production units are below the threshold for participation in the FADN survey and those that are large enough fall into the category of medium-sized holdings (Table 6).

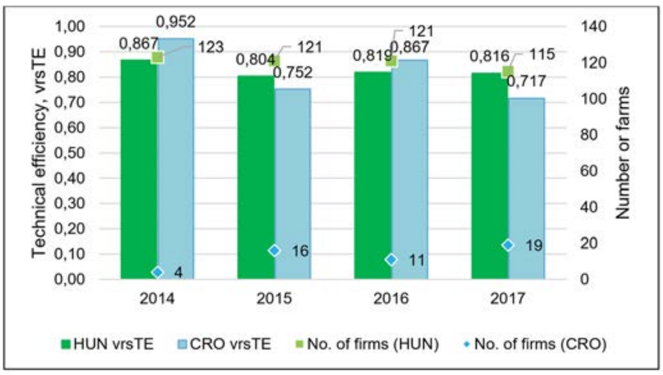

Figure 5. Technical efficiency of Hungarian and Croatian poultry farms, 2014-2017

Since there are no small and large poultry farms in the Croatian FADN sample, we could compare efficiency between the two countries only for medium-sized farms.

Table 6. The technical efficiency of medium-sized poultry farms in Hungary and Croatia 2014–2017

Year	Technical efficiency scores (vrsTE1)		Mean difference test results	
	Croatia	Hungary	t	p-value
2014	0.951	0.894	1.1395	0.327
2015	0.736	0.849	-1.4020	0.181
2016	0.867	0.874	-0.0878	0.932
2017	0.808	0.860	-0.8960	0.381
Average	0.841	0.869		

[1] vrsTE = variable returns to scale technical efficiency score

The efficiency of medium-sized poultry farms varies from year to year, with greater variability among Croatian farms (Table 6). The mean value of technical efficiency of Hungarian medium-sized poultry farms is slightly higher (86.9%) than that of Croatian farms (84.1%). Despite the fluctuations and specific differences in the mean values, no statistically significant difference was found in the average annual technical efficiency between medium-sized Croatian and Hungarian poultry farms in the observed period.

The average technical efficiency of Hungarian small poultry farms is 96.9% in the four years studied. The efficiency decreased from 2014 to 2015, but afterwards, it increased from 92.5% to 97.9%.

Large Hungarian poultry farms have the highest technical efficiency among the three size groups: 98.1% on average during the studied period. Moreover, the fluctuations of the indicator are small, so we can say that there is no room for efficiency improvement in the class of large poultry farms.

CONCLUSION

In this research, we compared the values of technical efficiency and their trends in livestock production in Croatia and Hungary based on FADN sample data for the period 2014-2017. The dairy, beef, pig, sheep and poultry sectors were analysed at sectoral level and by farm size groups. Hungarian farms have higher four-year average VRS values for technical efficiency in the dairy and beef sectors, while Croatian farms have higher values only in the sheep sector (Figure 6). The performance of farms in the pig and poultry sectors is almost the same in both countries: the values for technical efficiency are not considerably different between the two countries.

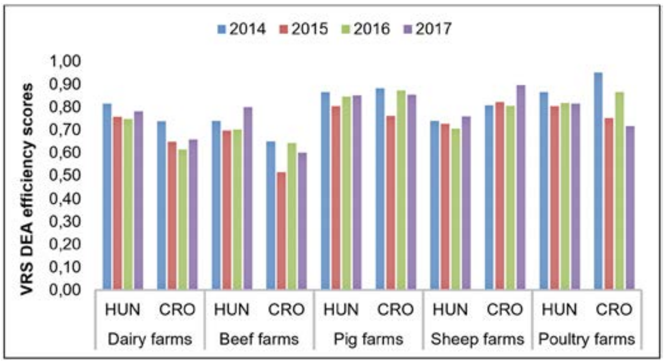

Figure 6. Variable returns to scale DEA technical efficiency scores of the Hungarian and Croatian livestock sectors in 2014-2017

We have found that in some sectors the technical efficiency of small-sized farms is better than that of medium-sized farms. This is the case in the Hungarian poultry and sheep sector, the pig sector in both countries, and the Croatian beef and dairy sector.

The advantage of the DEA methodology is the possibility to compare and rank production units of different groups or categories in terms of technical efficiency. However, comparisons are only meaningful if the input data and model assumptions are the same for all groups analysed. This must be taken into account if we want to apply this research to other areas and other sectors of agricultural production. One of the possible limitations of this research is the dependence on the quality of the data used, i.e. the quality of the sample. We used data from the FADN system, which is still developing and probably has certain shortcomings (Juračak et al. 2020). For example, the number of observation units is relatively small for certain farm types, which is a consequence of frequent departures of existing farms and the inclusion of new farms in the survey on an annual basis.

In this study, the DEA method was used for the first time to evaluate the technical efficiency of Croatian livestock farms using the FADN dataset. Moreover, the obtained results were compared with those for Hungarian farms. The FADN survey and the possibilities of using the data collected through this system in scientific and professional studies are underused in Croatia by agricultural policy makers and the research community. Therefore, in addition to the stated aim of this paper, we also have the following objectives:

- to raise awareness among policymakers about the potential and usability of FADN data,
- to promote greater use of the FADN dataset for scientific and professional research, and
- to encourage researchers to conduct further studies related to the assessment of farm efficiency and critical factors influencing it.

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