Technical and scale efficiency of corporate farms in Slovakia

Technická efektívnosť a efektívnosť z rozsahu korporatívnych poľnohospodárskych podnikov na Slovensku

P. FANDEL

Slovak University of Agriculture, Nitra, Slovak Republic

Abstract: The paper presents results of the analysis of technical and scale efficiency of 1 147 Slovak corporate farms (agricultural co-operatives and commercial farming companies) in 2000. The objective of the analysis was to examine efficiency differences among four size groups of farms. In the analysis, partial performance measures as well as complex efficiency measures – technical efficiency and scale efficiency – have been used. A nonparametric DEA approach has been applied to estimate technical efficiency measures. Significance of the impact of the farm size on efficiency measures has been tested by ANOVA. Analysis results show that from the aspect of technical efficiency the best performance is achieved by farms of the size group bellow 100 ha, and above 1 000 ha. Scale efficiency grows with the farms size and the highest scores are of farms of the size 500–1 000 ha and farms above 1 000 ha. All efficiency differences among farm size groups are statistically significant as regards all three efficiency measures.

Keywords: corporate farms, technical efficiency, scale efficiency, data envelopment analysis

Abstrakt: V článku prezentujeme výsledky analýzy technickej efektívnosti a efektívnosti z rozsahu 1 147 slovenských korporatívnych poľnohospodárskych podnikov (družstvá a obchodné spoločnosti) v roku 2000. Cieľom analýzy bolo zistiť či existujú rozdiely v efektívnosti medzi štyrmi veľkostnými skupinami podnikov. V práci boli použité tak parciálne, ako aj komplexné miery technickej efektívnosti a efektívnosti z rozsahu. K odhadu mier technickej efektívnosti bola použitá analýza dátových obalov. Významnosť vplyvu veľkosti podnikov bola testovaná analýzou rozptylu. Výsledky analýzy ukazujú, že z hľadiska technickej efektívnosti najvyššiu výkonnosť dosahujú podniky veľkostnej skupiny pod 100 ha a nad 1 000 ha. Efektívnosť z rozsahu rastie s veľkosťou podniku. Najvyššiu efektívnosť dosahujú podniky veľkostnej skupiny 500–1 000 ha a podniky nad 1 000 ha. Rozdiely v efektívnosti medzi veľkostnými skupinami podnikov sú štatisticky významné u všetkých skúmaných mier efektívnosti.

Kľúčové slová: korporatívne poľnohospodárske podniky, technická efektívnosť, efektívnosť z rozsahu, analýza dátových obalov

INTRODUCTION

Within the last 12 years, agriculture of Slovakia passed a period of significant changes. One of the most principal changes of the current agriculture is the change in the size structure of agricultural enterprises. It was caused by several factors. On the one hand, large-scale co-operative farms were transformed and state farms were privatised. As a result of this process, a number of smaller co-operative farms emerged by splitting of the pre-transformation co-operatives. A number of commercial companies are successors of privatised state farms or of the co-operatives.

On the other hand, new production units emerged. These *de novo* farms are typically family farms or small-scale companies operating on own and/or leased land.

Except legal and organisational factors of the change in size structure, of course there was a factor of increasing competitive pressure. The development in the number and average farms size is shown in Table 1.

As it is evident from the Table 1, state farms, which controlled 15% of land in 1989, have virtually disappeared. The share of agricultural co-operatives declined from 69% of land in 1989 to 46% in 2001.

A new category of corporate farms has emerged since 1992. These are so-called private business or commercial companies, whose share in agricultural land increased from zero before 1992 to 30% in 2001. The new private farming companies absorbed virtually all the land of the former state farms (15%) plus some of the land from agricultural co-operatives (10%). Another 5% of agricultural land shifted from co-operatives to individual farms (and public users).

Changes in the organisational structure of agriculture were also accompanied by substantial changes in the average size of corporate farms. The average co-operative today is by 40% smaller than in 1989 (Table 1). The average private farming company, at 1 100 hectares, is about 2/3 the size of the average co-operative (although there is a considerable variability of sizes among farms in

Table 1. Changing structure of the corporate sector 1989–2000

	Agricultural co-operatives			Private companies			State farms		
	No.	average size (ha)	(%) [1]	No.	average size (ha)	(%) [1]	No.	average size (ha)	(%) [1]
1989	631	2 642	68.6	–	–	–	70	5 099	14.8
1990	680	2 473	69.1	–	–	–	73	5 135	15.2
1996	977	1 509	60.3	394	1 173	18.9	49	2 205	4.4
1999	799	1 537	50.2	583	1 125	26.8	2	3 071	0.2
2000	774	1 547	47.7	647	1 113	29.5	–	–	0.0
2001	695	1 620	46.2	707	1 030	29.8	–	–	0.0

[1]In percent of 2.4 million hectares agricultural land
Source: VÚEPP Bratislava

this category, with joint-stock companies nearly twice as large as limited-liability companies). It should be noted, however, that at 1 000–1 500 hectares, the average corporate farm in Slovakia is larger than corporate farms in the neighbouring transition countries and certainly much larger than the fully commercial farms in market economies.

Table 2 shows increase in the number of commercial companies during the monitored period as well as their increasing percentage share in the agricultural land. Average size of commercial companies in last 4 years slightly decreases.

One of the major questions within above context is whether large-scale corporate farms perform better than small ones. This is a traditional question about the "optimal farm size" and "optimal farm structure", which has a long history in agricultural economics in general, and in transitional economics in particular.

There are a number of studies investigating impact of legal, organisational, and farm size structure on performance based on individual data. The most comprehensive study in this respect is the one carried by Macours and Swinnen (2000) using production function. Their calculation indicates positive impact of farm restructuring on productivity. There are a limited number of farm-level studies focused primarily on the impact of farm size and organisational form on efficiency. In this respect, it is possible to refer to Thiele and Brodersen (1999) and Mathijs and Swinnen (2001) for eastern Germany, Piesse and Thirtle (2000) for Hungary, Mathijs and Vranken (2002) for Bulgaria, Czech Republic, Hungary and Slovakia, Tritten and Sarris (2001) for Albania, Czech Republic and Slovakia, Sojková (2001) for Slovakia, Mathijs, Blaas and Doucha (1999) for Czech Republic and Slovakia, and Latruffe et al. for Poland (2000a, b).

The following part of the paper presents an empirical analysis of performance based on individual farm data. The objective of the paper is to contribute to the empirical evidence of farm efficiency by studying of the efficiency of corporate farms in Slovakia. The paper investigates the technical and scale efficiency of Slovak corporate farms by applying Data Envelopment Analy-

Table 2. Development of the number and average size of the commercial farming companies (1995–2001)

Subject		No.	Average size (ha)	Share in the total agricultural land (%)
Public trade companies	1995	1	N/A	N/A
	1997	3	443	0.10
	1998	7	399	0.11
	1999	4	203	0.03
	2001	3	233	0.03
Limited liability companies	1995	98	650	2.91
	1997	415	1 044	17.70
	1998	451	1 015	18.73
	1999	495	998	20.21
	2001	616	899	22.69
Joint stock companies	1995	29	1 271	1.68
	1997	67	1 950	5.30
	1998	71	2 113	6.14
	1999	84	1 914	6.58
	2001	88	1 974	7.12

Source: Green Report 2000, 2001, 2002

sis (DEA). The main focus of the study is on efficiency variation according to farm size and partially organisational form of farms.

The paper is structured as follows. The next section details the methodology, and the third section describes the used data. Section four presents the results and section five summarises conclusions.

METHODOLOGY

As a basic category for efficiency measurement, we elected Farrell measures of technical efficiency (TE). They are one of the most used performance indicators in the recent empirical analyses. In the study, we applied a non-parametric method based on application of mathematical programming known as Data Envelopment Analysis (DEA).

For the calculation of technical efficiency measures assuming constant returns to scale (CRS), we applied model of Charnes, Cooper and Rhodes (1978) and assuming variable returns to scale (VRS) we used model of Banker, Charnes, Cooper (1984). According to both models, a farm is efficient if TE = 1. Technical efficiency score less than one indicates to what extend a farm should equiproportionally reduce inputs to be able to produce its level of output as efficient as technically efficient farms.

A farm is said to display *total technical efficiency* (TE_{CRS}) if it produces on the boundary of the production possibility set, i.e. it maximises output with given inputs and after having chosen technology. This boundary or frontier is defined as the best practice observed assuming constant returns to scale. While total technical efficiency can be further decomposed into *pure technical efficiency* (TE_{VRS}) and *scale efficiency* (SE), we focus on the former as only this way small farms can be compared to large farms (Coelli et al. 1998).

For the calculation of the scale efficiency (SE), we applied the methodology suggested by Coelli et al. (1998). Calculation of SE itself assumes the calculation of TE measures under both CRS and VRS. If there is a difference between scores of technical efficiency under CRS and VRS for a certain farm, the difference indicates that a farm is scale inefficient. Scale efficiency measure can be calculated by dividing the total technical efficiency by pure technical efficiency:

$$SE = TE_{CRS}/TE_{VRS}$$

Scale efficiency can be interpreted as follows:

– If SE = 1, then a farm is scale efficient, i.e. its combination of inputs and outputs is efficient both under CRS and VRS.

– If SE < 1, then combination of inputs and outputs is not scale efficient.

The above described approach does not allow to identify whether a farm operates under increasing returns to scale (IRS) or decreasing returns to scale (DRS). This problem can be solved by application of a further DEA model under the non-increasing returns to scale (NIRS). Scale efficiency is then derived according to following rules (Färe, Grosskopf, Lovell 1994; Lothgren, Tambour, 1996):

– If $\frac{TE_{CRS}}{TE_{NIRS}} = 1$, then a farm operates under increasing returns to scale. It means that a farm is scale inefficient because to its possibilities it can achieve bigger output.

– If $\frac{TE_{CRS}}{TE_{NIRS}} < 1$, then a farm operates under decreasing returns to scale and inefficiency is caused by a too big output.

Formal notation of used DEA models is as follows.

$$\min_{\theta,\lambda,s+,s-} \quad z_i = \theta - \varepsilon \times \mathbf{1}'s^+ - \varepsilon \times \mathbf{1}'s^-$$

subject to

$$Y\lambda - s^+ = Y_i$$

$$\theta X_i - X\lambda - s^- = 0$$

$$\lambda,\ s^+,\ s^- \geq 0$$

and additional scale constraints:

a) $\lambda \geq 0$ in CRS program

b) $\mathbf{1}'\lambda = 1$ in VRS program

c) $\mathbf{1}'\lambda \leq 1$ in NIRS program

where θ is a measure of technical efficiency (TE), $Y_i = (y_1, ..., y_m)$ is an output vector, $X_i = (x_1, ..., x_k)$ is an input vector, Y is $(n \times m)$ matrix of m outputs of the each of n investigated farms and X is $(n \times k)$ matrix of k inputs of the each of n investigated farms and $\mathbf{1}' = (1, ..., 1)$ is a row vector. In the program (1) s^+ is m × 1 vector of slacks which represent output deficits, s^- is k × 1 vector of slacks representing excess of inputs and $\mathbf{1}' = (1, ..., 1)$ is a row sum-up vector of the appropriate dimension $(1 \times m$, or $1 \times k)$. Index i shows the evaluated farm and λ is a vector of k intensities that characterise each farm. A farm is efficient only if and only if following constraints are satisfied:

1. $\theta^* = 1$
2. all slack variables s^+ and s^- equals zero.

In the second phase of the analysis, significance of the impact of the farm size on efficiency measures has been tested by ANOVA.

DATA USED

The study employed data from the annual survey of a sample of individual farms carried by the Slovak Research Institute of Agricultural and Food Economics . The analysis was performed on data from year 2000. The used data set covered 1 147 corporate farms; in that number there were 438 commercial farming companies and 709 agricultural co-operatives.

For the calculation of technical efficiency we defined following variables:

Output variable:
Value of gross output (VGO)

Input variables:
1. Materials and energy (ME)
2. Contracted services (CS)
3. Costs of labour (CL)
4. Total assets (TA)

Selection of the variables was led by a criterion that they should be such categories that represent real inputs into production. Another criterion was that all variables should have positive values what is one of the requirements of DEA. All the selected variables meet the criteria.

In the statistical analysis, we used another two variables: (1) legal form of a farm, (2) size of a farm expressed in total cultivated land

In Tables 3–5, we present summary statistics of used data. In Table 3 we show summary statistics of all output and input variables. In Table 4, we present summary statistics of all variables with respect to legal form of a farm and in Table 5, we show descriptive statistics of output and input variables with respect to size groups of farms.

From the Table 4, it is evident that commercial companies are in average smaller than co-operatives. There is a considerable variability of sizes among farms in both categories. The same applies also for other variables. Absolute values of Table 5 show significant differences among the size groups of farms. Output variable "Value of gross output" has its greatest values in the size group "above 1 000 ha" and surprisingly in the group "up to 100 ha". Input variables have their lowest values in the second and third size groups.

More illustrative picture provides Table 6 where relative partial performance measures are presented. The best results are achieved farms up to 100 ha. In contrary, the worst results are in farm groups of "500–1 000 ha" and "above 1 000 ha". With respect to legal form of a farm, commercial farming companies perform better than agricultural co-operatives in most of partial performance indicators.

All partial measures provide only partial view on performance. Application of DEA methodology enables to examine impact of all inputs on outputs and thus is more complex. In the next section of the paper, we present results of analysis done by DEA and ANOVA.

EFFICIENCY ANALYSIS RESULTS

In the first phase of the analysis, technical efficiency measures for all farms were calculated. In total, 3 441 linear programs were calculated of which 1 147 under CRS,

Table 3. Summary statistics of input and output variables

Variable	Mean	Standard deviation	Minimum	Maximum
Value of gross output (1 000 SKK)	30 588.79	39 717.47	35	340 511
Materials and energy (1 000 SKK)	19 069.05	25 273.83	59	251 258
Contracted services (1 000 SKK)	4 583.30	5 218.97	17	48 981
Costs of labour (1 000 SKK)	7 557.64	7 948.06	8	69 033
Total assets (1 000 SKK)	63 844.51	72 227.00	251	571 675

Table 4. Summary statistics of all variables with respect to the legal form of a farm

Variable	Legal form	Mean	Standard deviation	Minimum	Maximum
Total cultivated land (ha)	CFC	1 351.47	1 564.06	1	10 810
	AC	1 612.93	1 098.81	26	6 950
Value of gross output (1 000 SKK)	CFC	27 353.76	42 289.35	61	317 915
	AC	32 587.30	37 934.81	35	340 511
Materials and energy (1 000 SKK)	CFC	17 909.73	29 280.78	156	251 258
	AC	19 785.25	22 436.54	59	191 002
Contracted services (1 000 SKK]	CFC	5 077.20	6 411.37	17	48 981
	AC	4 278.19	4 297.92	82	29 712
Costs of labour (1 000 SKK)	CFC	5 633.97	7 707.24	8	52 081
	AC	8 746.03	7 866.65	60	69 033
Total assets (1 000 SKK)	CFC	44 240.98	69 799.24	260	460 252
	AC	75 955.01	71 079.65	251	571 675

Number of Commercial Farming Companies (CFC): 438, Number of Agricultural Co-operatives (AC): 709

Table 5. Summary statistics of input and output variables with respect to size groups of farms

Variable	Size group (ha)	Mean	Standard deviation	Minimum	Maximum	Number of farms
Value of gross output	>100	18 024.63	41 631.17	61	175 897	38
(1 000 SKK)	101–500	8 797.52	26 259.94	43	317 915	159
	501–1 000	13 575.63	18 858.87	35	231 051	286
	1 001<	43 854.74	43 458.84	1 392	340 511	664
Materials and energy	>100	11 810.66	29 189.44	59	118 326	38
(1 000 SKK)	101–500	5 389.75	20 039.70	81	251 258	159
	501–1 000	8621.13	13540.93	314	171421	286
	1 001<	27 260.22	26 830.25	2 242	196 233	664
Contracted services	>100	2 006.76	3 674.16	39	20 207	38
(1 000 SKK)	101–500	1 887.18	3 321.11	17	27 574	159
	501–1 000	2 384.05	2 046.54	165	18 574	286
	1 001<	6 323.63	5 886.82	258	48 981	664
Costs of labour	>100	2 349.79	4 269.85	15	19 531	38
(1 000 SKK)	101–500	1 902.26	2 679.07	8	18 577	159
	501–1 000	3 499.28	2 704.35	19	24 636	286
	1 001<	10 957.94	8 684.00	294	69 033	664
Total assets	>100	28 797.16	61 132.29	260	288 780	38
(1 000 SKK)	101–500	15 879.53	22 819.30	251	149 383	159
	501–1 000	27 722.45	28 899.57	1 032	322 958	286
	1 001<	92 894.42	79 343.16	4 450	571 675	664

Table 6. Partial performance measures with respect to size groups of farms and legal form of farms

Size group (ha)	VGO per ha of land (1 000 SKK)	VGO per worker (1 000 SKK)	VGO per 1 SKK of ME (SKK)	VGO per 1 SKK of CS (SKK)	VGO per L 1 SKK of C (SKK)	VGO per 1 SKK TA (SKK)
>100	4 669.11	589.15	2.19	6.71	6.61	0.88
101–500	535.02	29.24	1.71	6.59	4.47	0.66
501–1000	509.35	17.86	1.55	5.96	5.03	0.61
1001<	473.75	19.78	1.58	7.25	4.16	0.54
CFC	423.45	686.14	1.62	5.19	7.20	0.81
AC	20.94	376.82	1.60	7.35	3.31	0.44

1 147 under VRS, and 1 147 under NIRS. Consequently, scale efficiency was calculated. Summary statistics of calculated efficiency measures is presented in Table 7.

For all of the three efficiencies, the maximum measure found within the sample is unity. The percentage of efficient farms represents the share of farms with an efficiency measure of unity. Minimum and maximum values of efficiency score show considerable variability among farms. Mean total technical efficiency for all farms is 0.583. It means that farms can reduce their inputs by

Table 7. Summary statistics of efficiency measures

	Total technical efficiency (TE_{CRS})	Pure technical efficiency (TE_{VRS})	Scale efficiency (SE)
Mean	0.583	0.623	0.940
Standard deviation	0.184	0.195	0.105
Minimum	0.005	0.022	0.057
Maximum	1.000	1.000	1.000
Share of farms fully efficient (%)	2.01	3.84	5.49

Table 8. Summary statistics of efficiency measures with respect to legal form of farms

	Legal form	Total technical efficiency (TE_{CRS})	Pure technical efficiency (TE_{VRS})	Scale efficiency (SE)
Mean	CFC	0.593	0.634	0.938
	AC	0.577	0.616	0.942
Standard deviation	CFC	0.201	0.208	0.111
	AC	0.172	0.187	0.100
Minimum	CFC	0.013	0.022	0.098
	AC	0.005	0.048	0.057
Maximum	CFC	1.000	1.000	1.000
	AC	1.000	1.000	1.000
Share of farms fully efficient (%)	CFC	1.74	2.53	2.79
	AC	0.26	1.31	2.70

Table 9. Summary statistics of efficiency measures with respect to size groups of farms

	Size group (ha)	Total technical efficiency (TE_{CRS})	Pure technical efficiency (TE_{VRS})	Scale efficiency (SE)
Mean	>100	0.670	0.764	0.865
	101–500	0.535	0.601	0.891
	501–1 000	0.564	0.579	0.963
	1 001<	0.599	0.638	0.947
Standard deviation	>100	0.280	0.252	0.208
	101–500	0.203	0.199	0.176
	501–1 000	0.200	0.198	0.086
	1 001<	0.160	0.183	0.069
Minimum	>100	0.028	0.196	0.098
	101–500	0.044	0.128	0.060
	501–1 000	0.005	0.022	0.057
	1 001<	0.148	0.160	0.526
Maximum	>100	1.000	1.000	1.000
	101–500	1.000	1.000	1.000
	501–1 000	1.000	1.000	1.000
	1 001<	1.000	1.000	1.000

41.7% and still produce the same level of output. When adjusted for firm size, it is clear that many farms have a higher level of (pure) technical efficiency, 0.623, but are not of the correct size of operation to ensure maximum total efficiency. The scale efficiency level of 0.940 indicates that the average farm is 6% scale inefficient. These results also show that if the scale of the farms is taken out, 5.49% are fully efficient rather than 2.01, 3.84 respectively, implying that if they were size-adjusted, technical efficiency could increase. The low pure technical efficiency in comparison to scale efficiency suggests that inefficiencies are mostly due to inefficient management practices.

Comparison of efficiency measures with respect to legal form of farm (Table 8) shows that in average commercial farming companies are more efficient than agricultural co-operatives as regards total (0.593) and pure technical efficiency (0.634). Co-operatives are in contrary more scale efficient (0.891) than commercial farming companies. However, *t*-test conducted for each efficiency measure showed that there is no statistically significant impact of legal form on efficiency at 0.01 level.

In the further analysis, we investigated size-efficiency relationship. Table 9 describes the relationship with respect to 4 size intervals. The most efficient farms were the smallest and the largest. Figure 1 depicts the total and pure efficiency scores and both have the curve of shallow U-shape. Turning to the scale efficiency, the smallest farms were in average the least efficient and the largest farms the most efficient.

ANOVA analysis for each farm size group was conducted and showed that farm size had a statistically significant impact on efficiency at 1 per cent level. Comparison of the total technical efficiency scores suggests that farms of the size group 101–500 ha are 20%, farms of 501–

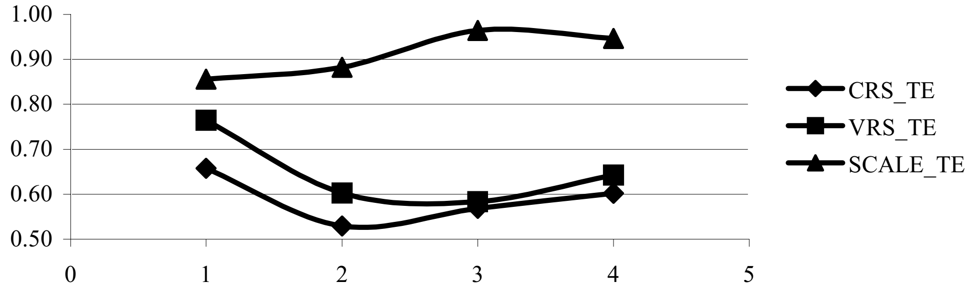

Figure 1. Total, pure, and scale efficiency with respect to farm size groups

1 000 ha are 16%, and farms above 1 000 ha are 11% less efficient than farms under 100 ha, which are in average the most efficient. Farms under 100 ha are also the best pure efficient farms. They are by 25% more efficient than farms of 101–500 ha, by 19% more efficient than farms of 501–1 000 ha, and by 12% more efficient than farms above 1001 ha. The highest scale efficiency score was achieved by farms of 501–1 000 ha. Farms under 100 ha are by 10%, farms of 101–500 ha are by 7%, and farms above 1 001 ha are by 2% less efficient than farms of 501–1 000 ha. Mean efficiency scores were analysed by ANOVA and in post hoc analysis examined with respect to size groups by Duncan test. Test results show that there are significant differences between total technical efficiency of farms under 100 ha and all other size groups at 1% level. Comparison of pure technical and scale efficiency measures with respect to size groups is presented in Table 10.

We received interesting results in two factors ANOVA post hoc analysis with respect to legal form and size group of farms. As it is evident from Table 11, there is not significant difference between the mean total efficiency scores of the same size farms of the two examined legal forms. It just confirms the conclusion mentioned above. There are significant differences between some size groups within the same legal form as well as between farm size groups of the two legal forms. In both legal forms, the most efficient (total and scale TE) farms are those under 100 ha and farms above 1 000 ha. In both legal form samples, the most scale efficient farms are those of 500–1 000 ha and above 1 000 ha. They are significantly better that farms of the smaller two size groups at 1% level.

More detailed analysis of scale economy (Table 12) shows that the highest share of scale efficient farms is in the group under 100 ha, 21%, and lowest share in the size group above 1 000 ha. In the first group, there are 63% of farms that have increasing returns to scale, that is, they are producing too little, and 16% have decreasing returns to scale, that is, they are too big. In the farm size group above 1 000 ha, the ratio is almost opposite: only 9% of farms have increasing returns to scale, that is, they could achieve higher efficiency by increasing of the production scale, and 87%, have decreasing returns to scale, that is, their efficiency could be improved by the decreasing of the production scale.

Table 10. Significance for Duncan post hoc tests with respect to size groups

Size group	>100	101–500	501–1 000	1 001<
Total efficiency (TE_{CRS})	0.670	0.535	0.564	0.599
>100		**	**	**
101–500	**			*
501–1 000	**			
1 001<	**	*		
Pure efficiency (TE_{VRS})	0.764	0.601	0.579	0.638
>100		**	**	**
101–500	**			
501–1 000	**			*
1 001<	**		*	
Scale efficiency (SE)	0.865	0.891	0.962	0.947
>100			**	**
101–500			**	**
501–1 000	**	**		
1 001<	**	**		

*, **: significance at 5%, 1%

Table 11. Significance for Duncan post hoc tests with respect to legal form and size group

Legal form / Size group	{1}	{2}	{3}	{4}	{5}	{6}	{7}	{8}
Total efficiency (TE_{CRS})	0.636	0.514	0.551	0.594	0.679	0.545	0.585	0.610
AC / 1 {1}		**						
AC / 2 {2}	**				**			
AC / 3 {3}					**			
AC / 4 {4}								
CFC / 1 {5}		**	**			**	*	
CFC / 2 {6}					**			
CFC / 3 {7}					*			
CFC / 4 {8}		*						
Pure efficiency (TE_{VRS})	0.765	0.608	0.568	0.633	0.764	0.597	0.599	0.652
AC / 1 {1}		**	**			**	**	*
AC / 2 {2}	**				**			
AC / 3 {3}	**				**			
AC / 4 {4}	**				**			
CFC / 1 {5}			**	**		**	**	*
CFC / 2 {6}	**				**			
CFC / 3 {7}	**				**			
CFC / 4 {8}					*			
Scale efficiency (SE)	0.840	0.856	0.958	0.947	0.871	0.909	0.971	0.946
AC / 1 {1}			**	**		**	**	**
AC / 2 {2}			**	**		*	**	**
AC / 3 {3}	**	**						
AC / 4 {4}	**	**						
CFC / 1 {5}							**	**
CFC / 2 {6}	**	*					*	
CFC / 3 {7}	**	**			**	*		
CFC / 4 {8}	**	**			**			

*, **: significance at 5%, 1%

Table 12. Share of farms under CRS (Scale Efficient), IRS and DRS with respect to farm size groups

Size group (ha)	Scale efficient farms (%)	Farms under IRS (%)	Farms under DRS (%)
>100	21.05	63.16	15.79
101–500	8.18	60.38	31.45
501–1 000	4.55	37.76	57.69
1 001<	4.37	8.73	86.90
All farms	5.49	24.93	69.57

DISCUSSION AND CONCLUSIONS

The results of the analysis of technical and scale efficiency show that there is a considerable variability among farms. On average, commercial farming companies were more technically efficient than agricultural co-operatives. Scale efficiency was high for both legal forms and slightly higher in agricultural co-operatives but *t*-test does not proved significant differences. There is a lot of debate whether there is a clear superiority of one legal/organisational type over others. Several studies done in transition countries show similar results. Results of an analysis performed in Slovakia and the Czech Republic in 1996 by Mathijs et al. (1999) do not give any evidence of differences in the total efficiency between the two types of corporate farms. Using pairwise comparison, Slovak commercial farming companies were found more (total) technically efficient in crop, and crop and dairy production specialisation. On the other hand, co-operatives were more efficient in livestock, and crop and / livestock production specialisation. Czech co-operatives were more efficient in all production specialisations except livestock one. Similar conclusion were found by Mathijs and Vranken (2000) in their empirical research done in Hungary and Bulgaria: "on average, co-operatives are less efficient than private companies, while companies in turn perform worse than family farms".

The primary attention in this study was given to the technical efficiency and scale efficiency of different size groups of farms. Four farm size groups were used: under 100 ha, 101–500 ha, 501–1 000 ha, and above 1 000 ha. The results show that the most (total and pure) technically efficient farms are those under 100 ha. They are in average at least by 12% more total technically and at least by 20% more pure technically efficient than other size groups of farms. Statistical tests proved significant differences at 1% level. Farms of 501–1 000 ha size are in average the most scale efficient. For the comparison, Hughes (1998) reports economies of scale in the Czech Republic up to 750 ha for arable farming. In the analysis of Curtis (2000), done also on Czech data, farms above 150 ha perform on average better than others for wheat and rapeseed production. Morrison (2000) reports for all commodities analysed positive relationship between the scale of production and level of efficiency. In another study, Hughes (2000) reports strong evidence of economies of size in crop production. Best performing farms in Slovakia are those above 2 000 ha, while in Hungary diseconomies of scale appear to set in above 500 ha.

The results presented in this study and findings of similar studies are that there is no uniform, cross-national optimum size. The fact that effective farm can be found in each size category may indicate a preposition that when corporate and also individual farms adopt more professional management approach, country variation can diminish. The programming models allow the separation of pure technical and scale efficiency and thus provide special view on the factors, which are central to the transformation programmes in agriculture.

REFERENCES

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): 1078–1092.

Charnes A., Cooper W., Rhodes E. (1978): Measuring the efficiency of decision making units. European Journal of Operations Research, *2*: 429–444.

Coelli T., Rao D.S. Prasada, Battese G.E. (1998): An introduction to efficiency and productivity analysis. Boston, Kluwer.

Färe R., Grosskopf S., Lovell C.A.K. (1994): Production frontiers. London, Cambridge University Press.

Hughes G. (1998): Agricultural productivity and farm structure in the Czech Republic. Paper 2/7 of EU FAIR project: Agricultural Implication of CEEC Accession to the EU. Wye College, University of London.

Hughes G. (2000): Total productivity of emergent farm structures in Central and Eastern Europe. In: Banse M., Tangerman S. (eds.): Central and Eastern European agriculture in an expanding European Union. Walingford: CABI Publishing: 61–87.

Latruffe L., Balcombe K., Davidova S., Zawalinska K. (2002a): Determinants of technical efficiency of crop and livestock farms in Poland. Working Paper 02-05, Aug., INRA – Unité ESR, Rennes Cédex.

Latruffe L., Balcombe K., Davidova S., Zawalinska K. (2002b): Technical and scale efficiency of crop and livestock farms in Poland: Does specialisation matter? Working Paper 02-06, Oct., INRA – Unité ESR, Rennes Cédex.

Löthgren M., Tambour M. (1996): Alternative approaches to estimate returns to scale in DEA-model. In: Working Paper No. 90, Stockholm, Stockholm School of Economics.

Macours K., Swinnen J. (2000): Causes of output decline in economic transition: The case of Central and Eastern European agriculture. Journal of Comparative Economics, *28* (1): 172–206.

Mathijs E., Blaas G., Doucha T. (1999): Organisational form and technical efficiency of Czech and Slovak farms. MOCT-MOST: Economic Policy in Transition Economies, *9* (3): 331–344.

Mathijs E., Swinnen J.F.M. (2001): Production organisation and efficiency during transition: The case of East German agriculture. Review of Economics and Statistics, *83*: 100–107.

Mathijs E., Vranken L. (2000): Farm restructuring and efficiency in transition: Evidence from Bulgaria and Hungary. Selected paper, 2000 Annual Meeting American Agricultural Economics Association, Tampa FL, USA, July 30–August 2.

Piesse J., Thirtle C. (2000): A stochastic frontier approach to firm level efficiency, technological change, and productivity during the early transition in Hungary. Journal of Comparative Economics, *28*: 473–501.

Sojková Z. (2001): Assessment of cooperatives efficiency using stochastic parametric approach. Agricultural Economics – Czech., *47* (8): 361–364.

Thiele H., Brodersen C. (1999): Differences in farm efficiency in West and East Germany. European Review of Agricultural Economics, *26* (3): 331–347.

Tritten C., Sarris A. (2001): Agrarian production organization under transition to a market economy in Albania. The Czech and Slovak Republics, Working paper WP1, Katholieke Universiteit Leuven, http://www.agr.kuleuven.ac.be/aee/clo/ace97/WP1.doc.

Arrived on 7th July 2003

Contact address:

Doc. Ing. Peter Fandel, CSc., Slovenská poľnohospodárska univerzita v Nitre, Tr. A. Hlinku 2, 949 01 Nitra, Slovenská republika, tel.: +421 376 508 176, fax: +421 376 511 589, e-mail: Peter.Fandel@uniag.sk