Scale efficiency of agricultural enterprises in Slovakia

Efektívnosť z rozsahu poľnohospodárskych podnikov na Slovensku

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Abstract: The scale efficiency enables to measure technical relationship between farm size and efficient land using as a basic production factor according to its different allocation. The research has been done on a selected sample of agricultural enterprises in the Slovak Republic. A non-parametric data envelopment analysis approach has allowed investigating the differences in efficiency among various size groups of 110 agricultural enterprises. The research has proved that about 10 per cent of the analysed farms were operating during the analysed period at the optimal scale, 77 per cent at the above optimal scale and 13 per cent of the farms could increase the efficiency by increasing their acreage of agricultural land.

Key words: data envelopment analysis, technical efficiency, scale efficiency, size of farm

Abstrakt: Efektívnosť z rozsahu je parametrom umožňujúcim merať technický vzťah medzi veľkosťou podniku a výsledkom efektívneho využitia pôdy ako základného výrobného faktora vo väzbe na rozsah jej diferencovanej alokácie. Výskum sa uskutočnil na vybranej vzorke poľnohospodárskych podnikov v Slovenskej republike. Neparametrická metóda analýzy dátových obalov (Data Envelopment Analysis) umožnila na vzorke 110 poľnohospodárskych podnikov preskúmať rozdiely v dosiahnutej efektívnosti v rozdielnych veľkostných skupinách podnikov. Výskum potvrdil, že v skúmanom období asi 10 percent sledovaných podnikov hospodárilo na optimálnej výmere, 77 percent podnikov hospodárilo na výmere vyššej ako optimálnej a 13 percent podnikov by mohlo zvýšiť svoju efektívnosť zvýšením ich výmery poľnohospodárskej pôdy.

Kľúčové slová: analýza dátových obalov, technická efektívnosť, efektívnosť z rozsahu, veľkosť podniku

INTRODUCTION

The question about optimal farm size has a long history in agricultural economics. Numerous authors have been analysing the relationship between farm size and efficiency (Bielik, Pokrivčák, Jančíková, Beňo 2002; Fandel 2002; Hughes 2000...).

In general, an increase in firm size first leads to higher marginal returns and lower marginal costs. However, beyond a certain size, marginal returns will decrease and marginal costs will rise (but not necessarily simultaneously). Optimal size is reached when marginal returns equal marginal costs. Scale economies are usually a consequence of the better and more efficient use of production factors. As firm size increases, labour and machinery can be better adjusted.

With the help of Data Envelopment Analysis, we try to identify significant differences among various size groups of farms in conditions of agriculture in Slovakia. This methodology was used to estimate the technical efficiency and analyse how much the farm performance could be improved.

METHODOLOGY

We have applied Data Envelopment Analysis (DEA) to ascertain the optimal size of farms. As explained in Färe et al. (1985), DEA constructs, in a non-parametric manner, the convex hull around a set of observations. The distance to this production frontier is then a measure of technical inefficiency. For the calculation of technical efficiency (TE) under the constant returns to scale (CRS), we used, the model suggested by Charnes, Cooper and Rhodes (1978) and assuming variable returns to scale (VRS), we applied model of Banker, Charnes and Cooper (1984). When assuming constant returns to scale, total technical efficiency is estimated, but total technical efficiency can be further decomposed into pure technical efficiency and scale efficiency (SE). To calculate pure technical efficiency, the production technology is assumed to display variable returns to scale. Scale efficiency is then the residual between the total and pure technical efficiency. Calculation of SE itself assumes the calculation of TE measures under both CRS and VRS. If there is a difference between the 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:

$$SE = \frac{TE_{CRS}}{TE_{VRS}}$$

Scale efficiency can be interpreted as follows:

– If SE = 1, then a farm is scale-efficient, its combination of inputs and outputs is efficient both under CRS and VRS
– If SE < 1, then the combination of inputs and outputs is not scale-efficient.

Further, we can also identify whether a farm operates under increasing returns to scale (IRS) or decreasing returns to scale (DRS) by using the DEA model under the non-increasing returns to scale (NIRS).

$$\text{If SE} = \frac{TE_{CRS}}{TE_{NIRS}} = 1$$

then a farm operates under increasing returns to scale

$$\text{If SE} = \frac{TE_{CRS}}{TE_{NIRS}} < 1$$

then a farm operates under decreasing returns to scale.

DATA

The analysis was performed on data from the years 1999–2001. The used data set covered 110 agricultural enterprises; in that number, there were 6 size groups of farms identified. The dynamics of changes of farm sizes nowadays is not very considerable, so the data used in our analysis for the years 1999–2001 correspond with the presence.

For the calculation of technical efficiency, we have chosen one output variable – value of production, and four input variables – costs of production, personnel costs, depreciation and total capital (Table 1). All the selected variables represent real inputs into production and have positive values, which are two basic criteria for the selection of variables. Suitability of the selected variables was endorsed also by the correlation analysis, when the

Table 1. Basic characteristics of output and input variables according to various farm size (thousand SKK)

Average	Size group (ha)	1999	2000	2001
Production	–500	68 293	70 714	90 017
	501–1000	26 914	23 707	27 317
	1 001–1500	37 330	33 463	39 134
	1 501–2000	37 409	33 016	41 986
	2 001–3000	77 236	64 202	78 872
	3 001–	160 814	145 452	166 665
Costs of production	–500	55 906	56 050	72 027
	501–1 000	18 108	17 234	18 694
	1 001–1 500	25 143	24 314	25 710
	1 501–2 000	26 911	24 891	27 641
	2 001–3 000	52 339	47 673	56 915
	3 001–	104 275	103 737	115 137
Personnel costs	–500	9 830	9 524	12 120
	501–1 000	7 075	6 883	7 047
	1 001–1 500	10 063	10 100	10 379
	1 501–2 000	10 435	94 05	11 932
	2 001–3 000	21 734	19 351	20 798
	3 001–	44 740	41 310	43 040
Depreciation	–500	3 381	3 537	3 850
	501–1 000	2 514	2 756	2 750
	1 001–1 500	3 977	3 609	3 675
	1 501–2 000	4 811	4 514	5 525
	2 001–3 000	9 603	8 382	8 261
	3 001–	19 792	17 629	18 506
Total capital	–500	69 828	78 990	88 407
	501–1 000	38 241	36 702	39 574
	1 001–1 500	65 647	80 035	63 633
	1 501–2 000	73 011	78 459	83 358
	2 001–3 000	149 472	135 667	142 748
	3 001–	279 336	263 708	264 067

Source: Own calculations

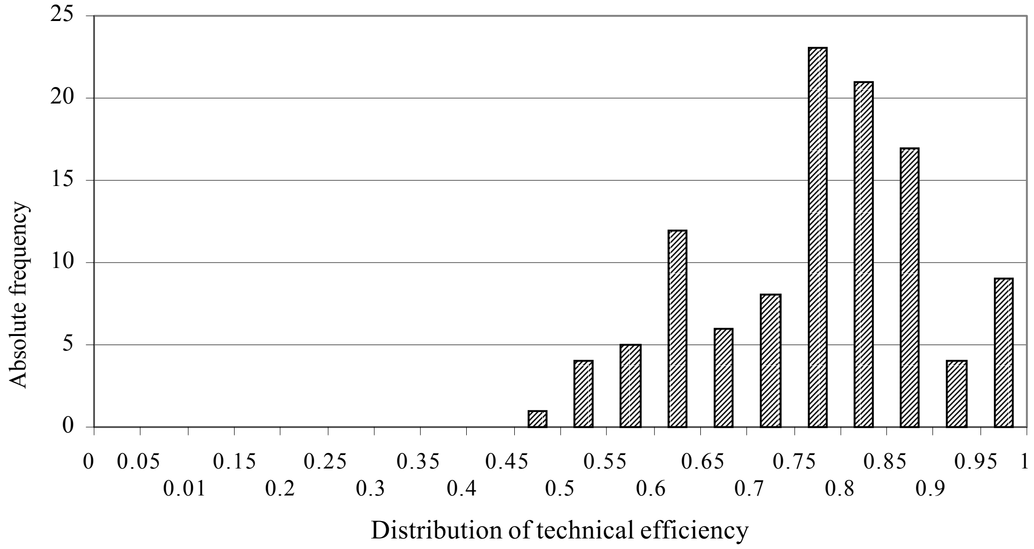

Figure 1. Distribution of the total technical efficiency (CRS-scores in 2001)

Source: Own calculations

output variable strongly correlate with all input variables (r ∈ <0.8258; 0.9797>).

RESULTS

Efficiencies were calculated by the input-oriented Data Envelopment Analysis Model with the assumption of constant (CRS) and variable return to scales (VRS). The distribution of the total technical efficiency (CRS) of Slovak farms is presented in the Figure 1. It shows that the majority of the farms (99 per cent) reach an efficiency level between 45 and 95 per cent. The mean equals 0.825 in 2001, and the standard deviation 0.115. There is also a smaller group of outstanding performers with efficiency values between 0.95 and 1.

In the next section, we have calculated the rate of technical efficiency under variable returns to scale (VRS). As we can see in the Figure 2, about 14 per cent of the sample of agricultural farms in 2001 are identified as technically efficient and operating at the best practice. The average VRS measure of technical efficiency for all farms in the sample is 0.857 and the standard deviation 0.119.

As seen earlier, the scale efficiency of enterprises can be measured by the ratio of constant returns to scale and

Table 2. Summary statistics of efficiency measures

Average	1999	2000	2001
Technical efficiency CRS	0.842	0.733	0.825
Technical efficiency VRS	0.872	0.827	0.857
Scale efficiency	0.966	0.89	0.964

Source: Own calculations

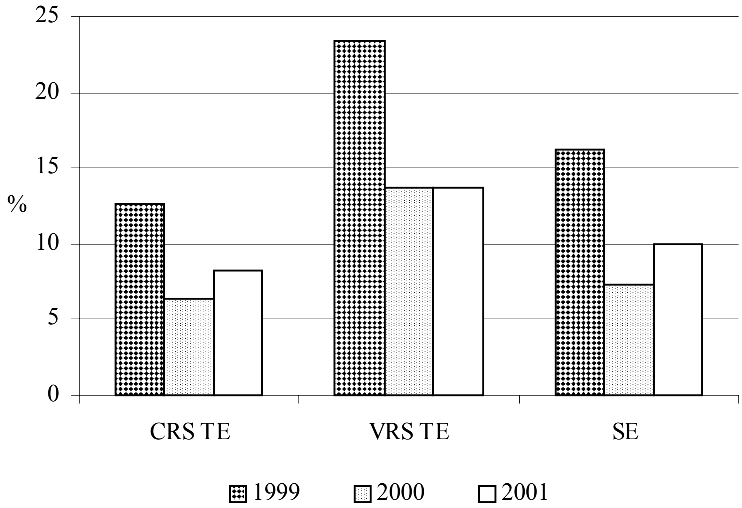

Figure 2. Proportion of efficient enterprises (%)

Source: Own calculations

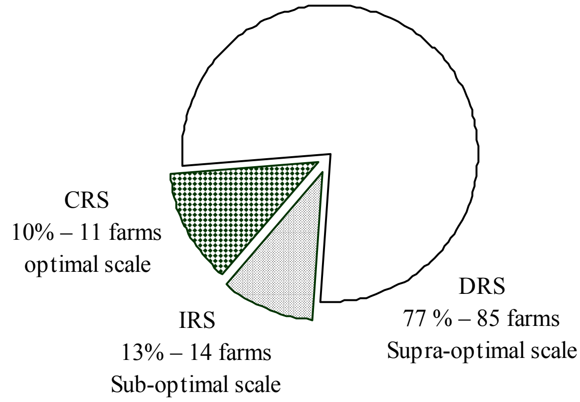

Figure 3. Proportion of efficient and inefficient enterprises

Source: Own calculations

variable returns to scale input measures of technical efficiency. The ratio of unity indicates that the farm is operating at optimal scale. The results of scale efficiency are also summarised in Table 2 and Figure 2. These results show that 10 per cent of enterprises in the sample in 2001 are operating at their optimal scale. In average, scale efficiency is about 0.964 per cent, the standard deviation is 0.115

As seen above, the existence of sub-optimal or supra-optimal scale is identified by the equality or the inequality of the variable returns to scale and the non-increasing returns to scale input measures of technical efficiency. The results of our analysis (Figure 3) show that about 13 per cent of the farms are operating below their optimal scale. This means that these farms could increase their technical efficiency by continuing to increase their size. The results also indicate that 77 per cent of the farms are above their optimal scale and hence could increase their technical efficiency by decreasing their size.

In the next section, we have calculated efficiency measures according to different size groups of farms. Six size groups were recognised: under 500 ha, 501–1 000 ha, 1 001–2 000 ha, 2 001–3 000 ha and above 3 001 ha. As seen in the Table 3, the most technically efficient farms (CRS and VRS) are under 500 ha and farms of 501–1 000 ha size are in average the most scale efficient.

CONCLUSION

In this paper, there are summarised the panel data of 110 Slovak agricultural enterprises. The main attention of this analysis was given to their technical efficiency and scale efficiency of different size groups of farms. Six size groups were recognised: under 500 ha, 501–1 000 ha, 1 001–2 000 ha, 2 001–3 000 ha and above 3 001 ha. The result indicates that the most technically efficient farms (CRS and VRS) are smaller than 500 ha. Curtiss (2000) has made similar analysis for Czech agricultural enterprises were the farms above 150 ha performed in average better than the other groups. In spite of it, according to Hughes (2000), small private farms (up to 10 ha) in Hungary perform remarkably better. Hughes has also investigated

Table 3. Summary statistics of efficiency measures according to various farm size

Average	Size group (ha)	1999	2000	2001
Technical efficiency CRS	–500	0.840	0.775	0.935
	501–1 000	0.873	0.766	0.831
	1 001–1 500	0.875	0.752	0.867
	1 501–2 000	0.743	0.682	0.742
	2 001–3 000	0.803	0.681	0.759
	3 001–	0.858	0.735	0.810
Technical efficiency VRS	–500	0.906	0.937	0.948
	501–1 000	0.894	0.821	0.852
	1 001–1 500	0.888	0.819	0.887
	1 501–2 000	0.774	0.752	0.760
	2 001–3 000	0.822	0.770	0.788
	3 001–	0.905	0.859	0.872
Scale efficiency	–500	0.924	0.830	0.985
	501–1 000	0.971	0.936	0.976
	1 001–1 500	0.984	0.917	0.978
	1 501–2 000	0.959	0.911	0.977
	2 001–3 000	0.978	0.888	0.965
	3 001–	0.950	0.858	0.930

Source: Own calculations

the situation in Slovakia and the result of his analysis indicates that the best performing farms are those over 2 000 ha. As seen in van Zyl et al. (1996), larger private farms (above 15 ha) in Poland are in general less efficient than the other size groups.

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