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Application of multi-faceted efficiency analysis on dairy farms

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Abstract

In Hungary, dairy sector is in a long-term critical period; therefore, it is vital for farm managers to harness the reserves in farming effectively. From side of inputs, mostly the prices of feed and animal health products, and as for outputs the fluctuation of end-product prices influence the profitability of this enterprise.

In this research the multi-faceted efficiency analysis of nine Hungarian dairy farms was made. The chosen method was the output-oriented Data Envelopment Analysis (DEA), because it makes possible to manage multiple decision problems simultaneously. After solving the model, it can be determined why either of the farms is not efficient by use of shadow prices.

Key words: deterministic DEA, efficiency, dairy enterprise, risk

Introduction

The cattle stock of the world has been showing a decreasing tendency year by year; according to FAO data in 2008 1.35 billion heads were registered. The cattle stock of the European Union followed a slightly downward trend. According to the data of EUROSTAT 88 million components were registered in 2008. Within the EU members, the cattle stock is the largest in France (19 million heads), this is followed by Germany with around 13 million heads, than the United Kingdom with the stock of 9.9 million components. The above-mentioned three countries give the half of the European Union's cattle stock. The next group is composed by Ireland, Spain, Italy, Poland, Denmark and the Netherlands. The cattle stock of these countries is around 5 million heads. Hungary's stock is going at around 700 thousand components and thus belongs to the group of Lithuania, Sweden, Portugal, Croatia, Slovakia and Bulgaria.

In Hungary, the agricultural enterprises are partaken by 4 percent from GDP. Within this the bovine sector gives one-fourth of the animal husbandry's GDP. It has the third largest volume after swine and poultry. The cattle stock has decreased by 200 thousand heads in the last 12 years (from 900 thousand to 700 thousand heads). As far as cow stock is concerned, the number of cows has declined by 100 thousand components during 12 years (from 380 thousand to 280 thousand heads). Considering the utilization of the domestic cattle-stock in 2009, 68 percent of it is dairy, 12 percent is for meat production and 20 percent is dual-purpose.

Analysing the milk production per cattle, it can be stated that our country makes a higher than EU-average relative production. If it is analysed by other indices, it is shown that considering the income per one employed, even among the best milk producers' income, it is a little above 60 percent of the famers' average income in the original member states. It has to do with the low labour efficiency. By the national milk producers the cattle for one employed is 11 (livestock-unit), while in the average of EU-15 this value is more than 26.

According to the declaration of the European Commission, in the average of the last four years the milk fat was 3.67 percent, the milk protein content was 3.26 percent. On the contrary, In Germany the average fat content was 4.15%, in France 4.02%, in Poland it was 3.99%, while the protein content also exceeded the

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national average. This makes obviously the attention of Hungarian milk producers to focus on improving the quality parameters of the milk, especially for the fat and protein concentration. For this purpose, the breeding and feeding have to be looked after more carefully. In Hungary, the average number of milking cattle per farms is about 38 heads (Varga, 2010).

The Hungarian dairy farms are behind the Western European farms both in their state of development and in their profitability. Therefore, for the sake of convergence it is worth selecting farms of having the best practice. Comparing the efficient farms to the non-efficient ones, it can be stated which are crucial points to be improved to be more viable on a long term. A suitable method for efficiency analysis is DEA (Data Envelopment Analysis).

Material and methods

The idea of Data Envelopment Analysis (hereinafter DEA) method is originated by Farrel (1957), who wanted to develop a method that is more suitable for measuring productivity. However, in 1978 Charnes et al. reformed this as a mathematical programming problem. This technique is a relatively new "*data-oriented" process*, which can be applied for measuring the performances of decision making units (DMU's) producing from several inputs several outputs (Cooper et al. 2004). Recent years the method of DEA has been used in many applications for performance measurement. It has been used for measuring the efficiency of a service's internal quality (Soteriou-Stavrinides, 2000; Becser, 2008), efficiency measurement of banks (Sherman-Ladino, 1995; Tóth, 1999), of educational (Tibenszkyné 2007) and other public bodies, and also for measuring the efficiency of business parks (Fülöp-Temesi 2000). However, its application in agricultural practice was not significant. The efficiency analysis of animal farms and agricultural production processes can be carried out by simulation methods (Szőke et al. 2009; Kovács-Nagy 2009), however, the quality of available database does not always allow the full mapping of technological processes. In these cases DEA is a more efficient tool.

DEA process has two known approaches: *input-oriented* (cost-oriented) and *output-oriented* (result-oriented). In case of the input-oriented approach it is examined how much and which proportion the inputs should be used to minimize the cost at the same emission level. In the output-oriented approach the partial increase of outputs without changing the quantity of inputs is examined (Farrel 1957; Charnes et al. 1978).

This is complicated by the fact that we must take into consideration at efficiency measurement that not every input benefits in the same way: if one calculates with the intake on the same level one counts with *Constant Return to Scale* (CRS), if not, with *Variable Return to Scale* (VRS) (Cooper et al. 2004).

It is an often arising question on a farm that in the course the operation of enterprise how efficient its units are working. The investment analysts are interested in the efficiency of competing participants within an industrial enterprise. DEA is a linear programming application by which the above-mentioned problems can be solved. In the course of DEA analysis one gets the result that at what efficient level the inputs are transformed into outputs, so it is suitable to find the unit (plant, university, restaurant, etc.) which has the "best-practice" (Albright-Winston 2007). The method of DEA was applied to determine the frontier efficiency by the efficiently operating units (Tofallis 2001; Bunkóczi-Pitlik 1999).

In this DEA model the efficiency of nine dairy farms in the North Great Plain region was examined. For this examination, the output-oriented version of DEA was used. For setting up and solving the model, the farms' production and financial data (for the business year of 2009) were used. The direct costs, the average number of dairy cows and the number of workers as input factors, and the milk production corrigated for 305 days, from the milk quality data the average milk fat and milk protein content and the revenue as outputs were taken into consideration. The aim of the analysis was *to examine the competitiveness* of the farms, and in case of the inefficient farms to explore the critical factors, and to determine the direction of the occurring further analyses.

The examined farms are different in size, technology and also in their ownership. Two farms are owned privately, and the others operate as a company. The smallest farm has 85 cows on an average, and the largest is the one which owns 970 cows. The farms, having more than 300 cows, are considered as large scale farms in Hungary.

Results and discussion

As the first step of the examination, the analysis of the revenues and costs of farms was made. Only the direct costs of the farms were set into the model, and the overheads were left out. When calculating the revenue, the milk quota and the subsidies were not taken into consideration. By the input and output variables in the DEA model those factors can be determined that decreases the efficiency, by which the non-efficient farms can be made competitive.

For the sake of the easier clarity, in the linear programming model the constraints were marked with points, the variables with stripes and the objective function with grey colour. The gotten maximum output values by solving the LP model are in the DEA efficiency column (Figure 1.). On this basis, it can be stated that considering the given input and output constraints the third, fifth and ninth farms are operating inefficiently, (DEA efficiency value is less than 1), and the others are efficient (DEA efficiency value is equal to 1).

Using the shadow prices of the efficient farms as weights such an input and output average vector can be 'made' that regards to a complex, hypothetic farm. The input and output characteristics of this farm can be compared with the current data of non-efficient farms, so the shortcomings and the factors that worse the efficiency can be explored.

	-------- Outputs --------				----- Inputs -----						
Farm code	Milk for 305 days (litre)	Milk protein (%)	Milk fat (%)	Turnover (million Ft)	Direct costs (million Ft)	Number of dairy cows (heads)	Number of workers (heads)	Weighted output	Weighted input	Difference	DEA efficiency
1	8900	3,24	3,65	609,811	604,756	970	42	2,6067	2,6067	0,0000	1,0000
2	8480	3,10	3,41	351,626	359,325	525	16	1,5051	1,5488	-0,0437	1,0000
3	8630	3,27	3,80	359,757	365,896	698	20	1,5404	1,5771	-0,0367	0,9858
4	8600	3,27	3,83	351,291	353,788	535	16	1,5043	1,5249	-0,0206	1,0000
5	6975	3,22	3,40	227,993	269,286	542	22	0,9778	1,1607	-0,1829	0,8430
6	9607	3,21	3,72	353,199	394,761	440	17	1,5123	1,7016	-0,1892	1,0000
7	7843	3,35	3,75	103,613	129,035	146	8	0,4478	0,5562	-0,1084	1,0000
8	7930	3,08	3,38	21,333	22,340	85	6	0,0963	0,0963	0,0000	1,0000
9	8500	3,20	3,91	230,468	232,000	554	26	0,9891	1,0000	-0,0109	0,9891
Weights	0,0000	0,0000	0,0016	0,0043	0,0043	0,0000	0,0000				

	9	
Output	0,9891	← objective function
Input	1,0000	

Figure 1. DEA model that is suitable for undertaking efficiency analysis on dairy farms

Source: Own model by using farm data

After this, the data of inefficient farms were compared to the optimal values, which result is summarised in Table 1.

Table 1. Summary table of the non-efficient farms

Farm code	Name	Milk for 305 days (litre)	Milk protein (%)	Milk fat (%)	Turnover (million Ft)	Direct costs (million Ft)	Number of dairy cows (heads)	Number of workers (heads)
	Original value	8 630	3,27	3,80	359,76	365,90	698	20
3	Optimal value	8 720	3,30	3,80	359,76	360,70	563	20
	Difference	90	0,03	0	0	-5,20	-135	0
	Original value	6 975	3,22	3,40	227,99	269,29	542	22
5	Optimal value	8 490	3,22	3,57	227,99	227,01	396	19
	Difference	1 515	0	0,17	0	-42,27	-146	-3
	Original value	8 500	3,20	3,91	230,47	232,00	554	26
9	Optimal value	9 292	3,53	3,91	230,47	229,48	406	19
	Difference	792	0,33	0	0	-2,52	-148	-7

Source: own calculation

The milk production of Farm 3 should be improved by 70 litres, and the average milk protein content is to be increased by 0.03 percent. Surprisingly, this farm would operate in an efficient way if without decreasing the number of workers, the number of cows would be reduced by 135 heads.

In the case of Farm 5, as for the input factors, the number of dairy cows and the variable costs as well, a lack of balance can be seen compared to the values of the composite farm. The number of dairy cows and the direct costs shall be also cut down. It can be observed that this should be done without reducing the revenue, which presupposes the betterment of milk production and the quantity of milk fat from the quality parameters as well.

At the values of Farm 9, among the output data the quantity of milk production and milk protein must be increased, and beside these, the number of cows and the number of workers should be also decreased by 7 workers.

Conclusions

The aim of this research was to analyse the efficiency of nine dairy farms in Hungary. According to the results, from nine farms only three were operating in an inefficient way, that is to say, that the efficient six farms' rates of outputs and inputs are 100 percent. This means that without changing the quantity of inputs, the partial increase of outputs is adequate.

The above-described data suggest that there are several significant technological, management or animal health problems on these inefficient farms. Generally speaking, by having used the shadow prices it can be stated that at a constant level of revenue, cost-reduction, yield-growth and quality improvement shall also be reached.

The results of the analysis suggest the need for further examinations. For the sake of production results and the improvement of quality considering the animal health and technological factors the proposal solution can be further fined, shaded.

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