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AN INPUT-SPECIFIC ANALYSIS OF THE COST EFFICIENCY ON LITHUANIAN FAMILY FARMS

Irena Krisciukaitiene[1*], Dr; **Tomas Balezentis**[2]; **Alvydas Balezentis**[3], Prof. Dr

[1] Lithuanian Institute of Agrarian Economics

[2] Vilnius University

[3] Mykolas Romeris University

Abstract. The productive technology can be analysed in terms of the technical and economic (cost) efficiency. This paper analyses the performance of the Lithuanian family farms in terms of the economic (cost) efficiency. Specifically, the economic efficiency is decomposed across specific inputs in order to identify the major sources of inefficiency. The livestock farms exhibited the highest overall cost efficiency (65%) and input-specific cost efficiencies. The mixed farms were peculiar with a somehow lower level of the cost efficiency (52%). Finally, the crop farms featured the lowest cost efficiency (42%). The dynamic analysis of the input-specific cost efficiencies was presented in the paper.

Key words: family farms, allocative efficiency, cost efficiency, frontier.

JEL code: C44, C61, Q12.

Introduction

The agricultural efficiency constitutes an important research object due to certain peculiarities of the agricultural sector and the prevailing production processes. Specifically, farming is the most important economic activity in the rural areas and, thus, is supported by the means of the public support. Accordingly, the support measures should meet the dynamic patterns of efficiency in the latter sector. The profitability of farming does also depend on the economic efficiency (Henningsen, 2009). Furthermore, the agricultural sector impacts the welfare of the population through the value added chain of the food products (Samarajeewa et al., 2012).

The productive technology can be analysed in terms of the technical and economic (cost) efficiency. The former one measures farm's ability to transform the certain inputs to outputs; whereas, the latter one involves input price data and, thus, enables to measure the degree to which the observed input-mix meets the structure of the optimal input-mix. The optimal input-mix is constructed by minimising input cost associated with a certain output level (Thanassoulis et al., 2008).

The Lithuanian agricultural sector has already been analysed by the means of the non-parametric frontier methods (Balezentis et al., 2013; Balezentis, 2013; Balezentis, Balezentis, 2013). The previous studies, however, did not analyse the cost efficiency associated with specific inputs. The present study aims at revealing the main sources of the cost inefficiency. The following tasks are thereby set: 1) to discuss the preliminaries for input-specific cost efficiency measurement; and 2) to analyse the dynamics

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[*] Corresponding author. Tel.: + 370 5 262 10 78; fax: +370 5 261 45 24
E-mail address: irena@laei.lt

of the cost efficiency indicators. The research relied on the micro-data for 200 farms reporting to the Farm Accountancy Data Network throughout 2004–2009. The efficiency estimates were obtained by the virtue of the non-parametric data envelopment models. Specifically, the linear programming problems were solved to obtain the optimal input quantities.

Preliminaries

The analysis of efficiency relies on the Koopmans definition of the productive efficiency. In order to relate the concept of efficiency to the structure of production technology, it is useful to introduce some notation and terminology (Fried *et al.*, 2008). Let producers use inputs $x=(x_1,x_2,...,x_m)\in\Re_+^m$ to produce outputs $y=(y_1,y_2,...,y_n)\in\Re_+^n$. Production technology then can be defined in terms of the production set:

$$T=\{(x,y)|x \text{ can produce } y\}. \tag{1}$$

Thus, Koopmans efficiency holds for an input-output bundle $(x,y)\in T$ if, and only if, $(x',y')\notin T$ for $(-x',y')\geq(-x,y)$.

Technology set can also be represented by input requirement and output correspondence sets, respectively:

$$I(y)=\{x|(x,y)\in T\}, \tag{2}$$

$$O(x)=\{y|(x,y)\in T\}. \tag{3}$$

There are two types of efficiency measures, namely, Shepard distance function and Farrel distance function. These functions yield the distance between an observation and the efficiency frontier. Shepard (1953) defined the following input distance function:

$$D_I(x,y)=\max\{\lambda|(x/\lambda,y)\in I(y)\}. \tag{4}$$

Here $D_I(x,y)\geq 1$ for all $x\in I(y)$, and $D_I(x,y)=1$ for $x\in isoI(y)$. The Farrel input-oriented measure of efficiency can be expressed as:

$$TE_I(x,y)=\min\{\theta|(\theta x,y)\in I(y)\}. \tag{5}$$

Comparing Eqs. 4 and 5 one can arrive at the following relation:

$$TE_I(x,y)=1/D_I(x,y), \tag{6}$$

with $TE_I(x,y)\leq 1$ for $x\in I(y)$, and $TE_I(x,y)=1$ for $x\in isoI(y)$.

Farrel (1957) defined the two types of efficiency which are known as technical and economic efficiency. The economic efficiency and its measures were described above. The economic efficiency is divided into cost, revenue, and profit efficiency. A respective frontier is established for each of the three measures. Here one may focus solely on cost efficiency. However, revenue efficiency is a straightforward modification of the cost efficiency.

Assume that producers face input prices $w = (w_1, w_2, ..., w_m) \in \Re^m_{++}$ and seek to minimise cost. Thus, a minimum cost function—cost frontier—is defined as:

$$c(y,w) = \min_x \{ w^T x | D_I(x,y) \geq 1 \} . \qquad (7)$$

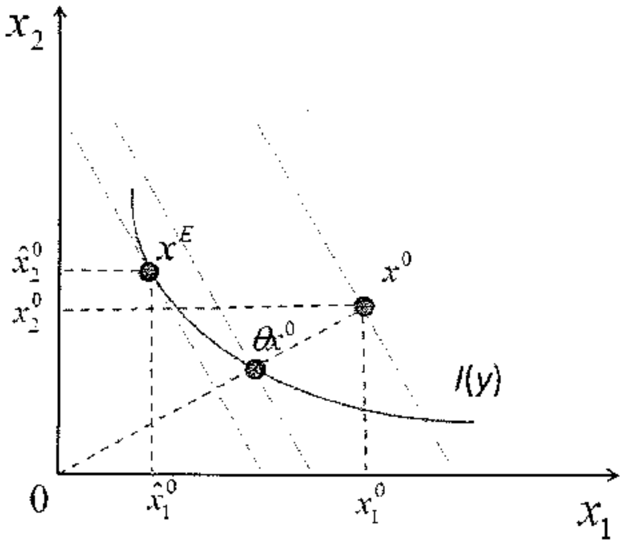
Then, a measure of the cost efficiency (CE) is defined as the ratio of the minimum cost to the actual cost:

$$CE(x,y,w) = c(y,w) / w^T x . \qquad (8)$$

A measure of input-allocative efficiency AE_I is obtained by employing Eqs. 7 and 9:

$$AE_I(x,y,w) = CE(x,y,w) / TE_I(x,y) . \qquad (9)$$

Thus, the cost efficiency can be expressed as a product of technical efficiency and cost allocative efficiency. Figure 1 depicts these measures.



Source: authors' construction

Fig. 1. The concept of cost efficiency

The three lines in Figure 1 represent respective isocosts, namely, $w^T x^E$, $w^T \theta x^0$, and $w^T x^0$ for points x^E, θx^0, and x^0, in that order. Here, the efficient point x^E minimises costs and, thus, defines the cost frontier $c(y,w) = w^T x^E$. The cost efficiency of the point x^0 is then given by ratio $c(y,w)/w^T x^0 = w^T x^E / w^T x^0$ (cf. Eq. 8). The cost efficiency of x^0 can be further decomposed into technical efficiency $\theta^0 = \theta^0 x^0 / x^0 = w^T(\theta^0 x^0)/w^T x^0$ and allocative efficiency determined by the ratio $w^T x^E / w^T(\theta^0 x^0)$.

The cost efficiency can be estimated by employing the non-parametric data envelopment methodology. Suppose that there are $k = 1,2,...,K$ farms, each producing $j = 1,2,...,n$ outputs from

$i = 1,2,...,m$ inputs. Hence, the *t*-th farm ($t = 1,2,...,K$) incurs cost equal to $\sum_{i=1}^{m} w_i^t x_i^t$. The optimal cost can be obtained by implementing the following linear programming problem (Thanassoulis et al., 2008):

$$\begin{aligned} & c(y,w) = \min_{\lambda_k, x_i} \sum_{i=1}^{m} w_i^t x_i \\ & \text{s. t.} \\ & \sum_{k=1}^{K} \lambda_k x_i^k \leq x_i, \quad i = 1,2,...,m \\ & \sum_{k=1}^{K} \lambda_k y_j^k \geq y_j^t, \quad j = 1,2,...,n \\ & \sum_{k=1}^{K} \lambda_k = 1 \end{aligned} \qquad (10)$$

where w_i^t are the input prices for the *t*-th farm. Indeed, this model yields the minimum cost, $c(y,w)$, at the given output level and input prices which can be used to estimate the cost efficiency.

Furthermore, the optimal input quantities, x_i, are obtained with respect to the underlying technologies and input prices. Denoting the input quantities that solve Eq. 10 for the *t*-th farm by $\hat{x}_i^t$, one can define the overall cost efficiency (CE) for the *t*-th farm as:

$$CE^t = \frac{c(y,w)}{\sum_{i=1}^{m} w_i^t x_i^t} \equiv \frac{\sum_{i=1}^{m} w_i^t \hat{x}_i^t}{\sum_{i=1}^{m} w_i^t x_i^t}, \qquad (11)$$

where CE^t approaches unity in case of the cost efficiency and $CE^t < 1$ otherwise. Similarly, the input-specific cost efficiency can be defined as the following ratio:

$$CE_i^t = \frac{\hat{x}_i^t}{x_i^t}, i = 1,2,...,m, \qquad (12)$$

where CE_i^t exceeds (is below) unity in case the farm should increase (reduce) the use of the *i*-th input and equals unity in case the observed input quantity corresponds to the optimal one.

Research results

The utilised agricultural area (UAA) in hectares was chosen as the land input variable, annual work units (AWU) – as the labour input variable, the intermediate consumption in Litas was treated as the variable costs, and total assets in Litas as a capital factor. On the contrary, the three output indicators represent crop, livestock, and other outputs in Litas, respectively. The cost efficiency was estimated by defining respective prices for each of the four inputs described earlier. The land price was obtained from the Eurostat and assumed to be uniform for all farms during the same period. The labour price is the average salary in agricultural sector from the Statistics Lithuania. The price of capital is depreciation plus interests per one Litas of assets. Meanwhile, the intermediate consumption is directly considered as a part of total costs.

The data for 200 farms selected from the FADN sample cover the period of 2004–2009. Thus, a balanced panel of 1200 observations is employed for the analysis. The analysed sample covers relatively large farms (mean UAA – 244 ha). As for labour force, the average was 3.6 AWU. The farms were classified into crop, livestock, and mixed ones. In case the crop (livestock) output constituted at least 2/3 of the total output, the respective farms were treated as the specialised crop (livestock) farms; whereas, the remaining ones were treated as the mixed farms.

The linear programming model given by Eq. 10 was implemented to estimate the optimal input consumption quantities. Subsequently, the input-specific cost efficiencies were derived in the spirit of Eq. 12. The general results are presented in Table 1. As one can note, the livestock farms exhibited the highest overall cost efficiency (65%). The latter farming type was followed by the mixed and crop farms in that order (52% and 42% respectively). An input-specific analysis implied that the UAA was used excessively in the production process. The latter finding might be partially resulted to the research methodology which assumed that all the UAA is owned rather than rented. Anyway, this assumption held for all the observations and, thus, did not affect a particular farming type.

Table 1

The average overall and input-specific cost efficiencies (CE) across different farming types

	Farming types			Weighted average
	Crop	Livestock	Mixed	
Labour CE	0.75	0.93	0.90	0.86
Land CE	0.33	0.51	0.40	0.41
Intermediate consumption CE	0.60	0.88	0.75	0.74
Asset CE	0.80	0.84	0.80	0.82
Overall CE	0.42	0.65	0.52	0.53

Source: authors' calculations

Assets and labour were the two inputs used in the quantities that were closest to the optimal ones. However, the labour input could be reduced in the crop farming (input-specific CE) in order to increase the cost efficiency. The input-specific CE associated with assets virtually did not vary across the farming types (80-84%). In order to analyse the input-specific cost efficiencies across different farming types and time periods, the following Tables 2–5 present the dynamics of the input-specific estimates.

The CE associated with labour input was generally declining during 2004-2009 (cf. Table 2). However, it still remained one of the highest if compared with those associated with the remaining inputs. Specifically, crop farms featured the lowest labour CE which fluctuated in between 70% and 87% during the research period. Livestock and mixed farms featured higher labour efficiencies even though they usually employ higher amounts thereof. Accordingly, the crop farms might require some additional measures aimed at the further modernisation of the agricultural practices.

Table 2

The average cost efficiencies associated with the labour input

Year	Farming types			Weighted average
	Crop	Livestock	Mixed	
2004	0.72	1.00	1.08	0.93
2005	0.74	0.97	0.80	0.84
2006	0.75	0.89	0.86	0.83
2007	0.87	0.95	0.86	0.89
2008	0.75	0.96	0.97	0.89
2009	0.70	0.85	0.86	0.80
Average	0.75	0.93	0.90	0.86

Source: authors' calculations

Land efficiency was the lowest one among the analysed inputs. Indeed, the annual averages were not extremely volatile if compared with those associated with other inputs (Table 3). Whereas, the crop farms maintained their land CE around the average value of 33%, the livestock and mixed farms exhibited decreasing CE. Specifically, land CE dropped from 57% down to 48% with the average of 51% in the livestock farming during 2004-2009. The same trend prevailed in the mixed farming: land CE fell from 47% down to 36% (average – 40%). Therefore, the crop farms exhibited rather stable land CE and the lowest average level; whereas, the remaining farming types featured negative trends of CE alongside with the higher levels.

Table 3

The average cost efficiencies associated with the land input

Year	Farming types			Weighted average
	Crop	Livestock	Mixed	
2004	0.32	0.57	0.47	0.45
2005	0.29	0.57	0.37	0.41
2006	0.24	0.40	0.36	0.33
2007	0.40	0.53	0.42	0.45
2008	0.40	0.55	0.44	0.46
2009	0.31	0.48	0.36	0.38
Average	0.33	0.51	0.40	0.41

Source: authors' calculations

The CE associated with the intermediate consumption was extremely time-variant in the crop and mixed farming (Table 4). Indeed, the technological peculiarities of the cropping induce these fluctuations. The livestock farming managed to somehow increase the latter type of efficiency from 69% in 2004 up to 76% in 2009.

Table 4

The average cost efficiencies associated with the intermediate consumption

Year	Farming types			Weighted
	Crop	Livestock	Mixed	average
2004	0.67	0.69	0.84	0.73
2005	0.55	0.85	0.77	0.72
2006	0.45	0.97	0.67	0.69
2007	0.73	1.07	0.86	0.88
2008	0.70	0.91	0.76	0.79
2009	0.49	0.76	0.65	0.63
Average	0.60	0.88	0.75	0.74

Source: authors' calculations

The asset input was that used in the closest-to-the-optimal quantities (Table 5). The CE associated with the latter input dropped during 2006 and 2009 across all the farming types. These declines can be explained by the fact that interests are paid and the depreciation is incurred at a stable rate and, thus, become excessive during the periods of decreasing agricultural production prices or increasing input prices. The livestock farms exhibited higher average CE (84%) than the initial level (81%); whereas, the remaining farming types featured the decreasing trends in CE.

Table 5

The average cost efficiencies associated with the asset input

Year	Farming types			Weighted
	Crop	Livestock	Mixed	average
2004	0.95	0.81	0.86	0.87
2005	0.80	0.92	0.95	0.89
2006	0.63	0.85	0.84	0.77
2007	0.88	0.90	0.82	0.87
2008	0.89	0.93	0.79	0.87
2009	0.64	0.61	0.61	0.62
Average	0.80	0.84	0.80	0.82

Source: authors' calculations

To sum up, the land and intermediate consumption were the two most problematic inputs in terms of the cost efficiency. On the one hand, these findings do indicate that the yields specific for the Lithuanian agriculture need to be increased given the input consumption remains at a similar level. On the other hand, the farm expansion processes occurred after the accession to the European Union might be related with the certain sunk costs, namely, increased intermediate consumption aimed at land amelioration.

Conclusions

The carried out input-specific cost efficiency analysis implied that the utilised agricultural area was too large given its price and the output levels. Assets and labour were the two inputs used in the quantities that were closest to the optimal ones. However, the labour input could be reduced in the crop farming in order to increase the cost efficiency. The input-specific cost efficiency associated with assets virtually did not vary across the farming types (80-84%).

The livestock farms exhibited the highest overall cost efficiency (65%) and input-specific cost efficiencies. The mixed farms were peculiar with a somehow lower level of the cost efficiency (52%). Finally, the crop farms featured the lowest cost efficiency (42%). However, the crop farming might require certain long- and short-term investments aimed at land amelioration which could reduce the cost efficiency in the short run.

The future studies might attempt to estimate the farm-specific prices of all the inputs involved in the production process and, thus, obtain even more robust results.

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