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Returns to scale in the Lithuanian family farms: A quantitative approach

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The paper analysed the returns to scale and scale elasticity prevailing in the Lithuanian family farms. The analysis was based on the farm-level data. Specifically, the three farming types were considered, viz. crop, livestock, and mixed farming. The non-parametric method, data envelopment analysis, was employed to define the production frontier and compute the estimates of the scale elasticity. The inefficient observations were projected on the production frontier and analysed both in input and output orientations. Meanwhile, the efficient observations were treated in accordance with Banker and Thrall (1992). The results enabled to estimate the most productive scale size for each of the considered farming types. The farm size was expressed both in absolute and relative terms. These estimates, indeed, might provide a momentum for discussions in regard to the farm structure and sustainable agricultural policy in Lithuania.

Key words: family farms, most productive scale size, efficiency, data envelopment analysis

INTRODUCTION

Returns to scale and scale elasticity constitute a fundamental issue for the economic analysis and performance management. Specifically, the analysis of the prevailing returns to scale enables to describe the structure of a certain sector in terms of scale efficiency. Accordingly, various studies attempted to estimate the underlying returns to scale (Growitsch et al., 2009; Atici, Podinovski, 2012). Indeed, the regulated economic sectors feature a particular need for suchlike analyses.

The agricultural sector features a substantial public support as well as some legal regulations related to land acquisition etc. It is, therefore, important to conduct the relevant researches to streamline the aforementioned policies. Furthermore, economies with relatively high importance of the agricultural sector need to develop it as a key economic activity in the rural areas. Noticeably, the Central and East European countries are specific with these circumstances and thus require researches on the agricultural efficiency and productivity (Gorton, Davidova, 2004). Consequently, Thiele and Brodersen (1999) analysed the performance of the West and East German farms with respect to returns to scale. Latruffe et al. (2005) focused on the Polish farms while analysing the technical and scale efficiencies. Vasiliev et al. (2008) conducted a similar analysis on the Estonian grain farms.

The Lithuanian agricultural sector was analysed in terms of the scale efficiency (Vinciūnienė, Rauluškevičienė, 2009), yet the question of the optimal (most productive) farm size in Lithuania needs to be further tackled. This paper thus aims at analysing the scale elasticity specific for the Lithuanian family farms and thus drawing insights on the most productive scale size.

The elasticity of scale can be estimated once the production frontier is established for a technology of interest. This paper employs the data envelopment analysis (DEA), which constitutes a proper tool for analysis of the scale elasticity (Soleimani-Damaneh et al., 2009). Therefore, we follow an axiomatic non-parametric deterministic approach. The axiomatic approach implies that the axioms of the free disposability, convexity, and minimal extrapolation (Afriat, 1972) are respected. The non-parametric approach implies that there are no assumptions on the distribution of the error terms. However, the DEA implicitly assumes the piecewise-linear functional form of the underlying production function. Finally, the deterministic approach means that the whole error term is assumed to arise due to inefficiency. The DEA can be employed in either qualitative or quantitative approach. The qualitative approach (Färe et al., 1983; Grosskopf, 1986) enables to determine what type of returns to scale is specific for a certain decision making unit. The quantitative approach enables to quantify scale elasticity in DEA. The latter analysis can be, in turn, implemented in an indirect or a direct approach. The indirect approach was introduced by Banker and Thrall (1992) and utilized by Førsund and Hjalmarsson (2004), Førsund et al. (2007), Podinovski et al. (2009), Zschille (2012). The direct approach was followed by Krivonozhko et al. (2004) and Førsund et al. (2007). This paper utilises the indirect quantitative approach to determine the most productive scale size of the Lithuanian family farms. A sample of 200 family farms reporting to the Farm Accountancy Data Network during 2004–2009 was used for the analysis.

The paper is organised in the following manner: Section 2 presents the quantitative analysis of scale elasticity by the means of DEA. Section 3 presents the data used for the analysis. Results of the empirical analysis are presented in Section 4.

Preliminaries for the quantitative assessment of RTS

Scale efficiency (SE) is obtained as the ratio of the constant returns to scale (CRS) efficiency score to the variable returns to scale (VRS) efficiency score. Figure 1 depicts the measure of scale efficiency as well as the associated properties of returns to scale. T_{CRS} and T_{VRS} denote the production possibility sets defined under the assumptions of CRS and VRS, respectively. In case of the input orientation the observation A is projected onto the VRS and CRS frontiers at A_{in}^{VRS} and A_{in}^{CRS}, respectively. It is due to Färe et al. (1983) and Grosskopf (1986) that the latter observation would fall in the region of increasing returns to scale (IRS). Clearly, the deviation from the most productive scale size (MPSS) would cause SE falling below unity. In case of the output orientation the observation A is projected onto the VRS and CRS frontiers at A_{out}^{VRS} and A_{out}^{CRS}, respectively. In the spirit of Färe et al. (1983) the latter observation would now be treated as that operating in the region of decreasing returns to scale (DRS). In addition, the SE would also be below unity (after inversion of the output-oriented efficiency scores). Therefore, (i) a certain observation can be considered as operating in different regions of RTS under different orientation of the DEA model, (ii) the SE cannot indicate the exact region of the prevailing RTS. Furthermore, the SE measure cannot render the elasticity of scale measure.

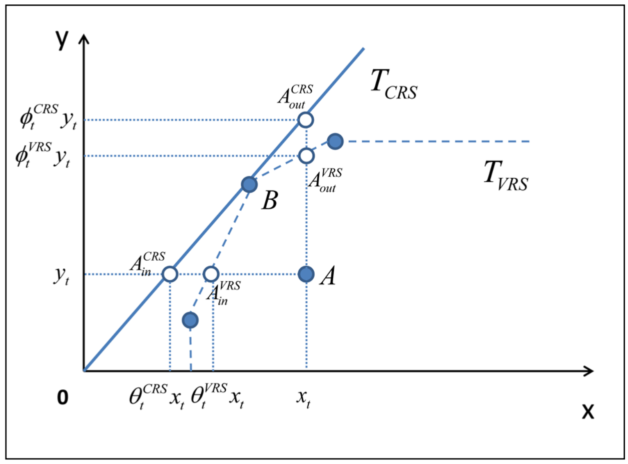

Fig. 1. Technical and scale efficiency

As a remedy to the aforementioned issues, one needs to analyse the returns to scale (scale elasticity) rather than SE. The qualitative approach (Färe et al., 1983; Grosskopf, 1986) can be employed to classify the observations in terms of the prevailing RTS, albeit no information about the differences within the groups would be recovered. The quantitative approach (Førsund, 2004) can thus be employed to analyse the underlying RTS. In the sequel we will focus on the indirect measurement thereof.

The initial efficiency scores, θ^{VRS}, are obtained by solving certain linear programming problems. Let there be K DMUs identified by the index $k = 1, 2,\ldots, K$ using input quantities given by vectors $x_k = (x_{1,k}, x_{2,k},\ldots, x_{m,k})$ and producing output quantities given by vectors $y_k = (y_{1,k}, y_{2,k},\ldots, y_{n,k})$, where m and n are numbers of inputs and outputs, respectively. The input-oriented VRS efficiency scores, θ_t^{CRS}, are then obtained by solving the following problem (t = 1, 2,..., K):

$$\begin{aligned}
&\theta_t^{VRS} = \min_{\theta,\lambda_k} \theta \\
&\text{s.t.} \\
&\sum_{k=1}^{K} \lambda_k x_{i,k} \le \theta x_{i,t}; i = 1,2,\dots,m; \\
&\sum_{k=1}^{K} \lambda_k y_{j,k} \ge y_{j,t}; j = 1,2,\dots,n; \\
&\sum_{k=1}^{K} \lambda_k = 1; \\
&\lambda_k \ge 0, k = 1,2,\dots,K.
\end{aligned} \tag{1}$$

In case of the output orientation, the output-oriented efficiency scores, ϕ, are the Farrell efficiency measures. The following DEA model yields the output-oriented measures of efficiency under CRS:

$$\begin{aligned}
&\phi_t^{VRS} = \max_{\phi,\lambda_k} \phi \\
&\text{s.t.} \\
&\sum_{k=1}^{K} \lambda_k x_{i,k} \le x_{i,t}; i = 1,2,\dots,m; \\
&\sum_{k=1}^{K} \lambda_k y_{j,k} \ge \phi y_{j,t}; j = 1,2,\dots,n; \\
&\sum_{k=1}^{K} \lambda_k = 1; \\
&\lambda_k \ge 0, k = 1,2,\dots,K.
\end{aligned} \tag{2}$$

The returns to scale can be quantified by considering some additional linear programming problems. First, the observed production plans are projected onto the efficiency frontier, i. e. the observations ($\theta^{VRS}x_0$, y_0) and (x_0, $\phi^{VRS}y_0$) are analysed for the input and output orientation (indexes t are dropped here for brevity). The dual DEA models are used for the further analysis. The input-oriented VRS technical efficiency score is given by:

$$\begin{aligned}
&\hat{\theta}_t^{VRS} = \max_{u_i,v_j,v_0^t} \sum_{j=1}^{n} v_j y_{j,t} + v_0^t \\
&\text{s.t.} \\
&\sum_{i=1}^{m} u_i x_{i,t} = 1; \\
&\sum_{j=1}^{n} v_j y_{j,k} - \sum_{i=1}^{m} u_i x_{i,k} + v_0^t \le 0, k = 1,2,\dots,K; \\
&u_i, v_j \ge 0, i = 1,2,\dots,m, j = 1,2,\dots,n; \\
&v_0^t \text{ unrestricted,}
\end{aligned} \tag{3}$$

where v_0 is the shadow price of the convexity constraint in Eq. 2, $\sum_{k=1}^{K}\lambda_k = 1$. Specifically, $v_0 < 0$ is associated with increasing returns to scale, $v_0 = 0$ implies CRS and $v_0 > 0$ is associated with decreasing returns to scale.

The output-oriented multiplier problem is defined in the following way:

$$\begin{aligned}
&\hat{\phi}_t^{VRS} = \min_{u_i,v_j,u_0^t} \sum_{i=1}^{m} u_i x_{i,t} + u_0^t \\
&\text{s.t.} \\
&\sum_{j=1}^{n} v_j y_{j,t} = 1; \\
&\sum_{j=1}^{n} v_j y_{j,k} - \sum_{i=1}^{m} u_i x_{i,k} - u_0^t \le 0, k = 1,2,\dots,K; \\
&u_i, v_j \ge 0, i = 1,2,\dots,m, j = 1,2,\dots,n; \\
&u_0^t \text{ unrestricted.}
\end{aligned} \tag{4}$$

The input-oriented scale elasticity is then computed as (Førsund, 2004)

$$\varepsilon_t^{in} = \hat{\theta}_t^{VRS} / \left(\hat{\theta}_t^{VRS} - v_0^t\right), \tag{5}$$

where v_0^t solves Eq. 3 for the t-th farm. The value of ε_t^{in} exceeds unity in case of IRS and is lower than unity in case of DRS. More specifically, the increase in the aggregate input of 1% renders an increase in the aggregate output of ε_t^{in} %. Indeed, similar computations are available for the output orientation:

$$\varepsilon_t^{out} = 1 - \hat{\phi}_t^{VRS} u_0^t. \tag{6}$$

It is due to Banker and Thrall (1992) that the efficient DMUs located on the facets of the production frontier (surface) feature shadow prices that are not unique. Accordingly, Banker and Thrall (1992) defined the linear programming problem aimed at finding the lower and upper bounds for scale elasticity of the efficient observations. The input- or output-oriented scale efficiencies are computed by employing the input- or output-adjusted observations, respectively, and restricting the efficiency score equal to unity. However, the orientation has no impact for an efficient observation lying on the frontier. The following model yields the estimates of the upper bound of the shadow price associated with the convexity constraint:

$$\begin{aligned}
&{}^{\max}v_0^t = \max_{u_i,v_j,v_0^t} v_0^t \\
&\text{s.t.} \\
&\sum_{j=1}^{n} v_j y_{j,t} + v_0^t = 1 \\
&\sum_{i=1}^{m} u_i x_{i,t} = 1; \\
&\sum_{j=1}^{n} v_j y_{j,k} - \sum_{i=1}^{m} u_i x_{i,k} + v_0^t \le 0, k = 1,2,\dots,K; \\
&u_i, v_j \ge 0, i = 1,2,\dots,m, j = 1,2,\dots,n; \\
&v_0^t \text{ unrestricted.}
\end{aligned} \tag{7}$$

Similarly, the lower bound of the shadow price, ${}^{\min}v_0^t$, is obtained by setting the objective function to $(-\nu_0^t)$. The corresponding bounds of the scale elasticity for the efficient observations are computed by inserting the values of ${}^{\min}\nu_0^t$ and ${}^{\max}\nu_0^t$ into Eq. 6:

$$\varepsilon_t^{\min} = 1/\left(1 - {}^{\min}\nu_0^t\right), \quad (8)$$

$$\varepsilon_t^{\max} = 1/\left(1 - {}^{\max}\nu_0^t\right). \quad (9)$$

The efficient points lie on the production frontier and we therefore do not need to consider the scale elasticity bounds based on the output-oriented shadow prices (Førsund, 2004). The estimator given by Eq. 7 can range in $(-\infty, 1)$ thus yielding elasticities of scale ranging in $(0, \infty)$. Elasticity of zero (resp. infinity) implies that an observation lies on the horizontal (resp. vertical) part of the efficiency frontier in the input-output space.

Data used

The data for 200 farms selected from the FADN sample covered the period of 2004–2009. Thus a balanced panel of 1 200 observations was employed for analysis. The technical efficiency was assessed in terms of the input and output indicators commonly employed for agricultural productivity analyses. More specifically, the utilized agricultural area (UAA) in hectares was chosen as land input variable, annual work units (AWU) as labour input variable, intermediate consumption in Litas, and total assets in Litas as a capital factor. The last two variables were deflated by respective real price indices provided by Eurostat. On the other hand, the three output indicators represent crop, livestock, and other outputs in Litas (LTL), respectively. The aforementioned three output indicators were deflated by respective price indices. The analysed sample covers relatively large farms (mean UAA – 244 ha). As for labour force, the average was 3.6 AWU.

In order to quantify the differences in efficiency across certain farming types, the farms were classified into the three groups in terms of their specialization. Specifically, farms with crop output larger than 2/3 of the total output were considered as specialized crop farms, whereas those specific with livestock output larger than 2/3 of the total output were classified as specialized livestock farms. The remaining farms fell into a residual category called mixed farming.

Each farming type was analysed independently in order to avoid infeasibilities associated with extreme observations specific for different farming types. Furthermore, the super-efficiency DEA model (Andersen, Petersen, 1993) was employed to identify the outliers. In our case, those farms exhibiting the input-oriented super-efficiency scores above 1.2 were excluded from the sample. As a result, the crop, mixed, and livestock farm samples comprised 706, 148, and 121 observations, respectively. The further studies, though, could focus on a step-wise analysis of the returns to scale under the framework of context-dependent DEA (Ulucan, Atici, 2010).

Returns to scale across farming types

The patterns of the prevailing returns to scale and scale elasticity were analysed across the three different farming types, viz. crop, mixed, and livestock farming. The analysis aimed at estimating the MPSS. Specifically, the three main variables describing the observed scale size were chosen for the research: UAA in hectares, land input in AWU, and the total output in Litas.

The relationships between each of the latter variables and scale elasticity were quantified by employing the log-log regression, which appeared to feature the best fit. The values of the scale elasticity were truncated at 3 to improve the visualisation. Both input- and output-oriented models were considered for inefficient observations. The efficient ones were treated by the virtue of Eqs. 5–7. Furthermore, certain ratios were then derived in order to analyse the labour intensity and land productivity at the MPSS. Note that the projections of the inefficient observations were analysed instead of the original data. Otherwise, the input (output) values would be inflated (contracted) due to technical inefficiency. Thus, one can focus solely on the scale efficiency by analysing the projections.

In the sequel, we will analyse the results across the three farming types, viz. crop, livestock, and mixed farming. The corresponding equations describing the relationships between input (output) indicators and the scale elasticity measure are given in Figs. 2–19. The optimal values of inputs and outputs were obtained by setting scale elasticity equal to one, logging both sides of the equation and then solving it for the variable of interest.

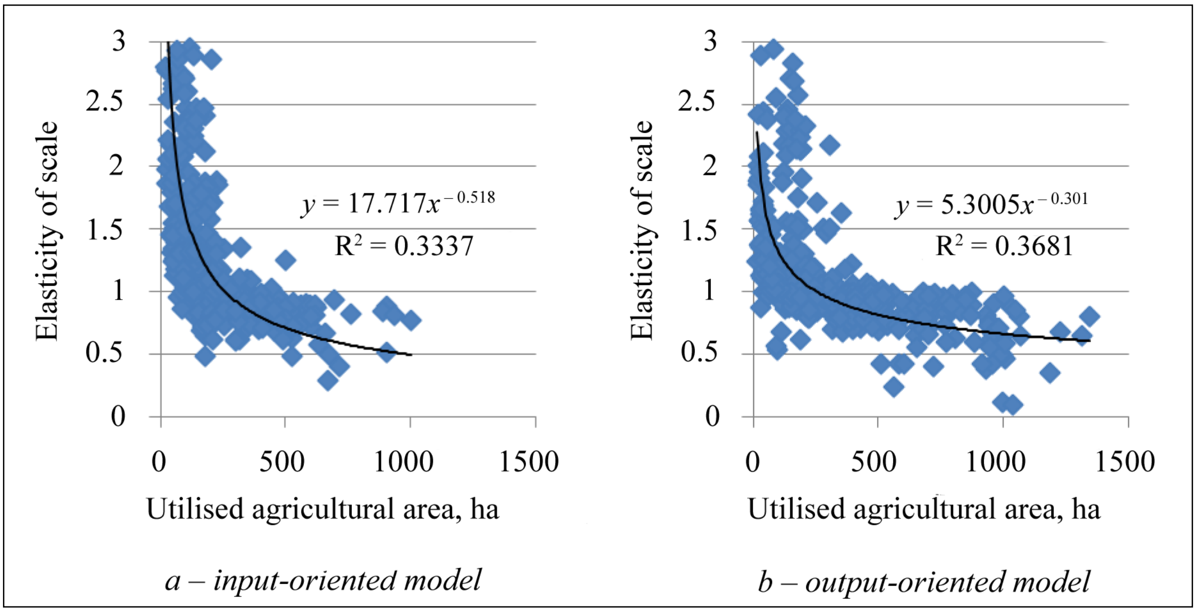

Fig. 2. Relationships between the UAA and scale elasticity for inefficient crop farms (Lithuania, 2004–2009)

Crop farming

The relationships between UAA and scale elasticity for crop farms are given in Figs. 2–3. As one can note, the point estimate of the UAA associated with the optimal scale varied, depending on the model's orientation, in between 83 and 409 ha. Specifically, the inefficient crop farm projections featured the optimal UAA of 257 and 255 ha for input and output orientations, respectively (Fig. 2). Clearly, the efficient farms were specific with a wider interval of the UAA associated with CRS (83–409 ha). Anyway, neither of these values exceeds the threshold of 500 ha stipulated in the Provisional Law on Agricultural Land Acquisition of the Republic of Lithuania (January 28, 2003, No. IX-1314, Article 4).

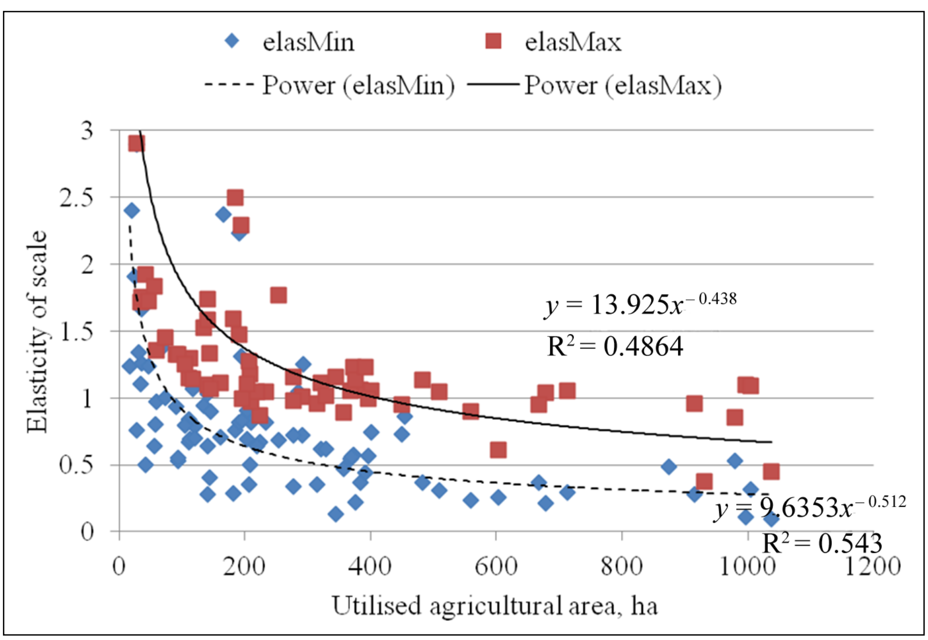

Fig. 3. Relationships between the UAA and scale elasticity for efficient crop farms (Lithuania, 2004–2009)

The optimal amount of the labour input ranged in between 1.4 and 5.3 AWU for the crop farms. Specifically, projections of the inefficient farms reached the MPSS in the interval bounded by 3 and 3.4 AWU (Fig. 4). The optimal labour input for efficient farms fluctuated in between 1.4 and 5.3 AWU (Fig. 5). The coefficients of determination associated with equations describing the relationships between labour input and scale elasticity measure were rather low if compared to those observed for other inputs or outputs. Indeed, the scatterplots do indicate that farms employing a relatively high amount of the labour force (>10 AWU) managed to deviate from the optimal scale to a lower extent if compared to farms employing less labour force.

The lower bound of the total output of the crop farms in the region of CRS was LTL 147 thousand, whereas the upper one was slightly over LTL 1 million considering the efficient farms

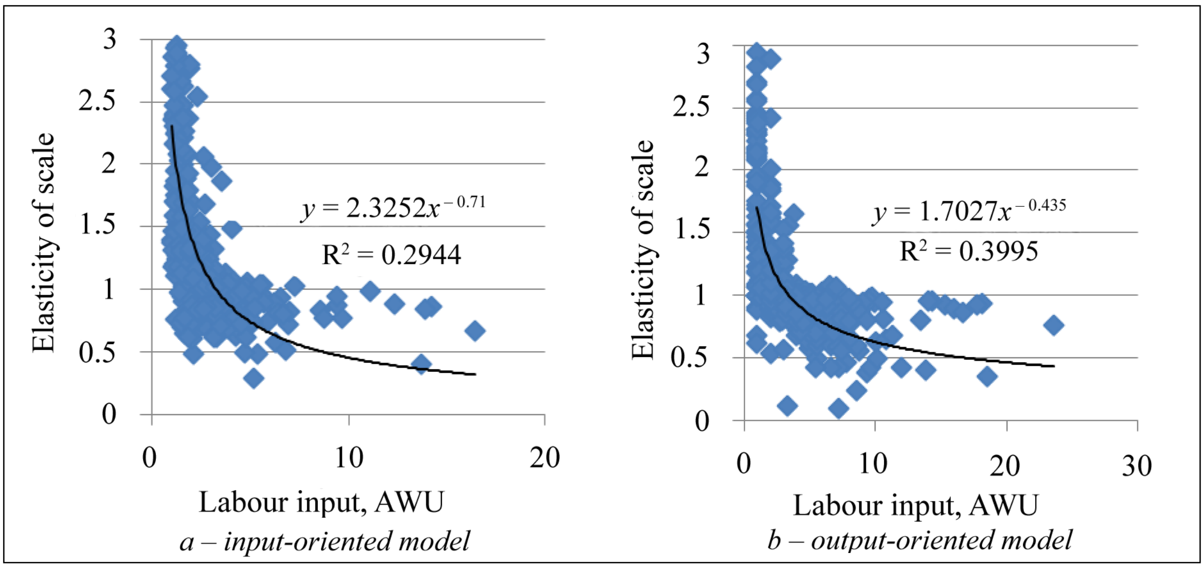

Fig. 4. Relationships between the labour input and scale elasticity for inefficient crop farms (Lithuania, 2004–2009)

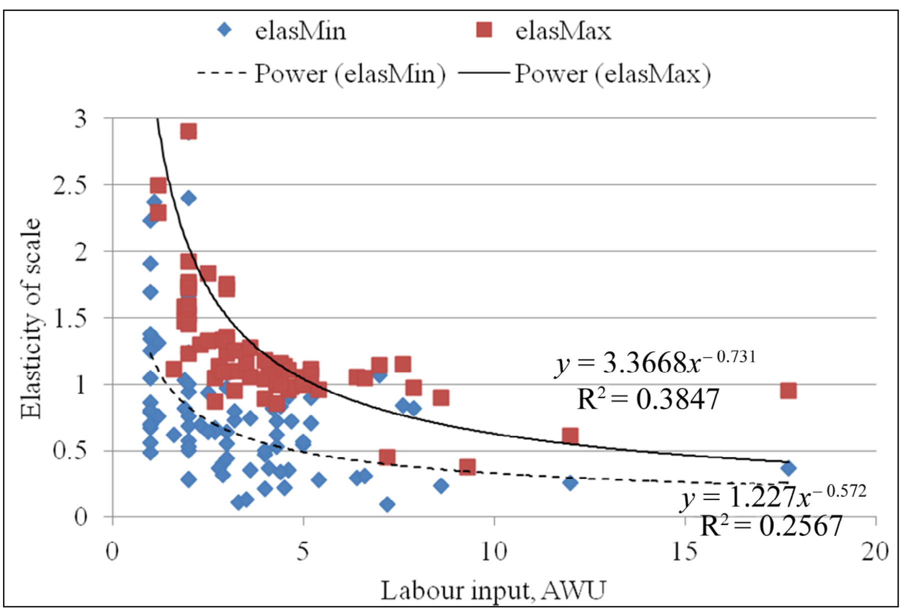

Fig. 5. Relationships between the labour input and scale elasticity for efficient crop farms (Lithuania, 2004–2009)

(Fig. 6). As for inefficient ones, the MPSS was achieved under LTL 609–709 thousand (Fig. 7). Therefore, the total output varied alongside the model's orientation to the highest extent.

Table 1 summarises the results for the crop farms. Generally, crop farms of some 250 ha in size appeared to be those operating in the region of CRS. However, the lower and upper values obtained for the efficient farms diverged from the latter figures to a certain extent. Noteworthy, Vasiliev et al. (2008) employed DEA and estimated that the optimal Estonian grain farm size should fall in the range of 239–341 ha. Meanwhile, Luik et al. (2009) concluded that the same figure should be in between 200 and 600 ha. As for the labour force, the optimal amount was some 3 AWU. Finally, the total output in the region of CRS was LTL 600–700 thousand (ca. EUR 175–200 thousand).

The farm size can also be analysed in terms of the relative indicators (i. e. ratios). The results did indicate that the amount of land per one unit of labour (AWU) fell in the interval of 58–84 ha. The total output generated per one hectare of UAA ranged in between LTL 1.8 and 2.8 thousand. Meanwhile, the amount of the total output per unit of labour (AWU) associated with CRS was LTL 100–216 thousand.

Livestock farming

The univariate regression suggested that the inefficient livestock farms reached the region of CRS at 139–147 ha (Fig. 8), whereas the efficient farms featured the respective solutions ranging in between 44 and 221 ha (Fig. 9).

The labour input specific for the inefficient farms was 4.3–4.5 AWU in the CRS region and 2.1–6.6 AWU for the efficient farms. Indeed, there were quite a few farms with extreme values of the labour

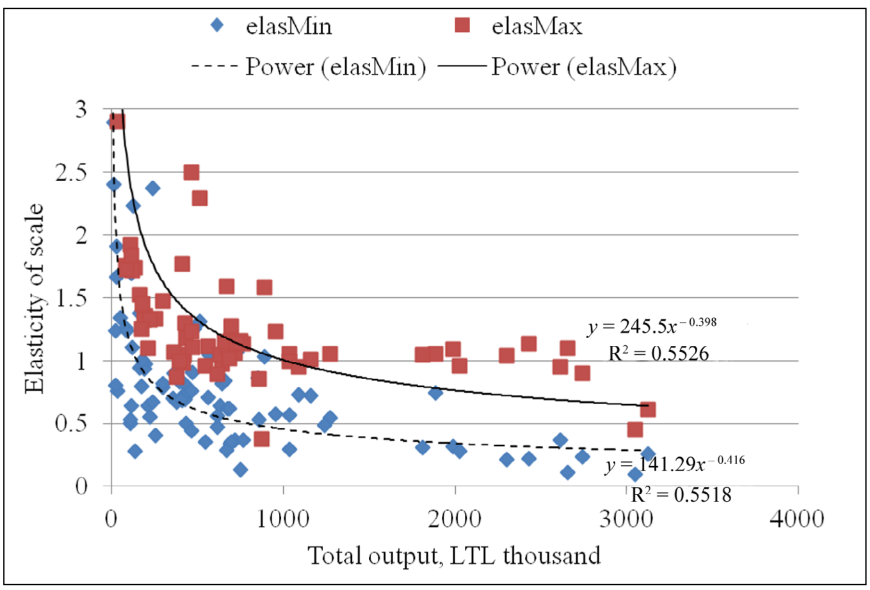

Fig. 6. Relationships between the total output and scale elasticity for efficient crop farms (Lithuania, 2004–2009)

Table 1. **The most productive scale size for the crop farms (Lithuania, 2004–2009)**

Indicators	Inefficient farms		Efficient farms	
	ε_t^{in}	ε_t^{out}	ε_t^{min}	ε_t^{max}
UAA, ha	257	255	83	409
Labour, AWU	3	3.4	1.4	5.3
Total output, LTL	709,137	609,460	147,413	1,011,939
UAA per labour unit, ha/AWU	84	75	58	78
Land productivity, LTL/ha	2,759	2,391	1,766	2,476
Labour productivity, LTL/AWU	216,067	179,305	103,089	192,277

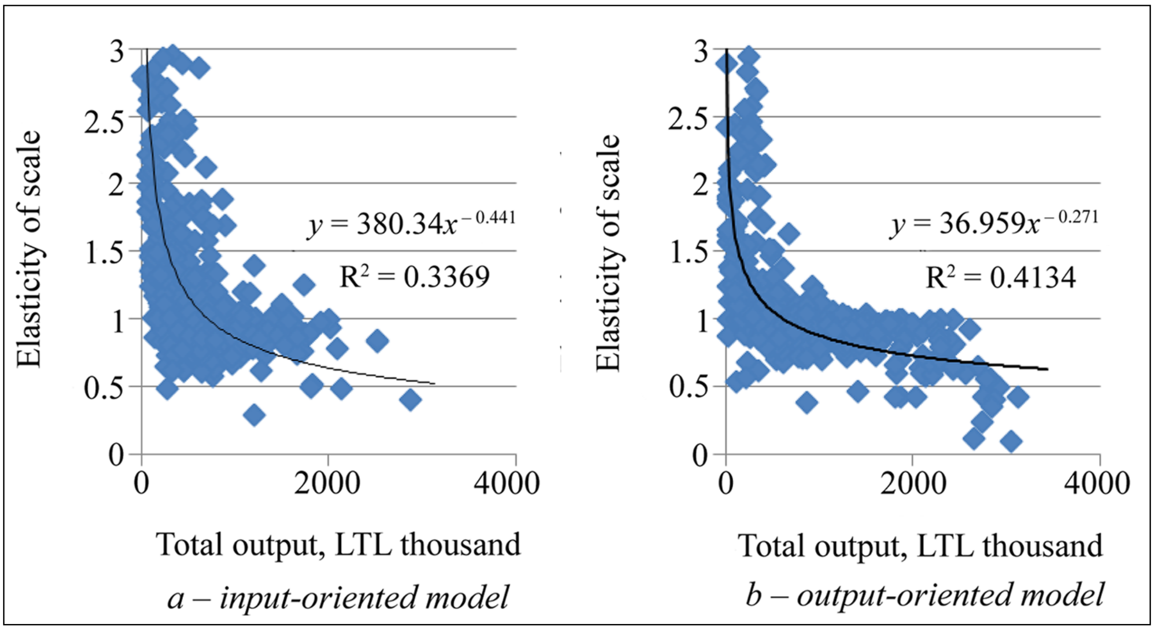

Fig. 7. Relationships between the total output and scale elasticity for inefficient crop farms (Lithuania, 2004–2009)

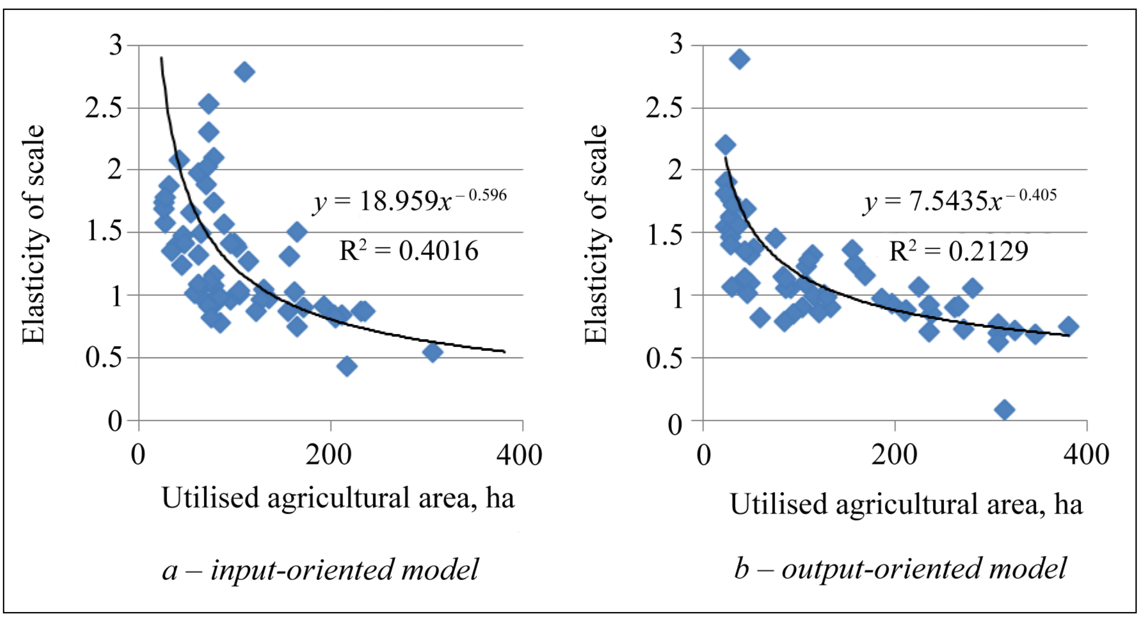

Fig. 8. Relationships between the UAA and scale elasticity for inefficient livestock farms (Lithuania, 2004–2009)

input. Therefore, the impact of farm expansion in terms of the labour input can be mainly established by the means of extrapolation. Accordingly, the coefficients of determination for the underlying equations were rather low (Figs. 10–11).

The inefficient livestock farms were specific with the total output amounting up to ca. LTL 440–480 thousand (EUR 128–138 thousand), see Fig. 12. The corresponding interval for the efficient farms was some LTL 140–820 thousand (EUR 40–237 thousand). Figure 13 depicts the relationship between elasticity of scale and total output in the efficient livestock farms.

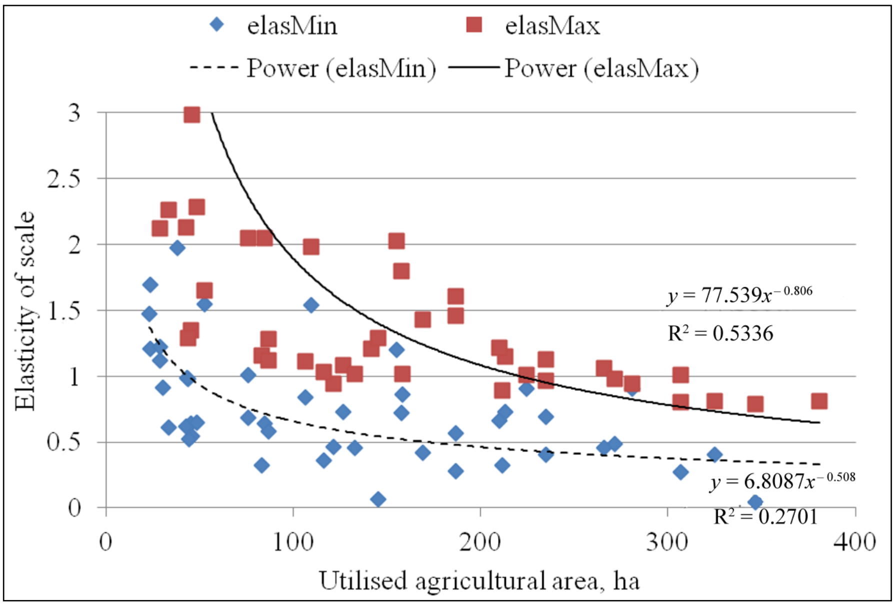

Fig. 9. Relationships between the UAA and scale elasticity for efficient livestock farms (Lithuania, 2004–2009)

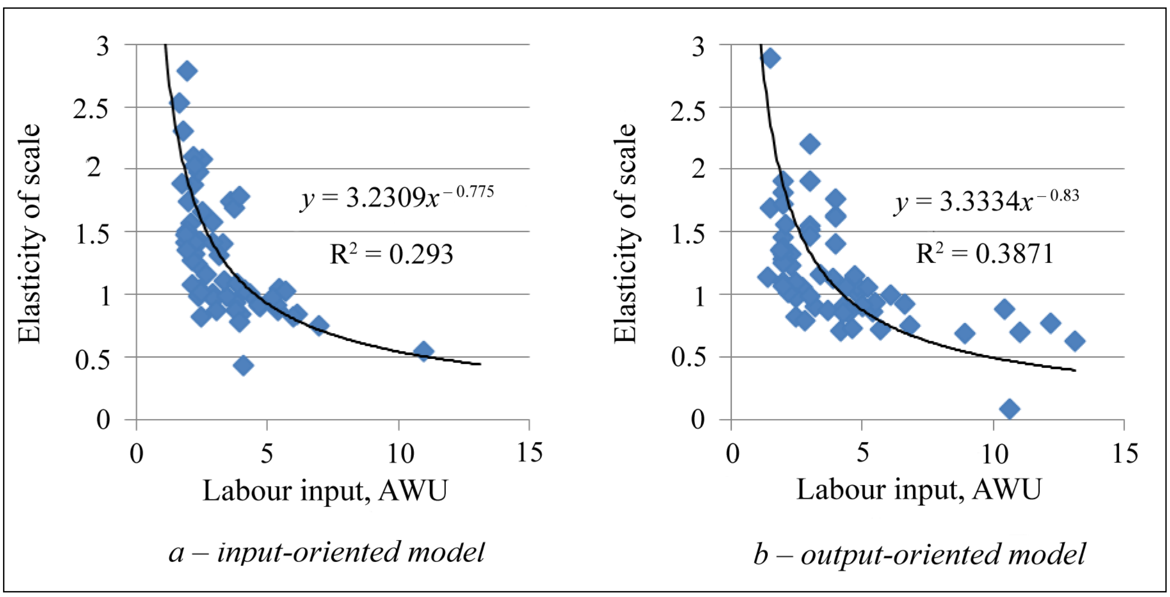

Fig. 10. Relationships between the labour input and scale elasticity for inefficient livestock farms (Lithuania, 2004–2009)

Table 2. **The most productive scale size for the livestock farms (Lithuania, 2004–2009)**

Indicators	Inefficient farms		Efficient farms	
	ε_t^{in}	ε_t^{out}	ε_t^{min}	ε_t^{max}
UAA, ha	139	147	44	221
Labour, AWU	4.5	4.3	2.1	6.6
Total output, LTL	478,938	438,801	141,411	821,745
UAA per labour unit, ha/AWU	32	34	20	33
Land productivity, LTL/ha	3,438	2,988	3,240	3,719
Labour productivity, LTL/AWU	105,460	102,868	66,337	123,720

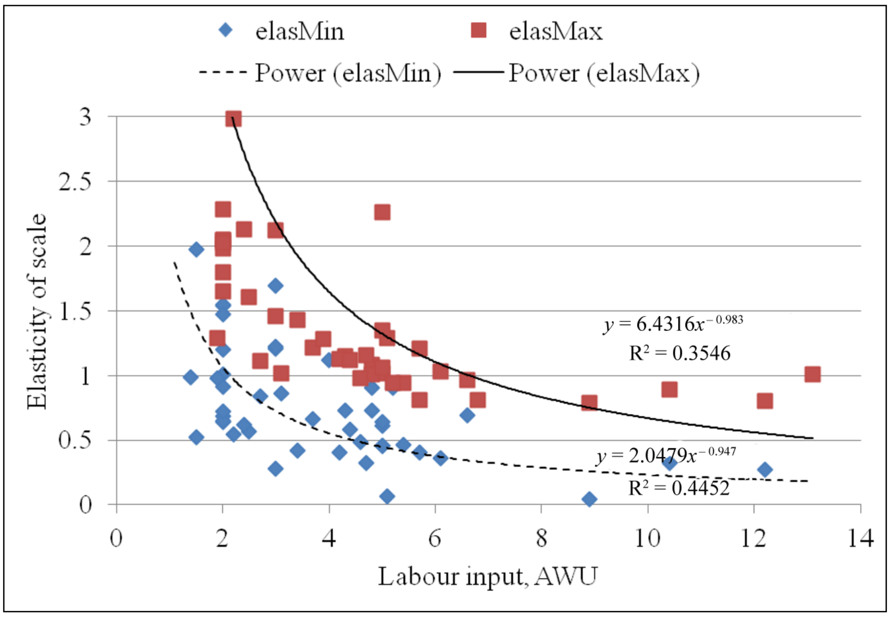

Fig. 11. Relationships between the labour input and scale elasticity for efficient livestock farms (Lithuania, 2004–2009)

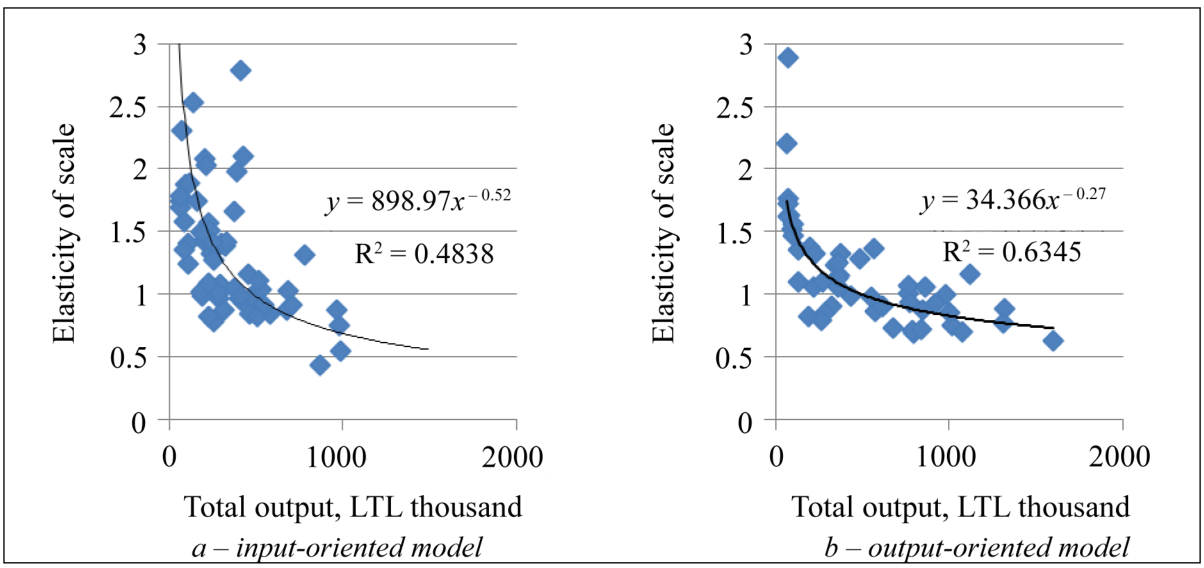

Fig. 12. Relationships between the total output and scale elasticity for inefficient livestock farms (Lithuania, 2004–2009)

Considering the inefficient farms, the MPSS for the livestock farms was achieved at some 140 ha of the UAA (Table 2). The labour force employed at the livestock farms operating at the optimal scale reached some 4.5 AWU and, thanks to the different technology, exceeded the respective figure for the crop farming. Meanwhile, the total output in the region of CRS was LTL 438–478 thousand.

The relative livestock farm size in the region can be described as follows: The amount of UAA per one unit of labour was 20–34 ha. Land productivity fluctuated around some LTL three thousand, whereas labour productivity ranged in between LTL 66 and 124 thousand. Note that these figures are lower than the respective ones associated with the crop farming. Accordingly, livestock farming might be less appealing at least in the range of CRS.

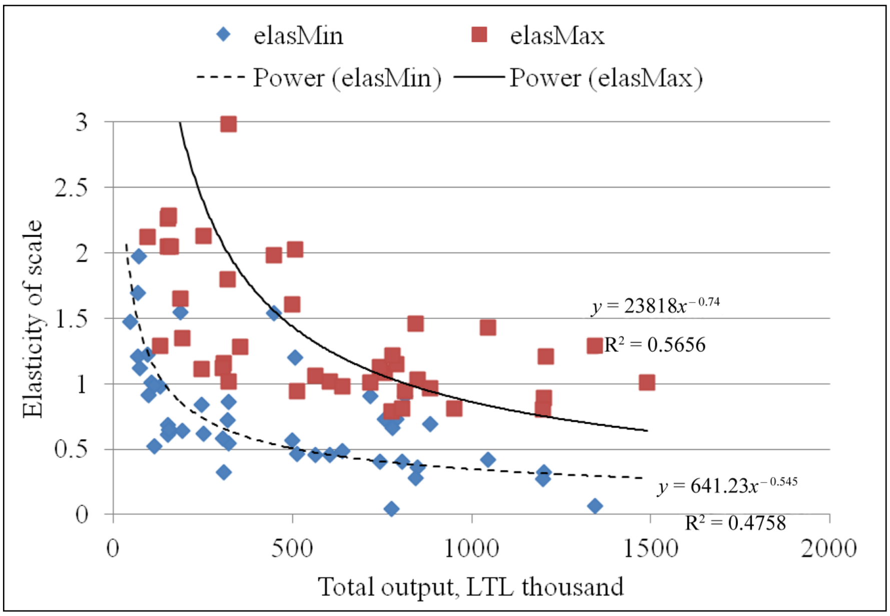

Fig. 13. Relationships between the total output and scale elasticity for efficient livestock farms (Lithuania, 2004–2009)

Mixed farming

The optimal mixed farm size in terms of UAA differed depending on the model's orientation for the inefficient farms: 195 ha in case of the input-oriented model, and 82 ha in case of the output-oriented one (Fig. 14). The UAA associated with CRS varied in between 59 and 249 ha for the efficient farms (Fig. 15). Thus mixed farms are rather vague in terms of the optimal UAA.

For the inefficient mixed farms, the full scale efficiency was achieved in between 2.9 and 4 AWU depending on the model's orientation (Fig. 16). Meanwhile, the efficient farms reached CRS at 2.3–5.2 AWU (Fig. 17).

The total output in the region of CRS varied significantly across the input- and output oriented models (Fig. 18): The input-oriented model yielded the value some LTL 370 thousand

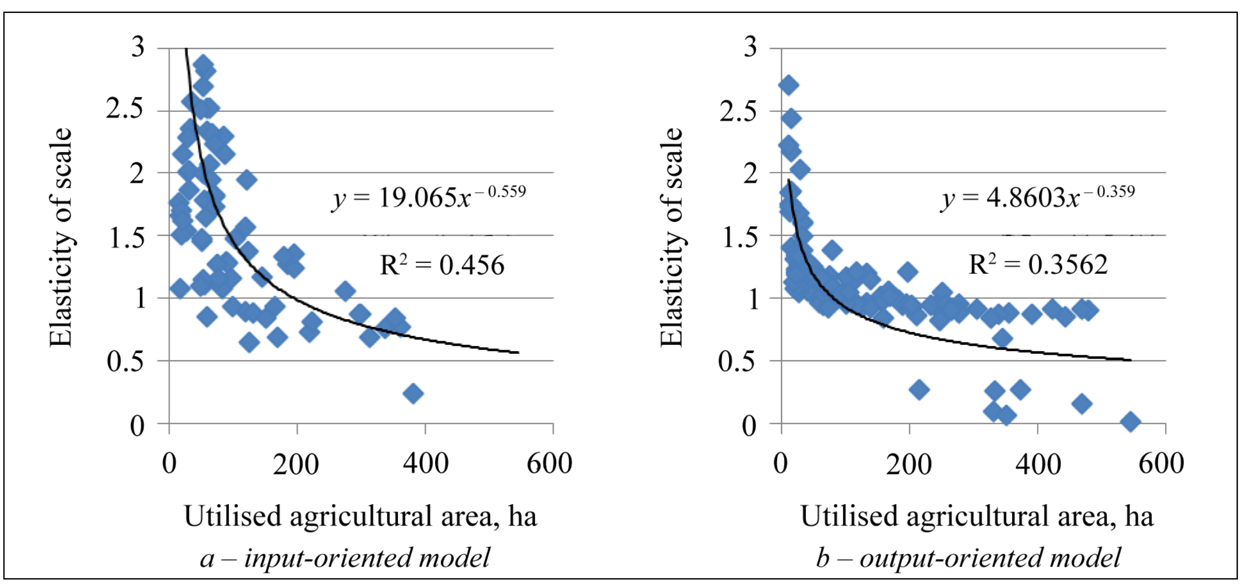

Fig. 14. Relationships between the UAA and scale elasticity for inefficient mixed farms (Lithuania, 2004–2009)

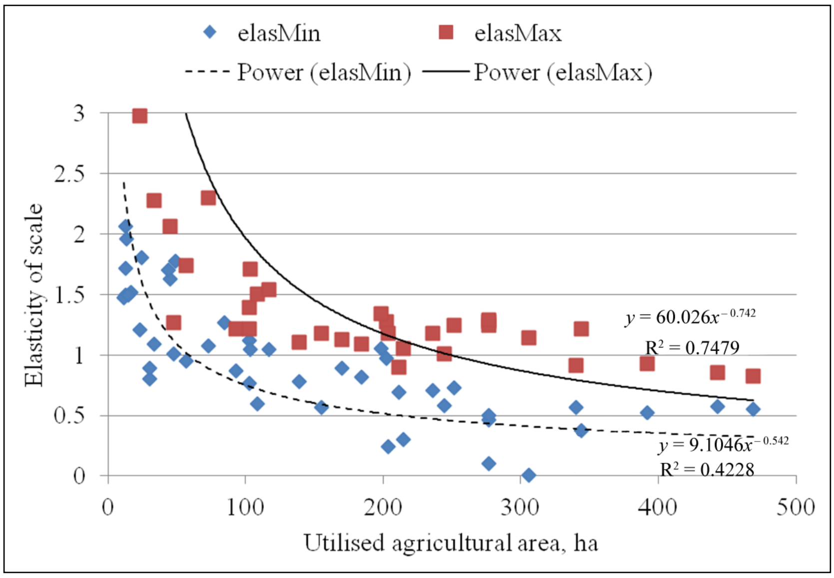

Fig. 15. Relationships between the UAA and scale elasticity for efficient mixed farms (Lithuania, 2004–2009)

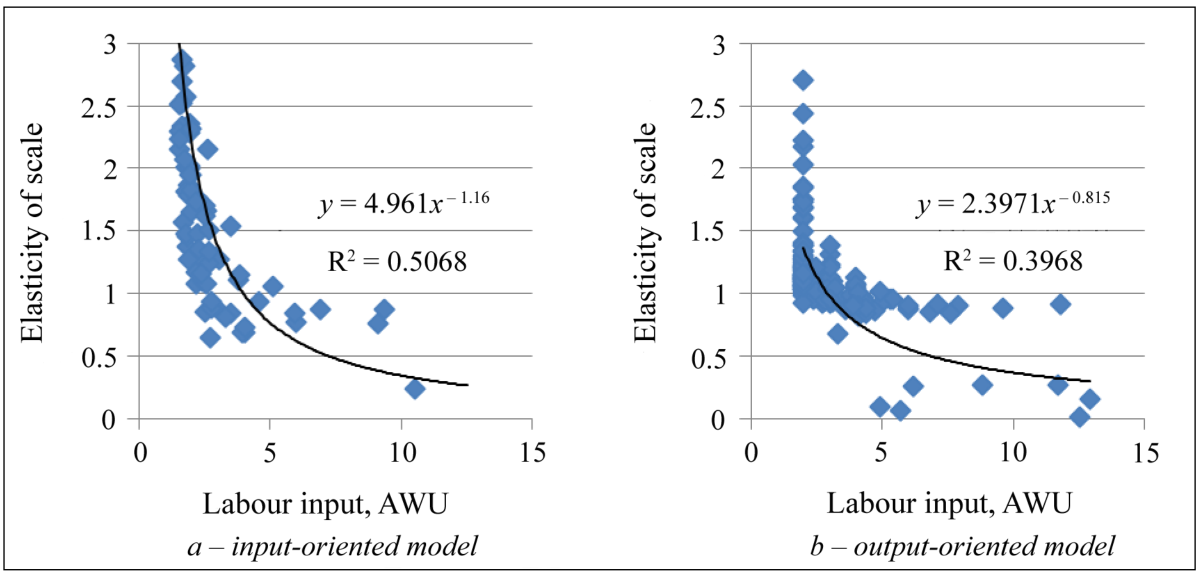

Fig. 16. Relationships between the labour input and scale elasticity for inefficient mixed farms (Lithuania, 2004–2009)

(EUR 107 thousand), whereas the output-oriented one yielded LTL 175 thousand (EUR 50 thousand). The efficient farms featured even wider interval of the total output at the optimal scale (Fig. 19), namely LTL 110–508 thousand (EUR 32–147 thousand).

Table 3 presents the main results regarding the optimal scale of the mixed farms. As one can note, these farms fell in between the specialised crop and livestock farms in terms of UAA and labour input. However, the mixed farms are more similar to the livestock ones: The UAA was 82–195 ha, whereas the labour input amounted to 2.9–4 AWU (based on inefficient observations).

The ratios describing farm size at the optimal scale were more consistent across the approaches of measurement. The results did indicate that scale efficiency had been ensured at farms which maintained the ratio of UAA and labour force at 26–50 ha/AWU. The land productivity fell into the interval of LTL 1.9–2.1 thousand/ha. The mixed

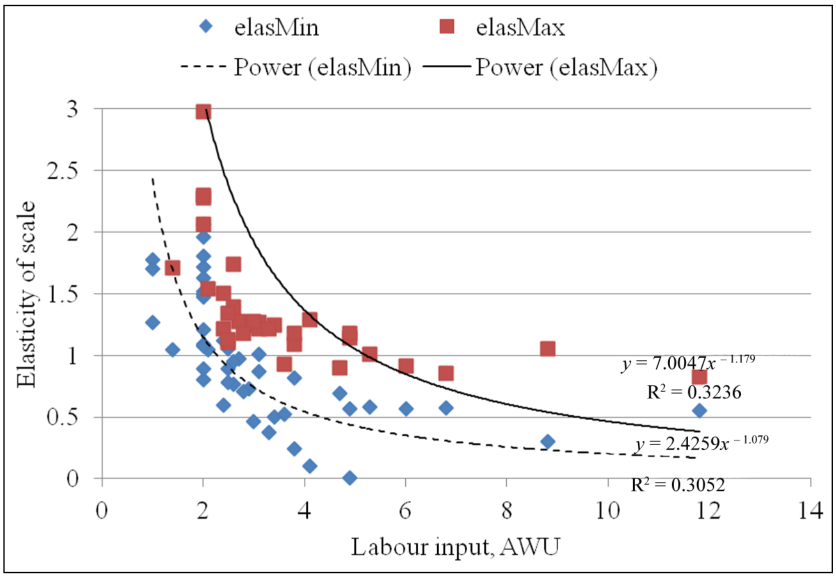

Fig. 17. Relationships between the labour input and scale elasticity for efficient mixed farms (Lithuania, 2004–2009)

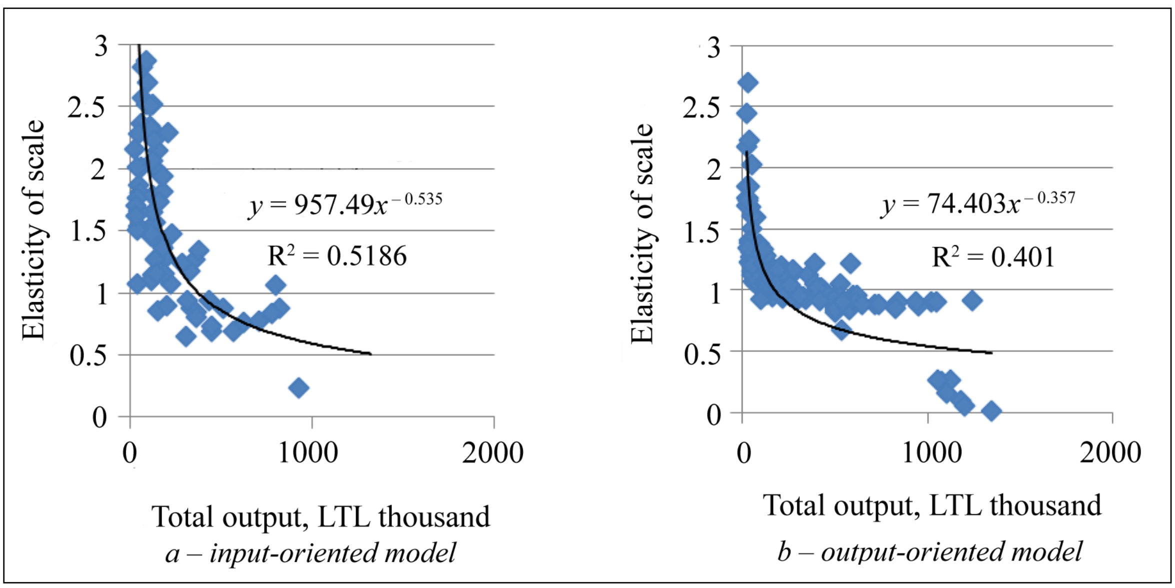

Fig. 18. Relationships between the total output and scale elasticity for inefficient mixed farms (Lithuania, 2004–2009)

Table 3. **The most productive scale size for the mixed farms (Lithuania, 2004–2009)**

Indicators	Inefficient farms		Efficient farms	
	ε_t^{in}	ε_t^{out}	ε_t^{min}	ε_t^{max}
UAA, ha	195	82	59	249
Labour, AWU	4.0	2.9	2.3	5.2
Total output, LTL	373,434	174,804	109,866	508,227
UAA per labour unit, ha/AWU	50	28	26	48
Land productivity, LTL/ha	1,914	2,137	1,866	2,039
Labour productivity, LTL/AWU	93,883	59,797	48,325	97,503

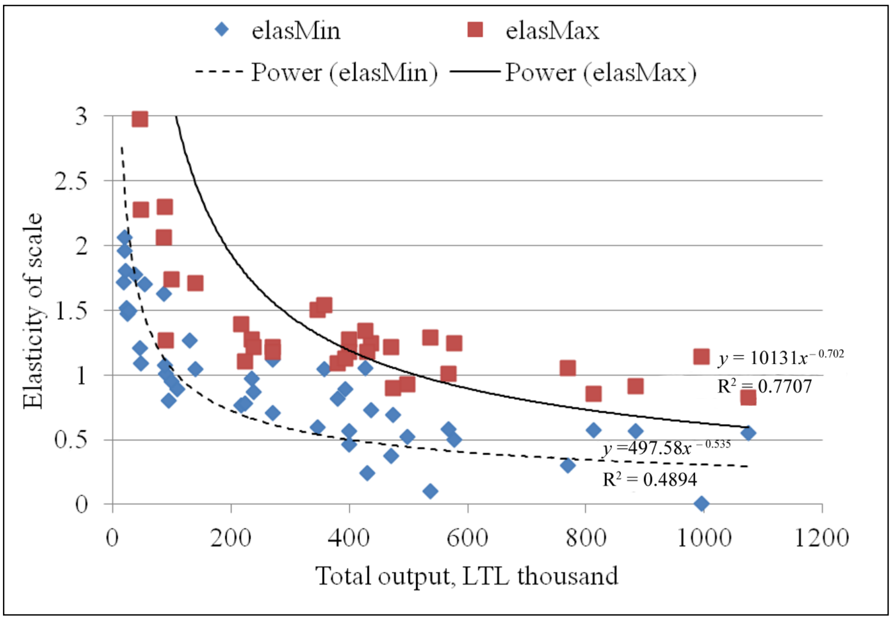

Fig. 19. Relationships between the total output and scale elasticity for efficient mixed farms (Lithuania, 2004–2009)

farms operating at CRS exhibited the labour productivity of LTL 48–98 thousand/AWU.

Comparison of the results

Given the results discussed above vary alongside the chosen measurement approaches, it is important to summarize those findings. The following Figs. 20–21 attempt to present the labour productivity and the amount of land per one labour unit, respectively.

The crop farms operating at the most productive scale size should maintain the highest labour productivity (Fig. 20). The livestock and mixed farms would face quite similar levels of the labour productivity. The mixed farms, though, would feature the lowest labour productivity across all the approaches of measurement.

As it was expected, the crop farms were followed by the mixed ones in terms of the amount of UAA per labour unit (Fig. 21). However, in one

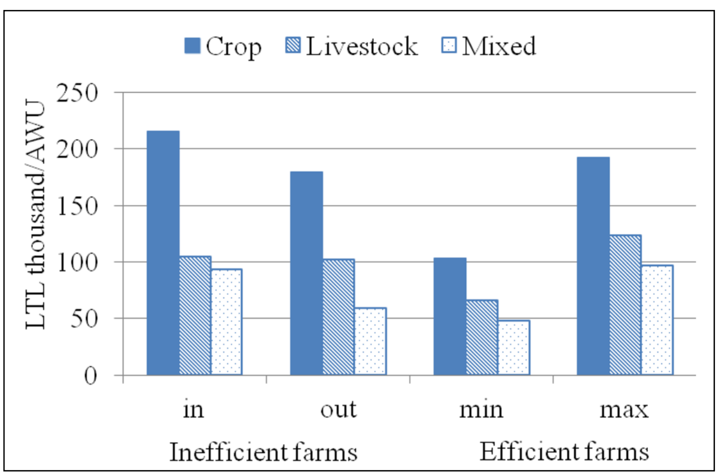

Fig. 20. Labour productivity at the most productive scale size across different farming types and approaches of measurement (Lithuania, 2004–2009)

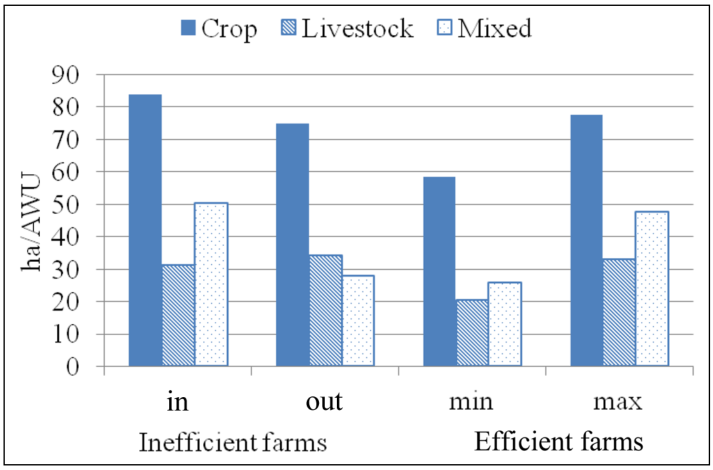

Fig. 21. The amount of land per annual work unit across different farming types and approaches of measurement (Lithuania, 2004–2009)

of the measurement approaches livestock farms featured a higher value.

The presented relative measures of farm size could be considered as some sort of guidelines for sustainable agricultural policy. The exact values, though, can be considered as tentative ones along with other objectives (e. g. employment, farm structure).

CONCLUSIONS

The quantitative analysis of the returns to scale in the Lithuanian family farms suggested that the crop farms should be some 250 ha in size with labour force amounting to 3–3.4 AWU. The total output associated with the optimal scale was LTL 600–700 thousand.

The livestock farms should be smaller in terms of land (soma 140 ha), albeit larger in terms of labour (4.3–4.5 AWU). Indeed, the total output associated with the optimal scale of production, LTL 438–478 thousand, suggests that the labour productivity in livestock farming (some LTL 100 thousand/AWU in the region of CRS) would be lower if compared to that in the crop farming (LTL 180–216 thousand/AWU in the region of CRS). Therefore, the livestock farming needs certain measures aimed at increasing the total output in order to increase its attractiveness and viability.

The mixed farming featured the size 82–195 ha and 2.9–4 AWU. The land productivity fluctuated around LTL two thousand/ha in the region of CRS, whereas the labour productivity ranged in between LTL 60 and 93 thousand/AWU. This farming type, therefore, featured the lowest land and labour productivity thus implying some sort of diseconomies of scope.

The carried out analysis revealed that the absolute measures of the farm size varied rather highly with the measurement approach. The relative measures, though, were less variant ones. Accordingly, it might be more reasonable to speak of farm size in terms of the relative measures, e. g. the amount of land per worker, land productivity, labour productivity.

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MASTO GRĄŽA LIETUVOS ŪKININKŲ ŪKIUOSE: KIEKYBINIS POŽIŪRIS

Santrauka

Straipsnyje nagrinėjama masto grąža ir masto elastingumas Lietuvos ūkininkų ūkiuose. Tyrimas remiasi ūkių lygmens duomenimis. Išskirti trys ūkininkavimo tipai: augalininkystė, gyvulininkystė ir mišrusis. Gamybos ribos sudarymui ir masto elastingumo įvertinimui taikytas neparametrinis metodas – duomenų apgaubties analizė. Neefektyvūs stebėjimai buvo projektuojami į gamybos ribą ir analizuojami sąnaudų taupymo ir gamybos didinimo požiūriais. Efektyvūs stebėjimai, priklausantys gamybos ribai, buvo nagrinėjami pagal Banker ir Thrall (1992) metodiką. Tyrimo rezultatai leidžia įvertinti ūkių dydį, užtikrinantį kiekvieno ūkininkavimo tipo didžiausią produktyvumą. Ūkių dydis buvo išreikštas tiek absoliučiais, tiek santykiniais rodikliais. Minėtieji dydžiai gali būti naudingi moksliniuose ūkių struktūros ir darnios žemės ūkio politikos tyrimuose.

Raktažodžiai: produktyviausias gamybos mastas, efektyvumas, duomenų apgaubties analizė, ūkininkų ūkiai