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**Lajos Zoltán Bakucs[*], Laure Latruffe[**],**
**Imre Fertő[*], József Fogarasi[***]**

[*]Institute of Economics, Hungarian Academy of Sciences
[**]INRA, Rennes, France
[***]Agricultural Economics Research Institute

email: bakucs@econ.core.hu

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## Abstract

In this study, we employ parametric (SFA) methods to analyse the technical efficiency (TE) of Hungarian farms before and after the accession. After years of decreasing technical efficiency scores, accession seems to have halted the process and positively influence the evolution of average technical efficiency. A number of determinants of TE provide a plausible explanation of the evolution of efficiency.

## 1. Introduction

Hungary is one of the ten countries that have joined the European Union (EU) in May 2004. Hungarian farmers are now entitled to receive direct payments per ha, in the frame of the Single Area Payment Scheme (SAPS). While these payments are still lower than the ones received by farmers in the EU-15, they are higher than what Hungarian farmers used to receive from national budget pre-accession. This raises the question of whether accession to the EU has had a positive impact on farmers' performance. In order to contribute to this issue, the paper will investigate technical efficiency of Hungarian farmers between 2001 and 2005 using a panel dataset of farms. This paper is organised as follows: section 2 presents the background of the research and the previous studies of efficiency in the Central European space, than

section 3 outlines the methodology. Data and results obtained with SFA and DEA methods are reported and discussed in section 4, and finally, section 5 concludes.

## 2. Previous studies about efficiency in the post communist economies

Research about farm technical efficiency in Central and Eastern European Countries (CEECs) has largely developed recently, with the objectives of investigating the evolution of efficiency during the transition from communist regime to market economy, and during the preparation of farmers to EU enlargement. The Czech Republic and Poland in particular have been the most focused on, in a view of comparing organisational forms, production specialisations and farm sizes.

In the Czech Republic, the earliest study is by Mathijs et al. (1999), who compared the efficiency of farms in 1996, in terms of their organisational form. They found that individual farms were more technically efficient than cooperatives in crop production, while the reverse was true for livestock specialisation. They also showed that there was no significant difference in terms of technical efficiency between crop and livestock farms. Curtiss (2002) focused on crop farms only, during the period 1996 to 1998, and found evidence of higher technical efficiency of individual farming in sugar beet production, but lower in wheat production, compared to corporate farming. More recently, Davidova and Latruffe (2006) calculated technical efficiency of Czech farms in 1999 and showed that the most efficient sub-sample of their study was the livestock corporate sample. In a second-stage regression, the authors found a positive influence of size on individual farms' efficiency, and a negative influence of indebtedness on livestock farms' efficiency.

In Poland, van Zyl et al. (1996) Munroe (2001), Lerman (2002) and Latruffe et al. (2004 and 2005) using data from 1993, 1996 and 2000 respectively, all focused the technical efficiency-size relationship, but found contradictory results. van Zyl et al. and Munroe found a negative relationship, while Lerman and Latruffe et al. found the opposite. Latruffe et al. report in addition a superiority of livestock farms over crop farms in terms of technical efficiency. Munroe (2001) and Latruffe et al. (2004) investigated the factors determining efficiency with a second stage, and both found the importance of age, although opposite influence.

By contrast, technical efficiency of Hungarian farmers has not been much explored. The only post-reform paper is by Mathijs and Vranken (2001), who used data from a survey of individual and corporate farms in 1998. The authors report that the former

are more technically efficient than the latter, in the crop sector only. In a second stage, the effect of several variables on efficiency was investigated by a regression. Education was found to play a positive role on individual farms' efficiency, while for corporate farms, important factors dealt with specific organisational characteristics.

While some studies have investigated other aspects of farm performance in Hungary (Total Factor Productivity in 1997 by Hughes, 2000; profitability and Total Factor Productivity in 2000 by Davidova et al., 2002), there is a clear gap regarding technical efficiency of Hungary's farming sector. This paper will therefore contribute to this research, using data covering a crucial period for Hungary, the end of the transition and the first accession year.

## 3. Methodology

Two main approaches have been developed to estimate the unknown production frontier. The nonparametric approach essentially requires the solving of a mathematical programming problem. The most common method, Data Envelopment Analysis (DEA), developed by Charnes et al. (1978), constructs a nonparametric frontier over the data points of the sample used, such that all observations are on or below the frontier. The distance to the frontier is interpreted as inefficiency. DEA is a deterministic method, not accounting for noise. However, it does not require assumptions or specifications of the functional form.

Within the parametric approaches, the Stochastic Frontier Analysis, (SFA) is commonly used. Aigner at al. (1977) and Meeusen and Van den Broeck (1977) have simultaneously yet independently developed the use of SFA in efficiency analysis. The main idea is to decompose the error term of the production function into two components, one pure random term ($v_i$) accounting for measurement errors and effects that can not be influenced by the firm such as weather, trade issues, access to materials, and a non-negative one, measuring the technical inefficiency, i.e. the systematic departures from the frontier ($u_i$):

$$y_i = f(x_i)\exp(v - u_i) \quad (1)$$

where $y_i$ is the output of the $i^{th}$ firm, $x_i$ the vector of inputs used in the production, $f(\cdot)$ the production function, and $u_i$ and $v_i$ the error terms explained above. The output orientated technical efficiency, (TE) is actually the ratio between the observed output of firm $i$ to the frontier, i.e. the maximum possible output:

$$TE_i = \exp(-u_i),\ 0 \le TE_i \le 1 \quad (2)$$

Applying SFA methods requires distributional and functional form assumptions. First, because only the $w_i=v_i$ - $u_i$ error term can be observed, we need to have specific assumptions about the distribution of the composing error terms. The random term $v_i$, is usually assumed to be identically and independently distributed drawn from the normal distribution, $N(0,\sigma_v^2)$. There are various assumptions that can be made regarding the distribution of the non-negative error term. However most often it is considered to be identically distributed as a half normal random variable, $N^+(0,\sigma_u^2)$ or a normal variable truncated from below zero, $N^+(\mu,\sigma_u^2)$.

Second, being a parametric approach, we need to specify the underlying functional form of the Data Generating Process, DGP. There are a number of possible functional form specifications available, however most studies employ either the Cobb-Douglas, CD (3) or TRANSLOG, TL (4) specifications.

$$f(x_i) = e^{\beta_0}\prod_{k=1}^{K} x_{ik}^{\beta_k} \quad (3)$$

$$\ln f(x_i) = \sum_{k=1}^{K}\beta_k \ln x_{ik} + \frac{1}{2}\sum_{k=1}^{K}\sum_{j=1}^{K}\beta_{kj}\ln x_{ik}\ln x_{jk} \quad (4)$$

Because the two models are nested, it is possible to test the correct functional form by a Likelihood Ratio, LR test. The TL is the more flexible functional form, whilst the CD restricts the elasticities of substitution to 1. The model could be estimated either with Corrected Ordinary Least Squares, COLS or Maximum Likelihood, ML. With the availability of computer software, the estimation by ML became less computationally demanding, and the ML estimator was found to be significantly better than COLS (Coelli et al.,1997).

With panel data, TE can be chosen to be time invariant, or to vary systematically with time. To incorporate time effects, Battese and Coelli (1992) define the non-negative error term as exponential function of time:

$$u_{it} = \exp[(-\eta(t-T)]u_i \quad (5)$$

TE either increases ($\eta$>0), decreases ($\eta$<0) or it is constant over time, i.e. invariant ($\eta$=0). LR tests can be applied to test the inclusion of time in the model. Given that TE is allowed to vary, the question arise what determines the changes of TE scores? Battese and Coelli (1995) proposed a one stage procedure where firm specific

variables are be used to explain the predicted efficiencies. The explanatory variables are related to the firm specific mean $\mu$ of the non-negative error term $u_i$:

$$\mu_i = \sum_j \delta_j z_{ij} \tag{6}$$

Using cross-section or panel data may often lead to heteroscedasticity in the residuals. With heteroscedastic residuals, OLS estimates remain unbiased but no longer efficient. In frontier models however, the consequences of heteroscedasticity are much more severe, as the frontier changes when the dispersion increases. Caudill et al. (1995) introduced a model which incorporates heteroscedasticity into the estimation. That is done by modelling the relationship between the variables responsible for heteroscedasticity and the distribution parameter $\sigma_u$:

$$\sigma_{ui} = \exp(\sum_j x_{ij} \rho_j) \tag{7}$$

It is possible to test whether any form of stochastic frontier production function is required or the OLS estimation is appropriate using a LR test. Using the parameterisation of Battese and Cora (1977), define $\gamma$, the share of deviation from the frontier that is due to inefficiency:

$$\gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2} \tag{8}$$

It should be noted however, that the test statistic has a 'mixed' chi square distribution, with critical values tabulated in Koddle and Palm (1996).

## 4. Data and model specification

### 4.1. Data

Hungarian FADN data between 2001 and 2005, provided by the Agricultural Research Institute, were used to build a balanced panel of 3210 observations (642 per year). The pooled sample was used for the estimation. One output variable, and four input variables were constructed (Table 1.). The output variable (Y) consists of total net farm revenue from sales. The input variables are: utilised agricultural area ($X_1$) measured in hectares, total intermediate consumption in value ($X_2$) including seeds, fertiliser, pesticides, fodder, purchase of animals and other direct material costs, capital ($X_3$) is defined as the total depreciated value of the machinery and finally labour ($X_4$), measured in total annual work hours (AWH). All variables expressed in national currency were deflated to year 2000 using the appropriate deflators

(agricultural output index, intermediate agricultural input price index, machinery investment price index, consumer price index). Time variables were added to the stochastic production function in order to capture the short and long-run evolution of the production frontier, to capture the possible technology change. To specify the model as flexible as possible, time was added into the production function.

Table 1. Descriptive statistics of the sample for output and input

| | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| | | 2001 | | |
| Y (000 HUF) | 65112.35 | 194058.6 | 305.6604 | 2056655 |
| $X_1$ (ha) | 257.7082 | 590.0878 | 0.35 | 5736 |
| $X_2$ (000 HUF) | 20069 | 66574.36 | 99.01873 | 1016417 |
| $X_3$ (000 HUF) | 20069 | 66574.36 | 99.01873 | 1016417 |
| $X_4$ (AWH) | 18176.58 | 50106.12 | 138 | 479482 |
| | | 2002 | | |
| Y (000 HUF) | 67210.26 | 190859.1 | 380.6328 | 1956250 |
| $X_1$ (ha) | 260.4061 | 585.2897 | 0.35 | 5736 |
| $X_2$ (000 HUF) | 20860.18 | 65616.47 | 134.7518 | 916424.6 |
| $X_3$ (000 HUF) | 15153.74 | 33614.98 | 20.14011 | 347232.1 |
| $X_4$ (AWH) | 18211.62 | 47216.71 | 250 | 457882 |
| | | 2003 | | |
| Y (000 HUF) | 63862.96 | 181219.4 | 39.819 | 1886836 |
| $X_1$ (ha) | 260.255 | 585.1293 | 0.35 | 6184 |
| $X_2$ (000 HUF) | 20325.87 | 62622.07 | 53.51171 | 878287.6 |
| $X_3$ (000 HUF) | 18629.24 | 40417.84 | 2.47117 | 395420.9 |
| $X_4$ (AWH) | 18236.31 | 46978.8 | 51 | 430128 |
| | | 2004 | | |
| Y (000 HUF) | 68038.9 | 196304.2 | 11.48325 | 2301627 |
| $X_1$ (ha) | 272.0243 | 597.6694 | 0.35 | 5669.54 |
| $X_2$ (000 HUF) | 18337.92 | 57819.98 | 115.6202 | 872072 |
| $X_3$ (000 HUF) | 17952.23 | 40324.58 | 16.34241 | 444498.1 |
| $X_4$ (AWH) | 17236.96 | 44454.66 | 22 | 410816 |
| | | 2005 | | |
| Y (000 HUF) | 68448.14 | 198410.3 | 90.30418 | 2035858 |
| $X_1$ (ha) | 271.4409 | 581.1455 | 0.65 | 5336 |
| $X_2$ (000 HUF) | 17207.6 | 52108.9 | 75.55898 | 649063.2 |
| $X_3$ (000 HUF) | 17329.44 | 40984.06 | 11.79072 | 582315.4 |
| $X_4$ (AWH) | 16764.5 | 42811.86 | 142 | 399091 |

There exists a large set of Z variables that could potentially explain the differences of technical efficiency between the farms in the sample (see for example Latruffe et al., 2004; Brümmer, 2001; Mathijs and Vranken, 2001). Several variables were constructed using the FADN database. After significance tests, the following variables

(Table 2.) were kept on the list of potential determinants of technical efficiency representing farm characteristics and management/production system characteristics.

- a trend variable;
- a legal form dummy, taking the value 1 if the farm is a company, and 0 otherwise (family);
- two region dummies, Region 1 collecting the farms from counties in Dunántúl, and Region 2 representing farms from counties in Alföld;
- the ratio of total subsidies received by the farms to their total output;
- the ratio of output from livestock activities to the total output, as well as its square value;
- the land to labour ratio;
- an index of soil quality, with larger values representing better quality;
- a dummy variable taking the value of 1 for the years 2004 and 2005, and 0 otherwise, thus collecting the effects of the May 2004 EU accession.

Table 2. Descriptive statistics of the sample for the explanatory variables of efficiency*

| | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| | 2001 | | | |
| Subsidies to Output Ratio | 0.1082 | 0.151951 | 0 | 3.155338 |
| Livestock Output to Total Output Ratio | 0.282218 | 0.357905 | 0 | 1 |
| Land to Labour Ratio | 0.027658 | 0.026672 | 0.000064 | 0.185874 |
| Soil Quality Index | 19.9664 | 8.276696 | 2.67 | 66.5 |
| | 2002 | | | |
| Subsidies to Output Ratio | 0.166325 | 0.229433 | 0 | 3.54626 |
| Livestock Output to Total Output Ratio | 0.270012 | 0.349975 | 0 | 1 |
| Land to Labour Ratio | 0.025547 | 0.024062 | 0.000071 | 0.160584 |
| Soil Quality Index | 19.73757 | 8.017778 | 3.23 | 63 |
| | 2003 | | | |
| Subsidies to Output Ratio | 0.243689 | 2.658097 | 0 | 67.15759 |
| Livestock Output to Total Output Ratio | 0.254155 | 0.349062 | 0 | 1 |
| Land to Labour Ratio | 0.025879 | 0.024228 | 0.000058 | 0.247451 |
| Soil Quality Index | 19.65146 | 7.882911 | 3.23 | 49.97 |
| | 2004 | | | |
| Subsidies to Output Ratio | 0.332432 | 2.513432 | 0 | 63.73249 |
| Livestock Output to Total Output Ratio | 0.240748 | 0.339122 | 0 | 1 |

| | | | | |
|---|---|---|---|---|
| Land to Labour Ratio | 0.028889 | 0.034622 | 0.000076 | 0.673182 |
| Soil Quality Index | 19.5322 | 7.77558 | 3.53 | 49.66 |
| | 2005 | | | |
| Subsidies to Output Ratio | 0.305011 | 0.539833 | 0 | 10.14438 |
| Livestock Output to Total Output Ratio | 0.21922 | 0.323282 | 0 | 1 |
| Land to Labour Ratio | 0.027565 | 0.022863 | 0.000094 | 0.175909 |
| Soil Quality Index | 19.6603 | 7.822724 | 3.57 | 49.66 |

* except dummy variables and county codes

### 4.2. Results with SFA

The gamma parameter is above 90%, and highly significant, meaning that the variation in technical efficiency can explain a large part of the variation in total error term. In order to specify the model as flexible as possible, a time trend was included in order to capture the yearly changes of parameters. The initial unrestricted model was used to test various hypotheses on parameters (Table 3.), than to formulate the final restricted model.

Table 3. Hypothesis testing

| Null hypothesis | Test Statistic | 5% Critical Value | Conclusion |
|---|---|---|---|
| Hypothesis 1: SFA invalid ($\gamma = 0$) | 884 | 'mixed' $\chi^2_{30} = 43.19$ | Reject |
| Hypothesis 2: No inefficiency ($\delta_i = 0$) | 822 | 'mixed' $\chi^2_{11} = 19.04$ | Reject |
| Hypothesis 3: Cobb-Douglas ($\beta_{ij} = 0$) | 391.8 | $\chi^2_{15} = 24.99$ | Reject |
| Hypothesis 4: Time invariant coefficients ($\beta_{Year} = 0.5\beta_{Year}^2 = \beta_{YearX1} = \beta_{YearX2} = \beta_{YearX3} = \beta_{YearX4} = 0$) | 23.26 | $\chi^2_6 = 12.59$ | Reject |
| Hypothesis 5: No constant efficiency term ($\delta_0 = 0$) | 0.66 | $\chi^2_7 = 3.84$ | Do not reject |
| Hypothesis 6: Time invariant efficiency scores ($\delta_{Year} = 0$) | 11.6 | $\chi^2_7 = 3.84$ | Reject |
| Hypothesis 7: No heteroscedasticity ($\rho_i = 0$) | 87.26 | $\chi^2_7 = 5.99$ | Reject |

The null hypothesis that OLS would suffice to estimate the production function is rejected (hypothesis 1), indicating that the use of SFA is appropriate. Coefficients are time varying (hypothesis 4), the positive coefficient of trend (Table 4.) suggests the frontier moving upwards. The group of explanatory variables ($Z_t$) are found to be

jointly significant, however without including a constant (hypothesis 2, 5). The time invariant efficiency scores null hypothesis (6) is rejected, the positive trend coefficient (Table 4.) indicates that efficiency scores are deteriorating over time. There is heteroscedasticity in the model, the null hypothesis that the coefficients of the heteroscedastic part are jointly zero being rejected. Finally, the null hypothesis that the estimated model can de reduced to the simpler however more restrictive Cobb-Douglas specification was strongly rejected (hypothesis 3). The estimates of the final restricted model are presented in Table 4. The first part presents coefficient estimates of the time varying TL function, followed by the heteroscedastic part and variables explaining the variation of efficiency scores.

Table 4. The final, restricted model

| | Coefficient | Std.Error | robust-SE | t-value | t-prob |
|---|---|---|---|---|---|
| Production Function | | | | | |
| Constant | 0.083354 | 0.02189 | 0.02159 | 3.86 | 0.000 |
| ln$X_1$ | 0.168925 | 0.01363 | 0.01333 | 12.7 | 0.000 |
| ln$X_2$ | 0.404391 | 0.01846 | 0.02465 | 16.4 | 0.000 |
| ln$X_3$ | 0.139387 | 0.01095 | 0.01342 | 10.4 | 0.000 |
| ln$X_4$ | 0.365551 | 0.01879 | 0.02348 | 15.6 | 0.000 |
| *Trend* | 0.010109 | 0.007908 | 0.008569 | 1.18 | 0.238 |
| ½ln $X_1^2$ | 0.095537 | 0.01049 | 0.01015 | 9.41 | 0.000 |
| ½ln $X_2^2$ | 0.161364 | 0.01669 | 0.02181 | 7.4 | 0.000 |
| ½ln $X_3^2$ | 0.058015 | 0.005986 | 0.005521 | 10.5 | 0.000 |
| ½ln $X_4^2$ | 0.222074 | 0.02009 | 0.02217 | 10 | 0.000 |
| ½$Trend^2$ | -0.02145 | 0.009284 | 0.009272 | -2.31 | 0.021 |
| ln$X_1$ln$X_2$ | -0.01585 | 0.008442 | 0.008097 | -1.96 | 0.05 |
| ln$X_1$ln$X_3$ | -0.01903 | 0.006629 | 0.00629 | -3.03 | 0.002 |
| ln$X_1$ln$X_4$ | -0.06198 | 0.01131 | 0.01087 | -5.7 | 0.000 |
| ln$X_1$*Trend* | 0.000668 | 0.005837 | 0.005511 | 0.121 | 0.904 |
| ln$X_2$ln$X_3$ | -0.04522 | 0.007828 | 0.008643 | -5.23 | 0.000 |
| ln$X_2$ln$X_4$ | -0.13785 | 0.01516 | 0.01901 | -7.25 | 0.000 |
| ln$X_2$*Trend* | -0.00574 | 0.007298 | 0.008087 | -0.71 | 0.478 |
| ln$\boldsymbol{X_3}$ln$X_4$ | 0.029343 | 0.007368 | 0.008187 | 3.58 | 0.000 |
| ln$\boldsymbol{X_3}$*Trend* | 0.008574 | 0.004334 | 0.004349 | 1.97 | 0.049 |
| ln$\boldsymbol{X_4}$ *Trend* | -0.01077 | 0.006917 | 0.0075 | -1.44 | 0.151 |
| ln{\sigma_v} | -1.14462 | 0.02346 | 0.02633 | -43.5 | 0.000 |
| Heteroscedastic Part | | | | | |
| ln$X_2$ | -0.2558 | 0.02498 | 0.03051 | -8.38 | 0.000 |
| ln$X_3$ | 0.062669 | 0.01661 | 0.02457 | 2.55 | 0.011 |
| ln$X_4$ | 0.185243 | 0.02853 | 0.03215 | 5.76 | 0.000 |
| Determinants of Technical Efficiency | | | | | |
| Trend | 0.556397 | 0.1626 | 0.2023 | 2.75 | 0.006 |
| EU dummy | -1.36894 | 0.3854 | 0.4354 | -3.14 | 0.002 |

| | | | | | |
|---|---|---|---|---|---|
| Company dummy | -1.82313 | 0.5376 | 0.7327 | -2.49 | 0.013 |
| Region 1 dummy | -1.04017 | 0.3035 | 0.3195 | -3.26 | 0.001 |
| Region 2 dummy | -0.67349 | 0.2268 | 0.2767 | -2.43 | 0.015 |
| Land to Labour Ratio | 5.33897 | 1.647 | 1.105 | 4.83 | 0.000 |
| Subsidies to Output Ratio | 0.150574 | 0.01237 | 0.01471 | 10.2 | 0.000 |
| Livestock Output to Total Output Ratio | -3.44241 | 1.192 | 1.061 | -3.24 | 0.001 |
| Livestock Output to Total Output Ratio$^2$ | 3.58264 | 1.304 | 1.224 | 2.93 | 0.003 |
| Soil Quality Index | -1.68387 | 0.2496 | 0.3089 | -5.45 | 0.000 |

The model appears to fit the data well, all the coefficients except trend and some input-time trend cross terms (the joint hypothesis that coefficients are time invarying was however rejected, see Table 3., hypothesis 4.) are statistically significant at 5%. Three input variables proved to be significantly explaining the heteroscedasticity in the model. Despite the significant differences between the amount of land farms are using (Table 1.), the total used land input was not significant in the heteroscedastic part. Regarding the determinants of efficiency, Table 4 shows that all explanatory variables included in the final model have a significant impact on efficiency. With the SFA approach, the estimated coefficients explain the cause of inefficiency in the model. Thus determinants with a positive sign suggest an obstacle to efficiency, while a negative sign indicates variables that enhance efficiency. Taken together, the parameters of the trend and the EU dummy jointly confirm what is suggested in Table 5, namely that pre-accession the efficiency was decreasing, starting to increase only u after accession.

The dummy for the legal form (Company dummy) indicates that companies are more efficient than family farms. This suggests that, despite the supervision and transaction costs problems that might arise in large farms, the size effect is prevailing.

Farms in regions 1 and 2 are more efficient than farms in region 3, with region 1 being the most efficient. Region 3 represents Észak Magyarország, (north of the

country) where both the economical, natural and geographic conditions for agriculture are worse than in the other two regions (Dunántúl, the western part of Hungary, and Alföld).

The positive sign of the land to labour ratio indicates that farms with a production system more intensive in labour are more efficient. The more labour per amount of land is used, the less inefficient farms are. This result it is somehow puzzling as it would suggest the scarcity of labour in the rural area. The large elasticity of labour (0.319) in the production function, (computed at the mean) supports this finding.

The subsidies to output ratio has a positive influence on inefficiency, suggesting that public subsidies prevent farms from being efficient. This result is in line with Guyomard et al.'s (2006) findings for French farms between 1992 and 2005.

The positive sign of the square of the livestock output to total output ratio indicates that mixed farms are more efficient than specialised farms, while the negative sign of the ratio indicates that, within specialised farms, livestock farms are more efficient than crop farms.

Finally, conform to the intuition, the effect of soil quality on technical efficiency is positive.

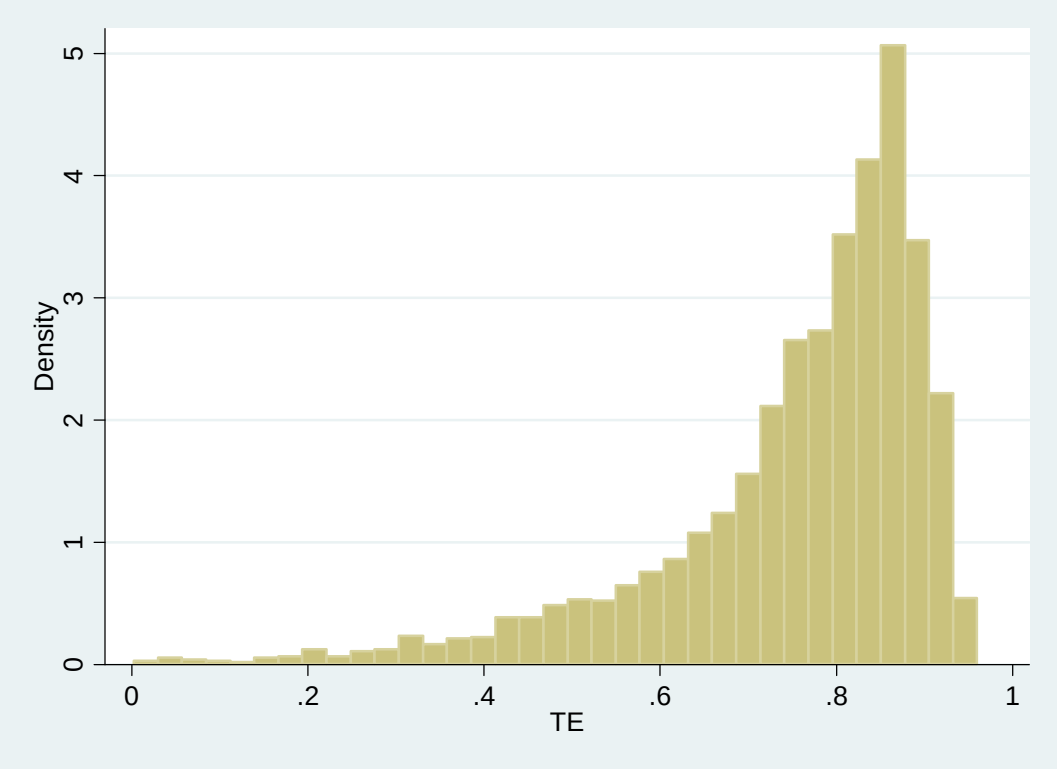
The distribution of average efficiency scores of all farms in Hungary, between 2001 and 2005 are depicted in Figure 1.

The individual yearly efficiency scores of farms were also computed, the average efficiency scores along with the descriptive statistics are presented in Table 5.

Table 5. Descriptive statistics of efficiency calculated with SFA

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| $Eff_{2001}$ | 0.776868 | 0.140404 | 0.034158 | 0.959925 |
| $Eff_{2002}$ | 0.760981 | 0.144353 | 0.058917 | 0.942716 |
| $Eff_{2003}$ | 0.727229 | 0.170429 | 0.001919 | 0.938317 |
| $Eff_{2004}$ | 0.759333 | 0.155343 | 0.002351 | 0.942024 |
| $Eff_{2005}$ | 0.745978 | 0.161478 | 0.04813 | 0.939528 |

Figure 1. The distribution of efficiency scores




The production factor elasticities for all Hungarian farms between 2001 and 2005 may be computed from the estimated model:

$$E_Y^{X_1} = \frac{\partial Y}{\partial X_1}\frac{X_1}{Y} = \frac{\partial \ln Y}{\partial \ln X_1} = 0.168 + 0.0955 \ln X_1 – 0.015 \ln X_2 - 0.019 \ln X_3 - 0.061 \ln X_4 + 0.0006t$$

$$E_Y^{X_2} = \frac{\partial Y}{\partial X_2}\frac{X_2}{Y} = \frac{\partial \ln Y}{\partial \ln X_2} = 0.404 + 0.161 \ln X_2 - 0.0158 \ln X_1 - 0.045 \ln X_3 - 0.137 \ln X_4 - 0.005t$$

$$E_Y^{X_3} = \frac{\partial Y}{\partial X_3}\frac{X_3}{Y} = \frac{\partial \ln Y}{\partial \ln X_3} = 0.139 + 0.058 \ln X_3 - 0.019 \ln X_1 - 0.045 \ln X_2 + 0.029 \ln X_4 + 0.008t$$

$$E_Y^{X_4} = \frac{\partial Y}{\partial X_4}\frac{X_4}{Y} = \frac{\partial \ln Y}{\partial \ln X_4} = 0.365 + 0.222 \ln X_4 - 0.0619 \ln X_1 - 0.137 \ln X_2 + 0.029 \ln X_3 - 0.01t$$

Than, the computed elasticities at the mean for Land, Intermediate Consumption, Capital, and Labour inputs are: 0.181, 0.411, 0.118 and 0.319. The highest elasticity corresponds to the Intermediate Consumption, and surprisingly Labour, suggesting

that output can be easily increased by using more seeds, fertiliser, pesticides and other variable inputs.

In the TL function, returns to scale are determined by the sum of output elasticities:

$$RTS = 1.075 - 0.001 \ln X_1 - 0.036 \ln X_2 + 0.023 \ln X_3 + 0.053 \ln X_4 - 0.006t$$

At the mean: *RTS=1.032*. The coefficient is close to 1, indicating that Hungarian farmers apply constant returns to scale (CRS) technology.

## 5. Discussion and Conclusions

This study has revealed that technical efficiency of Hungarian farms has increased post-accession. Access to better machinery and other inputs might be one reason. The EU direct payments per ha provided in the frame of the SAPS might have contributed to technological progress. On the other hand, subsidies were found to have a negative impact on efficiency. A positive influence on technological change and a negative influence on technical efficiency are not contradictory, and are conform to the theoretical expectations and previous studies (e.g. Guyomard et al., 2006). While subsidies enable farms to invest into high quality inputs, they reduce farmers' effort, implying greater waste of resources and further position from the efficient frontier (Martin an Page, 1983; Bergström, 1998).

The investigation of determinants of efficiency has also allowed to characterise the most efficient farms in Hungary: these are companies, mixed, located in Western Hungary (Dunántúl) and labour intensive.

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