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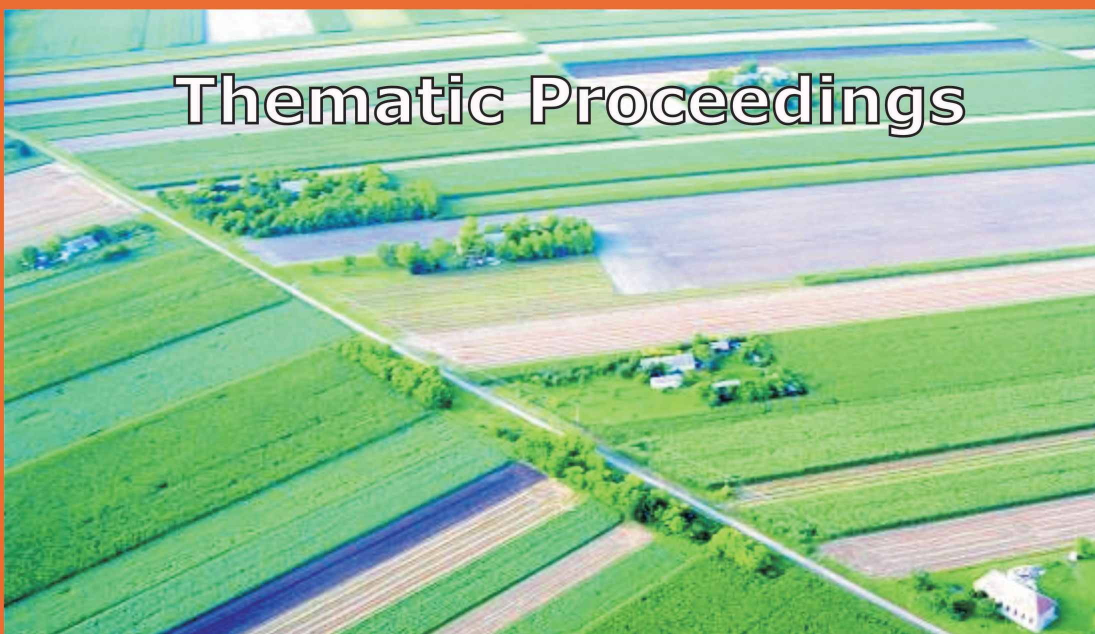

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TECHNICAL EFFICIENCY OF HUNGARIAN FARMS BEFORE AND AFTER ACCESSION

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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 pre-accession budget. 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. 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 (the only post-reform paper is by Mathijs and Vranken, 2001). 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. The paper is organised as follows: section 2 outlines the methodology. Data and results obtained with are reported and discussed in section 3, and finally, section 4 concludes.

METHODOLOGY

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):

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

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. 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, or TRANSLOG specifications. Since the two models are nested, it is possible to test the correct functional form by a Likelihood Ratio, LR test.

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:

$$u_{it} = \exp[(-\eta(t-T)]u_i \quad (3)$$

TE either increases (η>0), decreases (η<0) or it is constant over time, i.e. invariant (η=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 μ of the non-negative error term u_i:

$$\mu_i = \sum_j \delta_j z_{ij} \quad (4)$$

In frontier models, the consequences of heteroscedasticity are 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 σ_u:

$$\sigma_{ui} = \exp(\sum_j x_{ij}\rho_j) \quad (5)$$

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 Corra (1977), define γ, the share of deviation from the frontier that is due to inefficiency:

$$\gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2} \tag{6}$$

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

DATA AND MODEL SPECIFICATION

Hungarian FADN data between 2001 and 2005, provided by the Agricultural Research Institute, were used to build a balanced panel of 3210 observations. 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. 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). After significance tests, the following variables 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. The initial unrestricted model was used to test various hypotheses on parameters (Table 1.), than to formulate the final restricted model.

Table 1 Hypothesis testing

Null hypothesis	Test Statistic	5% Critical Value	Concl.
Hypothesis 1: SFA invalid ($\gamma = 0$)	884	'mixed' χ^2_{30} =43.19	Reject
Hypothesis 2: No inefficiency ($\delta_i = 0$)	822	'mixed' χ^2_{11} = 19.04	Reject
Hypothesis 3: Cobb-Douglas ($\beta_{ij} = 0$)	391.8	χ^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	χ^2_6 = 12.59	Reject
Hypothesis 5: No constant efficiency term ($\delta_0 = 0$)	0.66	χ^2_7 = 3.84	Do not reject
Hypothesis 6: Time invariant efficiency scores ($\delta_{Year} = 0$)	11.6	χ^2_7 = 3.84	Reject
Hypothesis 7: No heteroscedasticity (ρ_i=0)	87.26	χ^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 2.) 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 2.) 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 2.

Table 2 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
lnX_1	0.168925	0.01363	0.01333	12.7	0.000
lnX_2	0.404391	0.01846	0.02465	16.4	0.000
lnX_3	0.139387	0.01095	0.01342	10.4	0.000
lnX_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
lnX_1lnX_2	-0.01585	0.008442	0.008097	-1.96	0.05
lnX_1lnX_3	-0.01903	0.006629	0.00629	-3.03	0.002
lnX_1lnX_4	-0.06198	0.01131	0.01087	-5.7	0.000
lnX_1*Trend*	0.000668	0.005837	0.005511	0.121	0.904
lnX_2lnX_3	-0.04522	0.007828	0.008643	-5.23	0.000
lnX_2lnX_4	-0.13785	0.01516	0.01901	-7.25	0.000
lnX_2*Trend*	-0.00574	0.007298	0.008087	-0.71	0.478
lnX_3lnX_4	0.029343	0.007368	0.008187	3.58	0.000
lnX_3*Trend*	0.008574	0.004334	0.004349	1.97	0.049
lnX_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					
lnX_2	-0.2558	0.02498	0.03051	-8.38	0.000
lnX_3	0.062669	0.01661	0.02457	2.55	0.011
lnX_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 1., 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, the total used land input was not significant in the heteroscedastic part. Regarding the determinants of efficiency, Table 2 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 3, namely that pre-accession the efficiency was decreasing, starting to increase only 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 individual yearly efficiency scores of farms were also computed, the average efficiency scores along with the descriptive statistics are presented in Table 3.

Table 3 Descriptive statistics of TE scores

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

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.

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.

On a methodological point of view, this study has highlighted discrepancies in the results obtained from SFA and DEA. In particular, some determinants of efficiency are found to have an opposite sign. This suggests that, while both methods have advantages and shortcomings, their results alone should be treated with caution. Applying both methods can give clearer insights on the effects of several determinants on farm efficiency.

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