

Determinants of technical efficiency of Slovenian farms

Štefan Bojnec * and Laure Latruffe **



* University of Primorska, ** INRA Rennes



Motivation: To shed light on how farm performance might evolve and on which farms will possibly survive the international competition post-accession

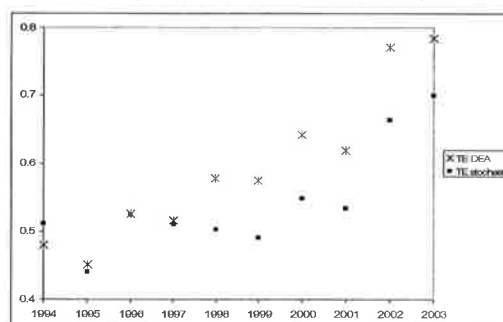
Methods: Farm performance is studied from the point of view of technical efficiency Calculated with stochastic frontier and non-parametric Data Envelopment Analysis (DEA)

Data: FADN, 1994-2003, family farms

Results:

- both methods give consistent results
- initial large inefficiencies (degree of technical efficiency increased from 0.5 to 0.8)
- a jump in efficiency prior the EU accession
- farm specialisation is a crucial determinant for increasing technical efficiency
- negative impact of farm commercialisation due to intra-farm intermediary consumption in livestock production
- negative influence of public support

Figure: Evolution of technical efficiency calculated with DEA (TE DEA) and with stochastic frontier (TE stochastic)



	Determinants of technical <u>inefficiency</u> calculated with stochastic frontier		Determinants of technical <u>efficiency</u> calculated with DEA	
	coefficient	significance	coefficient	significance
Constant	-0.110	***	0.870	***
Share of hired labour	-0.298		0.002	
Share of rented land	-0.178		0.001	**
Share of marketed output	0.225	***	-0.006	**
Herfindahl specialisation index	-0.263	*	0.206	***
Production subsidy to revenue ratio	0.214	***	-1.090	***
Time trend	-0.472	***	0.032	***
Log likelihood	25.60		134.05	

*** 1 percent level of significance; ** 5 percent level of significance; * 10 percent level of significance

Conclusions: technical efficiency growth might slow down after accession due to increased support; but positive influence of public support can be expected on technological change, and thus on farm productivity

Future research: impact of the EU accession on farm productivity

Determinants of technical efficiency of Slovenian farms

Štefan Bojnec * and Laure Latruffe **

* University of Primorska, ** INRA Rennes

Support for the poster presented at the 103rd seminar, Barcelona, 23-25 April 2007

Abstract

This paper investigates the determinants of technical efficiency of Slovenian farms employing the parametric stochastic frontier and non-parametric Data Envelopment Analysis (DEA) methods. The inherited initial inefficiencies of Slovenian family farms are confirmed by their relatively low technical efficiency. During the analysed period 1994-2003 the degree of technical efficiency has increased from around 0.5 to almost 0.8. Farm specialisation associated with technological change is found to be a crucial determinant for increasing technical efficiency. The negative impact of farm commercialisation on technical efficiency is explained by a specific nature of livestock farms, in particular, with intra-farm intermediary consumption. The use of hired labour has no significant influence, but mixed results are found for rented land. The results suggest possible sources of imperfections in farm input markets.

For correspondence:

Štefan Bojnec, Faculty of Management, University of Primorska,

Cankarjeva 5, 6000 Koper, Slovenia, e-mail: stefan.bojnec@fm-kp.si

Determinants of technical efficiency of Slovenian farms

1. Introduction

The Slovenian agriculture is based on family farms of a relatively small size. Most of land has always been in individual ownership and operation. During the communist system, the individual farms were constrained by institutional limitations on their size (Bojnec and Swinnen, 1997). Slovenia entered the transition process with a relatively large number of small, individual family farms often with a part-time orientation. They operated their owned land and, except for specific harvesting services, rarely used hired labour. They significantly produced for farm home consumption needs and sold surpluses of production. The process of specialisation was developed by more advanced, often more viable private farms.

The transition reform process has aimed to support individual farm development. Most of this support has been delivered in a form of market-price supports (OECD, 2001). Since 1994, Slovenia is part of regional bilateral and multilateral free-trade agreements in a view to adjust and prepare its agricultural sector for European Union (EU) membership. The process of trade liberalization has increased competitive pressures. The Slovenian agricultural sector was affected by a lack of international competitiveness, due to high production costs, high costs of capital and labour (Bojnec, 1999). Farm factors performance is related to farm input markets and farm structures, and might have impacts on competitiveness. The increasing competitive pressures on Slovenian agriculture motivates this research, as studying the factors of Slovenian farms' performance during the transition period might shed light on the farms that will possibly survive the international competition post-accession.

The paper contributes to the existing literature in two significant directions. Firstly, the performance of the Slovenian agriculture has rarely been investigated, and secondly not on an extended period. Only Brümmer (2001) studied the factors of technical efficiency for Slovenian farms, but for the years 1995-1996 only. Our paper investigates the determinants of technical efficiency of Slovenian individual farms over the period 1994-2003. By identifying the determinants explaining the increase in farm technical efficiency or decrease in farm technical inefficiency, we aim at investigating the causalities between possible farm factor market imperfections and farm performance for Slovenian farms. Farm performance is proxied here by technical efficiency, which refers to the ability of farms to use at best the existing technology, in terms of input or output quantities. We employ the parametric stochastic frontier and non-parametric Data Envelopment Analysis (DEA) estimation approaches to compare the consistency and relevance of our empirical results. We also compare our results with similar studies to underline similarity, but particularly possible country-specificity, for broader policy relevance.

2. Methodology

2.1. Methods used

There exist two main competing methods for investigating technical efficiency and its determinants: the parametric method using a stochastic frontier, and the non-parametric method DEA. Both having advantages and disadvantages, it is difficult to choose one over the other. For this reason, this paper applies both and compares their results with the idea that findings are reliable one when they are confirmed and consistent by both methods.

The stochastic frontier method assumes that the production function includes a double random error (Aigner et al., 1977; Meeusen and van den Broeck, 1977):

$$\ln Y = f(X) + v - u \tag{1}$$

where Y is the observed output, $f(X)$ is the production function using factors X , v is a standard error term and u is a non-negative random term, with $\exp(-u)$ representing the technical efficiency.

Determinants of technical efficiency are estimated simultaneously with the production function (1), with the mean of the conditional distribution $E(u|v-u)$ being parameterised in terms of several explanatory variables (Battese and Coelli, 1995).

In opposite to the stochastic frontier method, DEA is a deterministic method, meaning that all deviation from the frontier is attributed to inefficiency only. However, the method does not require any distributional or specification assumptions. DEA is non-parametric, in the way that linear programming is needed to solve a maximisation program under constraints (see Farrell, 1957, for the idea and Charnes et al., 1978, for the model). The idea of the DEA method is that the efficient frontier is constructed from the sample itself, and the inefficiency is given by the distance to the frontier. A farm on the frontier has an efficiency score of 1, while the further away a farm from the frontier is situated, the lowest its efficiency score. In order to have as close comparison as possible with the stochastic frontier method, we use an output-oriented model for DEA, that estimates the potential output increases without further input increases. In the case of DEA, the determinants of technical efficiency are investigated in a second stage, where the efficiency scores are regressed over a set of explanatory variables. Two main estimators have been used in the literature for this second stage: the Ordinary Least Squares (OLS) estimator or the Tobit estimator (e.g. Latruffe et al., 2004). The latter one is sometimes preferred due to the censored nature of the DEA distribution to 1. However, we argue that when a high share of farms is located on the frontier, a Tobit model is not the most appropriate model: the distribution is in fact not censored but truncated. Therefore, a truncated regression, based on maximum likelihood, is used in this paper for the second stage of DEA.

2.2. Variables used

To calculate technical efficiency of Slovenian individual farms, one output and four inputs are used. The output variable is the value of total revenue. The inputs consist in the utilised land in ha, labour in Annual Working Units (AWU), the value of total assets as a capital variable, and the value of variable inputs. All years in the period 1994-2003 are pooled together, and therefore values were deflated appropriately. The nominal output data are deflated by the agricultural producer price index and the nominal input data are deflated by the agricultural input price index, which were provided by the Statistical Office of the Republic of Slovenia (SORS).

Three main groups of variables are employed as determinants of technical efficiency, based on the literature of farm technical efficiency in transition and Western economies (Brümmer, 2001; Giannakas et al., 2001; Latruffe et al., 2004; Mathijs and Vranken, 2001; Rezitis et al., 2003). Firstly, three variables representing the family character of the farms are included: the share of hired labour in total labour used and the share of rented land in the utilised area, in order to capture the effects of the reliance on external factors on technical efficiency; and the share of marketed output in total output as a proxy for farm commercialisation and its non-subsistence character. The reliance on external production factors has ambiguous impact on technical efficiency. On the one hand, hired labour might be more qualified and skilled than family labour to provide specific farm services and thus enhance farm performance; on the other hand, the family workforce is the claimant for residual profit and hired labour might be plagued by shirking, therefore family's effort might be higher and thus more efficient. As for land, ownership gives incentives to farmers to apply soil improving techniques, which might result in higher technical efficiency. However, the obligation to pay rentals regularly might encourage tenanted farmers to limit waste of inputs and thus be more efficient. Regarding the share of marketed output, the common expectation is that farmers more integrated in downstream markets are more efficient as it enables them to acquire knowledge and information, and to collect cash receipts necessary for investing in high

quality inputs. However, by contrast subsistence farmers might be more efficient than commercialised farmers.

The second main variable used is a proxy for farm specialisation. Here again, the influence on technical efficiency is not clear-cut. Generally, it is thought that more specialised farms may be more efficient as there is no competition for land between activities, and farmers can concentrate and focus their managements. On the other hand, mixity can be a way to reduce production risk. Harvest losses for one activity can be offset by other productions, making mixity more efficient in this case. To proxy farm specialisation, we use the Herfindahl index, calculated as the sum of the squared shares of each activity in the farm total revenue. 13 activities retained for this index: cereals and maize, other field crops, vegetables and flowers, fruits, wine and grape, fodder crop, other crops, dairy, beef, pork, sheep and goat, other livestock, and other activities. A larger Herfindahl index indicates higher specialisation, that is to say less numerous activities, with an index of 1 for fully specialised.

The third main determinant is the ratio of subsidies for production to total revenue, to capture the effect of the reliance on subsidies. The latter might reduce farmers' effort, and thus their technical efficiency.

Finally, a time trend is included, in order to assess how technical efficiency has developed during the transition in Slovenia.

3. Data used

The data used in this paper relate to individual farming only. The data are obtained from the Slovenian Farm Accountancy Data Network (FADN) that was provided by the Ministry of Agriculture, Forestry and Food (MAFF) of Slovenia. Due to the small number of farmers in the

country, farm-level data are not released. Only averages per production branches are available. In total data for 13 branches over 1994-2003 were used here, thus a total of 130 observations.

Table 1 displays summary statistics for the output, inputs and explanatory variables, per year. By size, farms are relatively small, between 10 and 22 ha over the analyzed period 1994-2003, compared to the European average (40 ha in 2003). Most of the individual farms in Slovenia are even smaller, but the sample average is increased by extensive sheep farms (about 40 ha). Farm size (in terms of output and all inputs) has increased in 2000 and onwards. Farms really mostly on family production factors: about 10 percent of the labour is hired, and about 30 percent of the land is rented in. However, they are not really subsistence farming, as more than 90 percent of their production is commercialised. Regarding the Herfindahl index, it shows that farms are not highly specialised (index of 0.40 about), but specialisation has been steadily increasing up to 2001. Whereas OECD (2001) stresses the need to limit price-distorting policies, the direct reliance of farms on subsidies from the government budget seems to be relatively low or has been underreported by the Slovenian farms during the transition period, as the ratio of subsidies obtained from the government budget to total revenue is very low for all years, less than 4%, except of a high increase in 2001 to 12%.

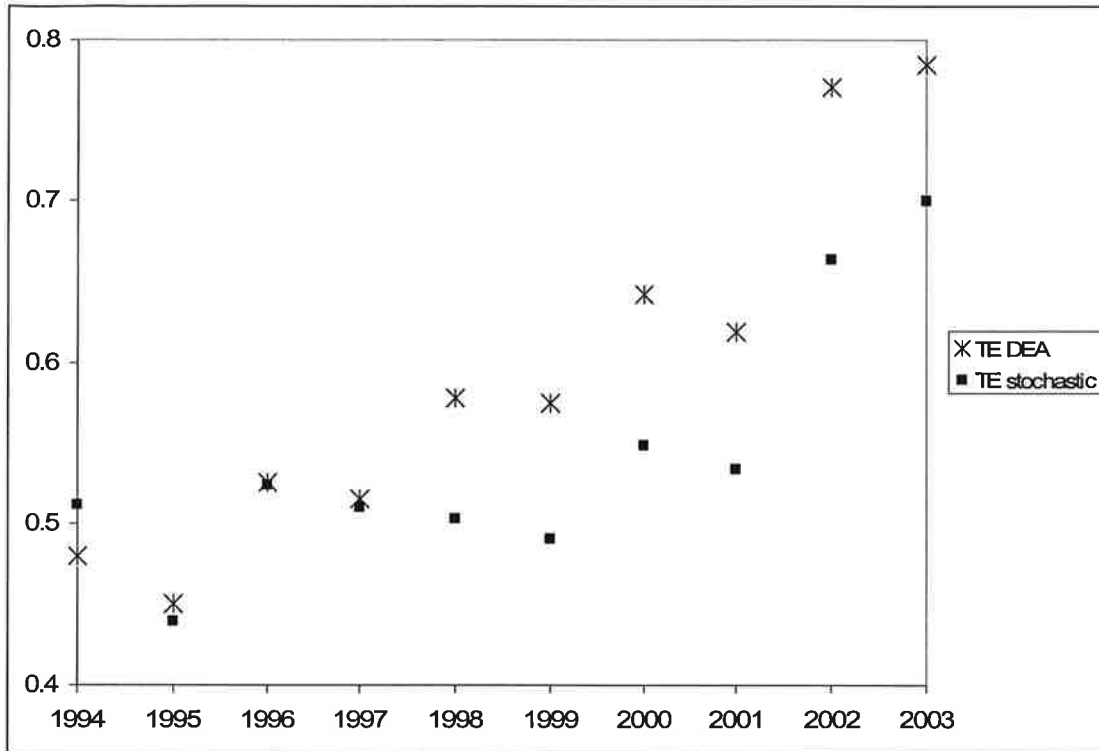
Table 1: Summary statistics of output, inputs and the determinants of the technical efficiency by years: sample's averages

	Total revenue (mio SIT 1994 prices)	Land (UAA ha)	Labour (AWU)	Capital (mio SIT 1994 prices)	Variable inputs (mio SIT 1994 prices)	Share of hired labour (%)	Share of rented land (%)	Share of marketed output (%)	Herfindahl specialisation index	Production subsidy to revenue ratio
1994	2.49	12.39	2.02	12.9	1.43	1.92	25.3	88.32	0.3224	0.0183
1995	2.99	12.59	2.05	15.2	1.65	4.13	30.8	92.31	0.3321	0.0222
1996	3.17	12.14	2.29	12.4	1.78	3.03	20.8	92.87	0.3593	0.0280
1997	3.32	11.14	2.08	12.6	1.92	3.19	19.7	93.66	0.3725	0.0235
1998	3.99	10.98	2.26	12.3	2.35	10.26	21.9	93.73	0.4110	0.0289
1999	4.36	12.15	2.01	14.7	2.70	4.42	25.0	92.42	0.4065	0.0387
2000	7.39	15.89	2.31	21.1	4.35	8.07	32.3	94.31	0.4604	0.0392
2001	7.72	16.40	2.09	22.4	5.29	8.79	38.0	95.37	0.4626	0.1221
2002	7.51	21.50	5.57	30.4	3.64	4.27	24.5	94.85	0.3859	0.0090
2003	7.27	18.49	5.39	29.4	3.52	4.09	25.2	94.85	0.3898	0.0090

4. Empirical results

For the whole period studied 1994-2003, technical efficiency calculated with stochastic frontier and with DEA, is on average 0.54 and 0.59, respectively. Results from both methods are comparable and consistent, and suggest substantial potential for technical efficiency improvement. They indicate that on average, between 1994 and 2003, farms of the sample could have increased their output by 46% or 41%, respectively, without increasing their input use. The technical inefficiency is reduced over time, as confirmed by the higher final 2003 situation of about 0.75 average technical efficiency. Figure 1 shows the yearly technical efficiencies calculated with DEA and stochastic frontier, as averages for the sample. Both methods show clearly that technical efficiency has clearly increased over the period studied, with noticeable increase during the last two years (2002-2003). As technical efficiency has been calculated over a pooled sample (all years 1994-2003 pooled together), it might suggest that not only farms have become more homogenous in terms of their practices (thus closer to the frontier), but also that the technology has improved over time.

Figure 1: Evolution of technical efficiency calculated with DEA (TE DEA) and with stochastic frontier (TE stochastic)



The results regarding the determinants of technical efficiency are provided in Table 2 for the stochastic frontier estimates and Table 3 for the DEA estimates. As it has been explained in Section 2, the determinants of inefficiency are investigated for the case of stochastic frontier model. Therefore, in Table 2, a negative (positive) sign indicates a source of (obstacle to) efficiency.

Firstly, the time trend variable in both methodological approaches indicates that technical efficiency has increased over time, confirming the findings from Figure 1.

Both methods show that the share of hired labour has not had significant influence on technical efficiency, suggesting that whether farms resort to hired labour or family labour mostly does not affect their efficiency. As for rented land, its share has a non significant coefficient in the case of

the stochastic frontier method, but a positive significant coefficient in the case of DEA. Because of this discrepancy in findings, we conclude that the influence of rented land is undetermined.

The share of marketed output as a measure of farm direct commercialisation has a negative impact on technical efficiency, as shown by both methods. This suggests that those farms that have a stronger intermediary subsistence character are more efficient. This unintuitive result is in opposite with theory and previous studies for some other transition countries (e.g. Latruffe et al., 2004 for Poland; Mathijs and Vranken, 2001 for Bulgaria and Hungary), but is likely to be related to types of farming rather than to integration in downstream market. The share of non-marketed output is the highest for livestock farms, suggesting that it is mainly fodder that makes a significant difference. Thus, this implies that livestock using the fodder produced on-site are more efficient than those purchasing it outside their farm, suggesting possible sources of imperfections in agricultural input as well as output markets.

The results from both methods are also consistent regarding the role of the degree of specialisation. The significant positive influence of the Herfindahl index of specialisation on technical efficiency indicates that the issue of harvest risk is less important for the performance of Slovenian farmers, than their ability to concentrate their management on a few activities only. The positive impact of specialisation found here is in opposite with Brümmer's (2001) results for the same country using stochastic frontier on data for the years 1995-1996. Our result suggests that the increase in technical efficiency over time can largely be attributed to the greater specialisation of Slovenian farms.

Finally, the effect of direct production budgetary subsidies is negative, in line with all previous studies incorporating such variable in their analysis (Bakucs et al., 2006; Giannakas et al., 2001; Guyomard et al. 2006, Rezitis et al., 2003). Thus, despite lower level of the direct production

budgetary support during the period studied, subsidies still had a negative effect on technical efficiency, by reducing farmers' efforts.

Table 2: Determinants of technical inefficiency calculated with stochastic frontier

	coefficient	t-ratio	significance
Constant	-0.110	-2.02	***
Share of hired labour	-0.298	-0.95	
Share of rented land	-0.178	-1.29	
Share of marketed output	0.225	3.69	***
Herfindahl specialisation index	-0.263	-1.77	*
Production subsidy to revenue ratio	0.214	5.27	***
Time trend	-0.472	-4.62	***
Log likelihood	25.60		

*** 1 percent level of significance; ** 5 percent level of significance; * 10 percent level of significance

Table 3: Determinants of technical efficiency calculated with DEA

	coefficient	z-ratio	significance
Constant	0.870	3.33	***
Share of hired labour	0.002	1.25	
Share of rented land	0.001	2.02	**
Share of marketed output	-0.006	-2.01	**
Herfindahl specialisation index	0.206	2.69	***
Production subsidy to revenue ratio	-1.090	-5.00	***
Time trend	0.032	7.20	***
Log likelihood	134.05		

*** 1 percent level of significance; ** 5 percent level of significance; * 10 percent level of significance

5. Conclusion

The Slovenian farms at the beginning of the 1990s had been burdened by the inherited limitations from the institutional constraints during the previous system. In this paper, their input-output mix was found to be less efficient as shown by the technical efficiency score, which is rather low (about 0.5) at the beginning of the period studied in 1994; this suggests that the Slovenian individual farms had been characterised by a heterogeneity in farming practices. However, the gap in technical inefficiency has been reduced during the transition, with average technical efficiency increasing steadily until 2003. The period was especially marked by a jump in efficiency in 2002 during the Slovenian preparation for accession to the EU that focused on structural adjustment to increase farm concentration and their specialisation.

Slovenian farms conform to the theory and previous studies on other countries, in terms of the negative influence of public support on their technical efficiency. With the accession to the EU and to the Common Agricultural Policy high subsidies, the efficiency increase might slow down after 2004. However, reduced technical efficiency does not contradict a possible technology improvement with the help of subsidies. A further research might thus be to investigate the productivity and technological change of Slovenian farms during the transition and after accession.

Acknowledgement

We thank Neva Pajntar from the Chamber of Agriculture and Forestry and Jože Boncelj from the Ministry of Agriculture, Forestry and Food in Slovenia for providing access to the Farm Accountancy Data Network (FADN) data.

References

- Aigner, D., Lovell, C., Schmidt, P. 1977. Formulation and estimation of stochastic production function models, *Journal of Econometrics*, 6: 21-37.
- Bakucs, L., Latruffe, L., Fertő, I., Fogarasi, J. 2006. Technical Efficiency of Hungarian Farms Before and After Accession. Paper presented at the conference 'Transition in Agriculture – Agricultural Economics in Transition III', Budapest, 10-11 November.
- Battese, G., Coelli, T. 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, 20: 325-332.
- Bojnec, Š., Swinnen, J.F.M. 1997. Agricultural Privatisation and Farm Restructuring in Slovenia, in Swinnen, J.F.M., Buckwell, A. and Mathijs, E. (eds.), *Land Reform, Agricultural Privatisation and Farm Restructuring in Central and Eastern Europe*, Aldershot: Ashgate, 281-310.
- Bojnec, Š. 1999. The competitiveness of Slovenian farms and food processing activities, *Agrarwirtschaft*, 48(8/9): 295-303.
- Brümmer, B. 2001. Estimating confidence intervals for technical efficiency: The case of private farms in Slovenia. *European Review of Agricultural Economics*, 28(3): 285-306.
- Charnes, A., Cooper, W., Rhodes, E. 1978. Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2: 429-444.
- Farrell, M. 1957. The measurement of productive efficiency. *Journal of the Royal Statistical Society*, 120(3): 253-281.
- Giannakas, K., Schoney, R., Tzouvelekas, V. 2001. Technical efficiency, technological change and output growth of wheat farms in Saskatchewan. *Canadian Journal of Agricultural Economics*, 49: 135-152.
- Guyomard, H., Latruffe, L., Le Mouél, C. 2006. *Technical Efficiency, Technical Progress and Productivity Change in French Agriculture: Do Farms' Size and Subsidies Matter?* Paper presented at the 96th EAAE Seminar 'Causes and Impacts of Agricultural Structures', Tänikon, Switzerland, 10-11 January.
- Latruffe, L., Balcombe, K., Davidova, S., Zawalinska, K. 2004. Determinants of technical efficiency of crop and livestock farms in Poland. *Applied Economics*, 36(12): 1255-1263.
- Mathijs, E., Vranken, L. 2001. Human capital, gender and organisation in transition agriculture: Measuring and explaining technical efficiency of Bulgarian and Hungarian farms. *Post-Communist Economies*, 13(2): 171-187.
- Meeusen, W., van den Broeck, J. 1977. Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review*, 18: 435-444.
- OECD. 2001. *Review of Agricultural Policies: Slovenia*. Paris: Organisation for Economic Co-operation and Development.
- Rezitis, A., Tsiboukas, K., Tsoukalas, S. 2003. Investigation of factors influencing the technical efficiency of agricultural producers participating in farm credit programs: The case of Greece. *Journal of Agricultural and Applied Economics*, 35(3): 529-541.