Research Institute of Agricultural Economics
Committee on Agricultural Economics, Hungarian Academy of Sciences

# STUDIES IN AGRICULTURAL ECONOMICS No. 110.

**Budapest**
**2009**

**Studies in Agricultural Economics No. 110.**

**The Studies in Agricultural Economics** is a scientific journal published by the Hungarian Academy of Sciences and the Research Institute of Agricultural Economics, Budapest. Papers of agricultural economics interpreted in a broad sense covering all fields of the subject including econometric, policy, marketing, financial, social, rural development and environmental aspects as well are published, subsequent to peer review and approval by the Editorial Board.



Manuscripts should be sent via e-mail to the Editor-in-chief (aki@aki.gov.hu). Instructions for the authors can be found on the website of the Research Institute of Agricultural Economics: http://www.aki.gov.hu

HU ISSN 1418 2106

Studies in Agricultural Economics No. 110. p. 75-84. (2009)

# Technical efficiency in dairy farming: A comparison of France and Hungary in 2001-2006

Fogarasi, József[1]
Latruffe, Laure[2]

**Abstract**

The paper investigates the difference in technical efficiency and potential technology gap between French and Hungarian dairy farms during 2001-2006, using Data Envelopment Analysis under each country's respective frontier and under a common frontier (metafrontier). Results indicate that French farms have a more optimal scale of production than Hungarian farms, but Hungarian farms make better use of the technology. They also have a more productive technology than French farms. The latter finding is obtained under the assumption of a hypothetical common frontier. Although French and Hungarian farmers do not have access to the same technologies and the metafrontier is still hypothetical, our paper adds to the thin literature that compares two countries in terms of performance.

**Keywords**

technical efficiency, technology gap, dairy farms, France, Hungary

## Introduction

The paper investigates the difference in technical efficiency between French and Hungarian dairy farms in the period 2001-2006, and compares their technology potential. Comparing two countries in terms of efficiency and technology has not been widely studied. In the European Union (EU), one can mention the study by Brümmer et al. (2002) about dairy farms in Germany, the Netherlands and Poland over the period 1991-1994. The authors use a parametric approach, namely the stochastic frontier analysis and found that Polish farms had the lowest average technical efficiency. In this paper the non-parametric approach Data Envelopment Analysis (DEA) is employed. Specifically, the method used here to compare Hungarian and French farms is the one proposed by Charnes et al. (1981) to compare two types of education programmes. The method has for example been used by Oude Lansink et al. (2002) to compare organic and conventional farms' technology in Finland. The method consists in calculating two technical efficiency scores. Technical efficiency, that is to say the ability of a farm to use the best existing technology in terms of quantities, is calculated firstly under each country's own efficient frontier, in order to assess the room for improvement within each country. Then, the measure is calculated under a common frontier (metafrontier), that is to say using the merged sample of both countries, in order to understand which country is lagging behind in terms of technology under the assumption of a common hypothetical frontier.

France and Hungary differ largely in terms of natural and economic conditions, and in terms of policy support. Dairy farming in France is mostly located in the Western lowlands (Brittany, Normandy; 45% of the country's dairy area) and in mountainous areas (Alps, Jura, Central France; 28% of the country's dairy area). During the period studied (2001-2006), French farmers benefited from intervention prices for specific dairy products in the frame of the Common Agricultural Policy (CAP) and were subject to production quotas. Intervention prices have however been reduced and compensating dairy premiums introduced. And since 2006, French farms receive Single Farm Pay-

[1] Research Institute of Agricultural Economics, H-1463 Budapest, POB 944. fogarasi.jozsef@aki.gov.hu
[2] INRA, UMR1302, F-35000 Rennes, France. laure.latruffe@rennes.inra.fr
Agrocampus Ouest, UMR1302, F-35000 Rennes, France.

ments (SFP), payments per hectare whose amount is specific to farms and depends on the level of support (on the quotas, in the case of dairy farms) previously received. In Hungary dairy farms are predominantly located in the Northern Great Plain and Southern Great Plain (43% of the country's dairy area) as well as in the Transdanubian area (Central Transdanubia, Western Transdanubia and Southern Transdanubia; 42% of the country's dairy area). During the analysed period, national support for milk production was mainly in the form of price support as an effort to stop the fall in milk production. Between 1990 and 2000 the production decreased from 2,763 to 2,081 million litres and from 2003 onwards, the country became a net importer of dairy products (Udovecz et al., 2008). The milk processing industry was privatised in the 1990s and the process was considered a success. The industry is now operated by international brands (Friesland, Danone, Bongrain, etc). Since EU accession in 2004, Hungarian dairy farms are subject to community regulation: the production is limited by milk quotas, and all farms receive payments in the frame of the CAP, namely Single Area Payments (SAP). By contrast to SFP in the EU-15, in Hungary all farms receive the same amount of SAP per hectare. In addition, dairy farms received coupled complementary payments from the national budget (top-up) as milk premium in the first three years of EU accession: 8.06, 17.65 and 32.27 EUR per thousands litres in 2004, 2005 and 2006 respectively. Since 2007, this milk premium of 31.99 EUR per ton has been shifted to decoupled payments, the amount being computed based on historical milk quotas (Aliczki et al., 2009).

The paper is structured as follows. The next section explains the methodology used, while the third section presents the data. The fourth and fifth sections provide the results and some conclusions, respectively.

## Methodology

The non-parametric method DEA is preferred in this paper over the stochastic frontier method. The latter necessitates assumptions about the production function and the error term distribution, and therefore may induce potential misspecifications. By contrast, DEA uses linear programming to construct the efficient frontier with the best performing observations of the sample used, so that the frontier envelops all observations (see Charnes et al., 1978). The distance from a farm to the frontier provides a measure of its efficiency, and the further the farm, the less efficient it is. DEA also enables to assess under which returns to scale each farm operates and to calculate its scale efficiency. Calculating efficiency under the assumption of constant returns to scale (CRS) gives the so-called total technical efficiency score, while assuming variable returns to scale (VRS) allows calculating one component of this total efficiency score, namely the pure technical efficiency. This component captures whether farmers make optimal use of the technology disregarding the farm size, while the residual between total technical efficiency and pure technical efficiency shows whether the farm operates under optimal farm size. This residual is called the *scale efficiency* and can be interpreted as the potential scale economies available to the farm (i.e. the potential move on the production frontier to reach the point of optimal production scale). Efficiency (total, pure and scale) scores that are obtained range between 0 and 1; the score 1 indicates a fully efficient farm (i.e. on the frontier) and a larger score indicates higher efficiency.

An *output-orientated* model is used, with two outputs – the quantity of milk produced in litres and the value of the other farm output in euros –, and five inputs – the agricultural utilised area in hectares, the labour used in Annual Working Units (AWU) equivalents (1 AWU corresponding to 2,200 hours of work per year), the value of total assets in euros, the value of intermediate consumption in euros, and the number of livestock units (calculated with the EU definition). All values were deflated by relevant price indices. The use of an output-orientated model against an input-orientated model implies that we assume that it is easier for farmers to modify their output volumes than their input quantities. However, as noted by Coelli et al. (2005), both models produce similar results, and therefore the choice of orientation is not important.

Yearly efficiencies are calculated, that is to say a frontier is constructed for each year. In order to compare the performance between France and Hungary, firstly separate frontiers for each country are used. This can show how farms in each country perform with respect to their own country's technology. Then both countries are merged in a common sample supposing a hypothetical common technology and a common frontier (metafrontier) is constructed. This allows investigating which country has the more productive technology, by calculating a technology ratio for each farm. This measure is calculated as the ratio between the efficiency score calculated under the common frontier and the efficiency score calculated under the respective country's frontier (Charnes et al., 1981). Average technology ratios for French farms and Hungarian farms are then compared, the higher average indicating the country with the more productive technology while the lower indicating a technology gap.

The calculations were performed using the software DEAP developed by Coelli (1996). The linear programming model for the output-orientation is as follows (Coelli et al., 2005).

$$\max_{\theta,\lambda} \theta \quad (1)$$

$$\text{s.t.} \quad -y_i + Y\lambda \geq 0 \quad (2)$$

$$x_i - X\lambda \geq 0 \quad (3)$$

$$\lambda \geq 0 \quad (4)$$

$$N\lambda \geq 0 \quad (5)$$

where Y and X are respectively the sample's outputs and inputs; $y_i$ and $x_i$ are respectively the i-th farm output and input; N is a vector of 1; $\lambda$ is a matrix of parameters. $1/\theta$ gives the technical efficiency score. Constraint (5) ensures the assumption of VRS; the assumption of CRS holds when this constraint is removed.

## Data

Farm Accountancy Data Network (FADN) data are used for both countries. Farms with the European type of farming dairy (TF41) were extracted each year between 2001 and 2006, providing unbalanced samples. Table 1 gives the number of observations in each year in each country.

Table 1

**Samples' size: number of observations per year and per country**

| | France | Hungary |
|---|---|---|
| 2001 | 1,257 | 100 |
| 2002 | 1,219 | 104 |
| 2003 | 1,116 | 98 |
| 2004 | 1,038 | 78 |
| 2005 | 956 | 94 |
| 2006 | 963 | 100 |

Source: French and Hungarian FADN data.

Table 2 presents the average outputs and inputs for both countries over the period studied. Hungarian farms are much larger than French farms; for example, they operate on average 258 ha of land against 77 ha for French farms. The size discrepancy is visible for both outputs and inputs: Hungarian farms produce much more outputs and use much more inputs. However, the difference is not so sharp with regard to the capital. This may come from the fact that, during the transition, Hungarian dairy farmers may have faced financing constraints and may not have been able to replace a potentially obsolete technology or to increase their owned equipment. Fertő et al. (2009) for example showed that Hungarian farmers' investment decisions were constrained between 2000 and 2004 due to a lack of financing. Table 2 also provides country's averages of animal yield (milk output per livestock unit) and of animal density (livestock unit per agricultural utilised land). Values are fairly similar in both countries.

Table 2

**Description of the samples: average values per country for the whole period 2001-2006**

| | France | Hungary |
|---|---|---|
| Milk output (thousand litres) | 264.9 | 976.8 |
| Other output (thousand euros) | 35.8 | 174.9 |
| Agricultural utilised land (ha) | 77.2 | 257.8 |
| Labour (AWU) | 1.8 | 13.4 |
| Capital (thousand euros) | 219.4 | 341.9 |
| Intermediate consumption (thousand euros) | 68.7 | 214.2 |
| Livestock units | 88.9 | 254.3 |
| Milk output (litres) per livestock unit | 2,747 | 2,935 |
| Livestock units per agricultural utilised land (units per ha) | 1.3 | 1.4 |
| Total number of observations | 6,549 | 574 |

Source: Authors' calculations based on French and Hungarian FADN data.

## Results

### Technical efficiency calculated under each country's respective frontier

Table 3 presents the descriptive statistics for technical efficiency calculated with regard to the countries' respective frontier. For the whole period 2001-2006, the average total technical efficiency (i.e. under CRS) is slightly lower for France (0.723) than for Hungary (0.791). This indicates that French farms can increase their output production by 27.7% and Hungarian farms by 20.9%, without having to increase their input use. The difference between both countries' total technical efficiency mainly stems from a difference in pure technical efficiency (i.e. under VRS) (0.762 vs. 0.842) rather than from a difference in scale efficiency (0.950 vs. 0.940). This suggests that within the French sample there are more farms far from the efficient frontier than in the Hungarian sample. One quarter of Hungarian farms are scale efficient (i.e. operating under CRS) while the share is only 8% of the French sample. In both countries, farms that are not scale efficient are almost equally split between too small farms (i.e. operating under IRS) and too large farms (i.e. operating under DRS).

Table 3

**Yearly technical and scale efficiency as averages for the whole period 2001-2006; calculation under the countries' respective frontiers**

| | France | Hungary |
|---|---|---|
| Total number of observations | 6,549 | 574 |
| Average total technical efficiency (under CRS) | 0.723 | 0.791 |
| Average pure technical efficiency (under VRS) | 0.762 | 0.842 |
| Average scale efficiency | 0.950 | 0.940 |
| Share of farms with score of 1: | | |
| for technical efficiency under CRS (%) | 8 | 25 |
| for technical efficiency under VRS (%) | 8 | 39 |
| for scale efficiency (%) | 8 | 27 |
| Share of farms operating under: | | |
| CRS (%) | 8 | 28 |
| IRS (%) | 43 | 34 |
| DRS (%) | 49 | 38 |

Source: Authors' calculations.

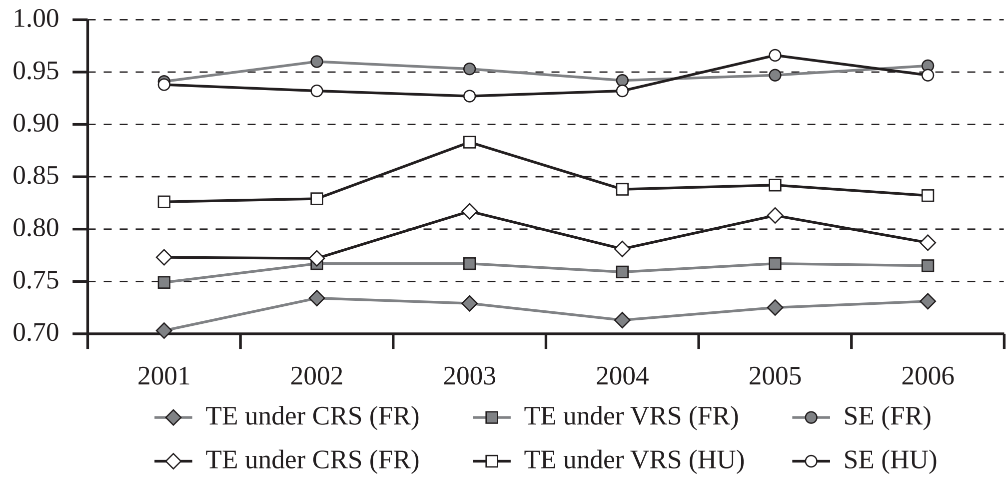


**Figure 1: Evolution of yearly technical (TE) and scale (SE) efficiency over the period 2001-2006 for France (FR) and Hungary (HU); calculation under the countries' respective frontiers**

Source: Authors' calculations.

Figure 1 shows the evolution of efficiency averages for both samples over the period studied. The figure reveals that the average efficiency scores of French farms have fluctuated less than the average scores of the Hungarian sample. Scale efficiency has improved for the Hungarian farms after 2004, while pure technical efficiency (i.e. under VRS) has decreased. This suggests that accession to the EU has enabled farms to reach a more optimal scale of production, but has implied a worsening of farming practices. The evolution of the Hungarian farms' milk output indicates that it has decreased over the period studied, as well as input use, suggesting a decrease in the scale of production. This downsizing may be due to the CAP support provided to Hungarian farmers, support that is higher than what they received before accession: thus, farmers may need to produce less, as a reduction of profit is now compensated by higher support. However, farmers have not been able to adapt properly yet to the new production conditions brought by EU accession, as pure technical efficiency has decreased.

**Comparison of the countries' technologies**

Comparing the technology in both countries is done by merging both samples and calculating efficiency with this merged sample, i.e. under a common frontier. As the interest is in the comparison of countries, the results using a common frontier are not presented for the whole merged sample, but for each country only. Table 4 shows the descriptive statistics of the technical efficiency of France and Hungary, when a common frontier is used. The results for the whole merged sample are given in Appendix.

Table 4 reveals that Hungarian farms display much higher average total and pure technical efficiency than French farms over the period studied; the average total technical efficiency (i.e. under CRS) is 0.759 for Hungarian farms, and 0.670 for French farms. This suggests that more Hungarian farms are on or closer to the efficient common frontier than French farms. French farms however seem to perform slightly better in terms of scale efficiency (0.969 vs. 0.929). Thus, it suggests that, if it is assumed that French and Hungarian farms have access to the same technology, Hungarian farmers would have better farming practices and use better the technology, while French farms would have a more efficient operational size.

Table 4

**Yearly technical and scale efficiency as averages for the whole period 2001-2006; calculation under the common frontier; results for each country**

| | France | Hungary |
|---|---|---|
| Total number of observations | 6,549 | 577 |
| Average total technical efficiency (under CRS) | 0.670 | 0.759 |
| Average technical efficiency (under VRS) | 0.691 | 0.821 |
| Average scale efficiency | 0.969 | 0.929 |
| Share of farms with score of 1: | | |
| for technical efficiency under CRS (%) | 3 | 20 |
| for technical efficiency under VRS (%) | 4 | 36 |
| for scale efficiency (%) | 8 | 21 |
| Share of farms under operating: | | |
| CRS (%) | 9 | 22 |
| IRS (%) | 52 | 37 |
| DRS (%) | 39 | 41 |
| Average technology ratios | | |
| under CRS | 0.928 | 0.961 |
| under VRS | 0.907 | 0.975 |

Source: Authors' calculations.

Table 4 also presents the technology ratios, calculated under CRS and VRS. The average technology ratio over the whole period is greater for Hungarian farms (0.961 and 0.975 under CRS and VRS respectively) than for French farms (0.928 and 0.907). This suggests that, under the assumption of a hypothetical common frontier, Hungarian farms would have on average a more productive technology than French farms. This is confirmed by the shares of farms on the efficient common frontier, which are larger for Hungary than for France. Hungarian farms thus lead the merged sample in terms of technology over 2001-2006 while French farms face a technology gap. As shown by Figure 2 picturing the evolution of the productivity factors over the period, the discrepancy between both countries is consistent, except in 2003 and 2004 where the average technology ratio under CRS of the Hungarian sample is very close to the French sample's one.

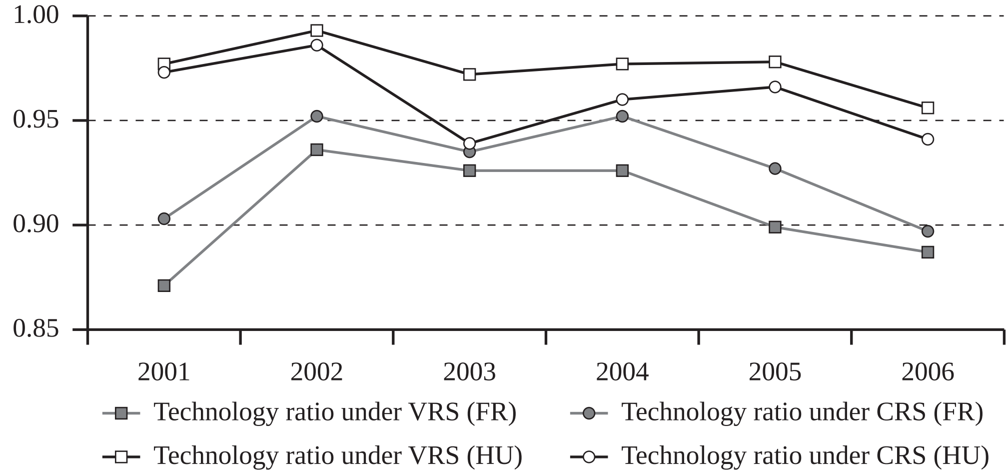


**Figure 2: Evolution of technology ratios over the period 2001-2006 for France (FR) and Hungary (HU)**

Source: Authors' calculations.

## Conclusions

The paper has investigated the performance of French and Hungarian dairy farms, with respect to their own technology frontier, and has compared their technology. The analysis was performed during the period 2001-2006, partly during Hungary's preparation for EU accession (2001-2003) and during the first three years of accession (2004-2006).

Regarding the performance related to their own country's frontier, Hungarian dairy farms showed similar scale efficiency than French farms, but were found to use better their technology than French farms. The results obtained with a common frontier indicated that Hungarian farms would be consistently leading the hypothetical common technology. It could have been expected, instead, that Hungarian farms would lag far behind French farms, as they may not have had access to modern technology during the transition period, either because this technology was not available or because farms were financially constrained. This paper suggests that, by contrast, Hungarian farms have had access to technological improvement as much as French farms did. The high support received by Hungarian dairy farms pre-accession may be one reason. The Producer Support

Estimate (PSE) calculated by the OECD for milk production in Hungary[3] was 42%, 57% and 53% in 2001, 2002 and 2003 respectively, while the figures were 42%, 49% and 51% in the EU. Public subsidies may have helped farms' structural change before the EU enlargement by relaxing financial constraints. However, further research is needed regarding the effect of policy. As noted by Just and Pope (2001), it is often difficult to disentangle productivity differences that are solely due to technology, from effects of policy. Moreover, our yearly analysis does not account for dynamics such as technological change.

Results obtained under the hypothetical common frontier showed that French farms had a more optimal scale of production than Hungarian farms. Despite this, they were still experiencing a technology gap. The reduction in output produced and input use by Hungarian farms over the period studied may be the reason why they remained technology leader. French farms may thus find it difficult to compete with Hungarian farms in the future.

## Appendix

Table 5

**Yearly technical and scale efficiency as averages for the whole period 2001-2006; calculation under the common frontier; results for the whole merged sample (France + Hungary)**

| | Merged sample |
|---|---|
| Total number of observations | 7,123 |
| Average total technical efficiency (under CRS) | 0.678 |
| Average pure technical efficiency (under VRS) | 0.702 |
| Average scale efficiency | 0.966 |

Source: Authors' calculations.

**Acknowledgements**

This research benefited from financial support from the French Ministry of Foreign Affairs (ECO-NET program).

[3] The PSE calculations for Hungary provided to OECD are performed by AKI.

## References

1. **Aliczki**, K., **Bartha**, A., **Garay**, R., **Nyárs**, L., **Papp**, G., **Popp**, J. (ed.), **Potori**, N. (ed.) and **Vőneki**, É. (2009): A főbb állattenyésztési ágazatok helyzete (The situation of the main livestock sectors). Agrárgazdasági Tanulmányok. Budapest: Research Institute of Agricultural Economics.
2. **Brümmer**, B., **Glauben**, T. and **Thijssen**, G. (2002): Decomposition of productivity growth using distance functions: The case of dairy farms in three European Countries. American Journal of Agricultural Economics, 84(3): 628-644.
3. **Charnes**, A., **Cooper**, W. and **Rhodes**, E. (1978): Measuring the efficiency of decision making units. European Journal of Operational Research, 2: 429-444.
4. **Charnes**, A., **Cooper**, W. and **Rhodes**, E. (1981): Evaluating program and managerial efficiency: An application of Data Envelopment Analysis to Program Follow Through. Management Science, 27(6): 668-697.
5. **Coelli**, T. (1996): A Data Envelopment Analysis Computer Program. Centre for Efficiency and Productivity Analysis, University of New England, Australia.
6. **Coelli**, T., **Rao**, D., **O'Donnell**, C. and **Battese**, G. (2005): An Introduction to Efficiency and Productivity Analysis. Second Edition, Springer, New York.
7. **Fertö**, I., **Bakucs**, L. and **Fogarasi**, J. (2009): Investment, financial constraints and soft budget constraint in Hungarian agriculture. Economic Letters (in press).
8. **Just**, R. and **Pope**, R. (2001): The agricultural producer: theory and statistical measurement. Chapter 12 in Gardner, B. and Raussen, G. (eds), Handbook of Agricultural Economics, Volume 1A, Elsevier, Amsterdam.
9. **Oude Lansink**, A., **Pietola**, K. and **Bäckman**, S. (2002): Efficiency and productivity of conventional and organic farms in Finland 1994-1997. European Review of Agricultural Economics, 29(1): 51-65.
10. **Udovecz**, G., **Popp**, J. and **Potori**, N. (2008): New challenges for Hungarian agriculture. Studies in Agricultural Economics 108: 19-31.