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Technical efficiency and productivity change of dairy farms:

A comparison of France and Hungary

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Abstract

The paper investigates the difference in technical efficiency, productivity and technology between French and Hungarian dairy farms during 2001-2004, using Data Envelopment Analysis with separate and a common frontier. Results indicate that Hungarian farmers are more clustered to their own frontier than French farms are, but are as scale efficient. Both samples have a slight technological progress over the period. Comparing the technology of both countries reveals that Hungarian farms have a superior technology. Under a common hypothetical technology, Hungarian farms would be the leaders but it seems that this leadership is reduced in 2004, raising question on the adequacy of the EU agricultural policy for large-scale dairy farming.

Keywords: technical efficiency, productivity factor, dairy farms, France, Hungary

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1. Introduction

The paper investigates the difference in technical efficiency, productivity and technology between French and Hungarian dairy farms in the period 2001-2004. 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 separate frontiers, in order to assess the room for improvement within each country. Then, the measure is calculated with a common frontier, that is to say with a merged sample of both countries, in order to understand which country is lagging behind in terms of technology and thus might hinder productivity growth in the European Union (EU). Productivity change for both countries is also investigated and compared, as well as its components technical efficiency change and technological change.

Comparing two countries in terms of efficiency and technology has not been widely studied. In the 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, which enables them to perform a test of poolability of the three samples. On the basis of the test's results, the authors reject the hypothesis of the possible merging of the three countries, and therefore provide results for country-specific efficiency and productivity change. Poland is found to have the lowest average technical efficiency and experienced a decrease in productivity change (with regards to its own frontier), while there was a growth in both EU-15 countries.

By contrast, in this paper the non-parametric approach Data Envelopment Analysis (DEA) is employed, giving the possibility to merge countries and investigate the technology gap between

them, without having to test for the poolability hypothesis. The method is that proposed by Charnes et al. (1981) in the case of two types of education programmes, and has for example been used by Oude Lansink et al. (2002) to compare organic and conventional farms' technology in Finland.

France and Hungary, the countries compared in this paper, have been chosen because they differ largely in terms of natural and economic conditions. 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 and Central France) (28% of the country's dairy area). During the period studied, French farmers benefited from intervention prices for specific dairy products in the frame of the Common Agricultural Policy (CAP); for example, intervention price for butter was about 328 euros per 100 grams in 2001. However, French dairy farms are subject to production quotas, and they can also receive financial assistance for closing down their dairy activity, both measures being active since 1984 in an objective of reducing the milk production. 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 studied period market economy in Hungary became effective due to political and economic reforms started after the fall of the communist regime at the same time agricultural policy was focused on EU accession. The privatised milk processing industry operated by famous brands (Parmalat, Friesland, Danone, Bongrain, etc.) influenced the milk production in terms of quantity and quality. National support to milk production was mainly in the form of price support as an effort of agricultural policy to prevent milk production falling which decreased from 2,763 to 2,081 million litres in 1990 and 2000 respectively. Fertő et al. (2006) showed with an accelerator model that Hungarian farmers' investment decisions were constrained between

2000 and 2004 due to lack of financing. During the transition, Hungarian dairy farmers might thus not have been able to replace a potentially obsolete technology. Public support can however help relaxing credit constraints and thus undertaking investment. This might have been the case in Hungary, as the Producer Support Estimate (PSE) calculated by the OECD for milk production in Hungary was 42% and 57% in 2001 and 2002 respectively, while the figures were 31% and 45% in the EU. Thus, whether French farms have a superior technology than Hungarian farms, due to the potential financing obstacles from Hungarian farmer during the period studied, might not be certain.

The paper is structured as follows. The next section explains the methodology used, while the third section presents the data. Results and conclusions are given in the fourth and fifth sections, respectively.

2. Methodology

2.1. Yearly technical efficiency

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 might comprise 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. DEA also enables to assess under which returns to scale each farm operates and to calculate their scale inefficiency. Calculating efficiency under the assumption of constant returns to scale (CRS) gives the 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. The latter captures the management practices, while the residual between total technical efficiency and pure technical efficiency shows whether the farm operates under optimal farm size. This residual is called scale efficiency. Efficiency scores are given between 0 and 1, 1 indicating a fully efficient farm (i.e. on the frontier) and a larger score showing a higher efficiency.

An output-orientated model is used, with two outputs – the quantity of milk produced in litres and the value of other output in euros –, and five inputs – the utilised area in hectares, the labour used in Annual Working Units (AWU), 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). Values were deflated by relevant price indices.

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 and a common frontier is constructed. This allows to investigate which country has the most productive technology, by calculating a productivity factor for each farm, as the ratio between the efficiency calculated under the common frontier and the efficiency calculated under the respective country's frontier. Average productivity factors for French farms and Hungarian farms are then compared, the higher average indicating the superior technology.

2.2. Efficiency, technological and productivity changes

Productivity change is also calculated with DEA, using the concept of Malmquist indices (see Färe et al., 1992). These indices rely on comparing the distance of each farm to the frontier in year t with the distance to the frontier in year $t+1$. Malmquist indices of Total Factor Productivity

(TFP) change can be decomposed into technical efficiency change and technological change. The former shows whether farms move closer or further from the frontier over time, while the latter captures the shift in technology. Moreover, technical efficiency change can itself be decomposed into pure technical efficiency change and scale efficiency change. An index of 1 indicates no change, while an index greater (less) than 1 reveals an increase (decrease) in the variable considered (efficiency, technology, productivity).

Productivity, efficiency and technological changes are firstly investigated for each country with respect to their own frontier. Secondly, the indices are calculated for the merged sample (France and Hungary together), that is to say as if the technology was common between both countries.

3. Data

FADN data are used for both countries. Farms with the type of farming dairy (TF41) were extracted in order to have a balanced panel between 2001 and 2004 in both countries. The French sample consists of 684 farms per year, while the figure is 35 for Hungary.

Table 1 presents the average output and inputs for both countries over the period studied. Hungarian farms are much larger than French farms; for example, they operate on average 356 ha of land against 74 for French farms. The evolution over the period is not shown in the table. The main features of this evolution is that the French sample has experienced very slight changes in their output produced and their input use, while the Hungarian outputs and inputs have rather fluctuated. A common characteristic to both countries is the steady increase of capital.

Table 1: Description of the samples: Average values for the whole period 2001-2004

	France	Hungary
Milk output (ths litres)	255.4	1,434.0
Other output (ths euros)	34.5	264.1
Utilised land (ha)	74.2	355.9
Labour (AWU)	1.78	19.1
Capital (ths euros)	219.3	498.8
Intermediate consumption (ths euros)	67.7	334.4
Livestock units	85.5	380.4
Number of observations	684	35

4. Results

4.1. Performance in each country (separate frontiers)

Table 2 presents the descriptive statistics for technical efficiency calculated with regard to the respective frontier. For the whole period 2001-2004, the average total technical efficiency (under CRS) is lower for France (0.764) than for Hungary (0.868). This difference mainly stems from a difference in pure technical efficiency (under VRS) (0.801 vs. 0.914) rather than a difference in scale efficiency (0.954 vs. 0.948). This suggests that the French sample was less homogenous in terms of management practices but as homogenous in terms of size as the Hungarian sample. Hungarian farms that were not scale efficient were operating for the majority under DRS,

indicating that they were too large, while the non scale efficient farms in the French sample were equally split between too small farms (under IRS) and too large farms (under DRS).

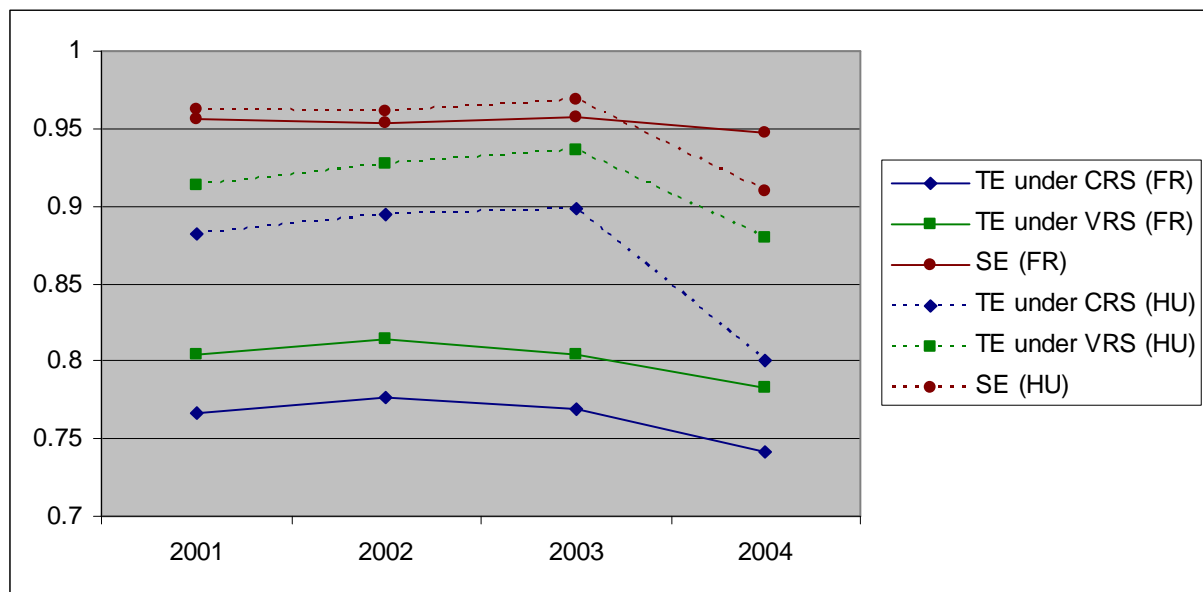
Table 2: Yearly technical (TE) and scale efficiency as average for the whole period 2001-2004; separate frontiers

	France	Hungary
Number of observations	684	35
Average TE under CRS	0.764	0.868
Average TE under VRS	0.801	0.914
Average scale efficiency	0.954	0.948
Share of farms with score of 1:		
for TE under CRS (%)	6	46
for TE under VRS (%)	12	64
for scale efficiency (%)	9	46
Share of farms under:		
CRS (%)	9	46
IRS (%)	45	17
DRS (%)	46	37

As Figure 1 shows, comparing the technical efficiency statistics between each year reveals that, while the homogeneity of both samples remained approximately the same over the first three years, farms in both samples sample became less clustered to the efficient frontier, since the average technical efficiencies (total, pure and scale) decreased in 2004. This suggests that there

has been a worsening in the farming practices in both countries between 2001 and 2004, especially in Hungary where the decrease in efficiency is sharper.

Figure 1: Evolution of yearly technical (TE) and scale (SE) efficiency over the period 2001-2004 for France (FR) and Hungary (HU); separate frontiers



Calculating the productivity change with Malmquist indices allow to investigate this issue more in depth. Table 3 displays the results regarding these calculations. The main result is that in both samples the majority of the farms has experienced a productivity regress or stagnation (TFP indices equal or less than 1 for 61% of the French farms and 77% of the Hungarian farms). This results in an average productivity stagnation for French farms (progress by 0.5%) and regress for Hungarian farms (regress by 2.2%). For both samples farms have worsened their efficiency but have experienced a slight technological progress (by about 2%). It is usual to see opposite patterns between technological change and efficiency change, as a technological progress often results in a delay for some farmers to adopt the new technique or use it efficiently (e.g. Brümmer

et al., 2002; Balcombe et al., 2005). This seems to be the case for both countries: not all farmers have managed to follow and adapt their practices to the new technology.

Table 3: Change over time of technical efficiency (TE), technology and Total Factor Productivity (TFP) as average for the whole period 2001-2004; separate frontiers

	France	Hungary
Number of observations	684	35
Average total TE change	0.987	0.962
Average pure TE change	0.990	0.983
Average scale efficiency change	0.997	0.979
Average technological change	1.018	1.016
Average TFP change	1.005	0.978
Share of farms with total TE change:		
=1 (stagnation) (%)	3	29
>1 (increase) (%)	39	23
<1 (decrease) (%)	58	48
Share of farms with technological change:		
=1 (stagnation) (%)	1	0
>1 (increase) (%)	73	60
<1 (decrease) (%)	26	40
Share of farms with TFP change:		
=1 (stagnation) (%)	1	0
>1 (increase) (%)	54	37
<1 (decrease) (%)	45	63

4.2. Comparison of the countries' technologies (common frontier)

As the interest is in the comparison of the performance of each country, the results using a common frontier are not presented for the pooled 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 pooled sample are given in Appendix.

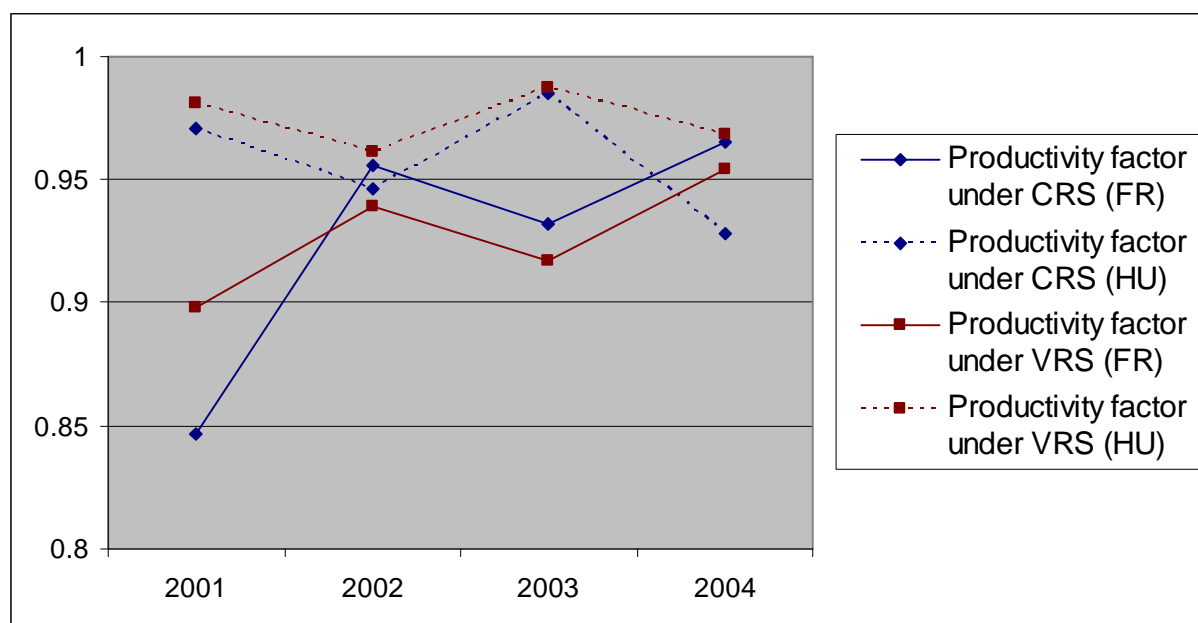
Table 4: Yearly technical efficiency (TE) as average for the whole period 2001-2004; common frontier; results for both countries

	France	Hungary
Number of observations	684	35
Average TE under CRS	0.707	0.835
Average TE under VRS	0.743	0.892
Average scale efficiency	0.950	0.934
Share of farms with score of 1:		
for TE under CRS (%)	4	37
for TE under VRS (%)	5	61
for scale efficiency (%)	7	38
Share of farms under:		
CRS (%)	8	38
IRS (%)	35	19
DRS (%)	57	43
Average productivity factors		
under CRS	0.925	0.958
under VRS	0.927	0.974

Table 4 reveals that Hungarian farms display much higher average total and pure technical efficiencies than French farms over the period studied; the average total technical efficiency was 0.835 for Hungarian farms, and 0.707 for French farms. This suggests that more Hungarian farms are closer to the efficient common frontier than French farms. French farms however seem to perform slightly better in terms of scale efficiency (0.950 vs. 0.934). Thus, it suggests that, if it is assumed that French and Hungarian farms have access to the same technology, Hungarian farmers would have better management practices, while French farms would be more able to adjust their operational size. Not shown in the table is the evolution of technical efficiency over the period, but the main point to note about this evolution is that it is similar to the evolution of technical efficiency calculated with separate frontiers (efficiency decrease in the last year, indicating a reduced homogeneity in both samples, especially for Hungarian farms).

Table 4 also gives the productivity factors, calculated under CRS and VRS. The average productivity factor over the whole period is greater for Hungarian farms (0.958 and 0.974 under CRS and VRS respectively) than for French farms (0.925 and 0.927). This suggests that Hungarian farms had on average a more performing technology than French farms. This is confirmed by the shares of farms on the efficient frontier, which are larger for Hungary than for France. Hungarian farms thus lead the sample in terms of technology. As shown by Figure 2 picturing the evolution of the productivity factors over the period, the discrepancy between both countries is not so definite. Under VRS (management practices only), while the average productivity factor of the Hungarian sample is greater than the French sample's one in each year, the difference between both countries is reduced in 2004. Regarding the productivity factors under CRS (management practices and scale), in two years (2002 and 2004) the French average is greater than the Hungarian average. Thus, French and Hungarian farms' technology is actually more similar than Table 4 was showing, with French farmers catching up in the last year.

Figure 2: Evolution of productivity factors over the period 2001-2004 for France (FR) and Hungary (HU)



A similar picture is given by the results regarding the Malmquist indices for each country under a common frontier, presented in Table 5. They indicate that, while efficiency, technological and productivity changes for Hungarian farms are on average the same as under a separate frontier, French farms have a regress in their technology, while they had a technological progress with respect to their own frontier. This confirms that French farms would not contribute to the hypothetical common technological progress. This low result is however compensated by a large increase in technical efficiency (3.4%), which enables the French farms to have a similar TFP slight progress as when they are considered with respect to their own frontier only (1%).

Table 5: Change over time of technical efficiency (TE), technology and Total Factor Productivity (TFP) as average for the whole period 2001-2004; common frontier; results for both countries

	France	Hungary
Number of observations	684	35
Average total TE change	1.034	0.947
Average pure TE change	1.011	0.979
Average scale efficiency change	1.022	0.968
Average technological change	0.977	1.023
Average TFP change	1.011	0.969
Share of farms with total TE change:		
=1 (stagnation) (%)	2	23
>1 (increase) (%)	69	20
<1 (decrease) (%)	28	57
Share of farms with technological change:		
=1 (stagnation) (%)	1	0
>1 (increase) (%)	29	63
<1 (decrease) (%)	70	37
Share of farms with TFP change:		
=1 (stagnation) (%)	2	0
>1 (increase) (%)	57	40
<1 (decrease) (%)	41	60

The French sample is considerably larger than the Hungarian sample. To control for a potential sample size bias in the results, All analyses have been redone with a French sample of 35 farms only, drawn randomly from the original 684 farms. Output and input characteristics of this 35-farm sample are similar to those of the 684-farm sample. As for the results, they are in general confirmed. The two major differences are: i) the average technical efficiencies for French farms under the separate frontier are greater for this small sample than for the 684-farm sample (it is expected that smaller samples show larger average efficiency), bringing these efficiencies as high

as the Hungarian ones that were shown in Table 2; this suggests that French and Hungarian samples are similarly homogenous under their own frontier; ii) the average productivity factors for Hungarian farms are higher than those of the 35-farm French sample in each year of the period, indicating a superior technology over the whole period.

5. 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 2001-2004, when Hungary was at the end of its transition period and preparing for EU accession, while French farms were not subject to major policy changes (the Agenda 2000 did not affect deeply the Common Market Organisation for milk).

Regarding the performance related to their own frontier, Hungarian dairy farming shows similar scale heterogeneity than French farming, but Hungarian farms were found to be more homogenous in terms of their farming practices than French farms. However, the homogeneity of Hungarian farms decreased sharply in 2004, suggesting that a large part of farmers in this country were not able to adapt their practices to the new environment brought by EU accession. Both samples show similar average technological progress, but a larger efficiency reduction for Hungarian farms (due to the large decrease in 2004), leaving them with a TFP regress while French farms' productivity stagnated.

Looking at the results with a common frontier showed that Hungarian farms were leading the technology, at least over the period 2001-2003. It could have been expected, by contrast, that Hungarian farms would lag far behind French farms, as they might not have had the access to modern technology during the transition period, either because this technology was not available or because most farms were financially constrained. This paper seems to reveal that, however,

Hungarian farms have had access to technological improvement as much as French farms, and the higher PSE for these farms, compared to EU farms, suggests that public subsidies have helped in the transformation before the EU enlargement. It could therefore be expected that the accession of Hungary to the EU in 2004 would increase even more Hungarian farms' technological superiority, as it enables its farmers to receive European subsidies, in the form of Single Area Payments. Although this support is lower than what the French farmers receive at the same time due to the phasing-in, it is higher than pre-accession support. However, this paper shows the opposite: in 2004 Hungarian farmers seem to have experienced a decrease in efficiency and a lower productivity factor than French farms. This suggests that the EU agricultural policy might not be appropriate for large-scale dairy farming in Hungary. Those farms will have to adapt their scale and practices to the new EU environment in the next year if they want to remain competitive.

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Appendix

Table 6: Yearly technical efficiency (TE) as average for the whole period 2001-2004; common frontier; result for the pooled sample (France + Hungary)

	Pooled sample
Number of observations	719
Average TE under CRS	0.713
Average TE under VRS	0.750
Average scale efficiency	0.950

Table 7: Change over time of technical efficiency (TE), technology and Total Factor Productivity (TFP) as average for the whole period 2001-2004; common frontier; results for the pooled sample (France + Hungary)

	Pooled sample
Number of observations	719
Average total TE change	1.030
Average pure TE change	1.010
Average scale efficiency change	1.020
Average technological change	0.980
Average TFP change	1.009