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Could small dairy farms in Switzerland compete with their French counterparts? A metafrontier analysis during 1990-2004

Ali Ferjani [1] and Laure Latruffe [2,3]

[1] Agroscope Reckenholz Tänikon, Switzerland; ali.ferjani@art.admin.ch
[2] INRA, UMR1302, F-35000 Rennes, France; Laure.Latruffe@rennes.infra.fr
[3] Agrocampus Ouest, UMR1302, F-35000 Rennes, France

Abstract of the paper

The objective of the paper is to investigate whether Swiss farms specialised in dairy (the prevailing production of the country), which are small in international standards, would have a survival potential if they had to compete more directly with EU farms. More specifically, we investigate whether Swiss dairy farms would be able to compete with their French counterparts (located in mountainous areas, but larger than Swiss ones) in a future made of increased globalisation and reduced borders. For this we evaluate which country, during the period 1990-2004, would have been more able to use efficiently a common hypothetical technology, and would have had a more productive (own) technology. Efficiency scores and technology ratios are calculated using the concept of metafrontier and the Data Envelopment Analysis (DEA) approach.
Results indicate that Swiss farms would have been slightly less efficient on average with respect to the common frontier, and that they had a less productive technology, the productivity gap with France being however only 5 percent. Regression results suggest that the efficiency differential and the productivity gap between Swiss farms and French farms were mainly due to larger Swiss farms with lower labour per livestock unit and higher proportion of family labour.

Keywords: technical efficiency, technology gap, Data Envelopment Analysis, dairy farming, Switzerland, France

JEL codes: Q12, D24

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1 INTRODUCTION

This paper is concerned by the future of Swiss farms specialised in dairy, the prevailing production of the country, which are small in international standards. The issue of the future survival of small farms is common to all industrialised countries. In the past decades the number of farm holdings has strongly diminished in these countries, while farm size has increased. The disappearance of small farms, to the benefit of large farms' concentration, raises worries among politicians, as it may imply an abandonment of rural areas, and may cause social, economic and environmental problems. Since the Second World War a lot of small farms have been forced to shut down because of the pressure caused by the "technological treadmill". Moreover, agricultural policies encouraging productionist behaviour, such as government support coupled to output or to production factors, have given incentives to farms to enlarge. Nowadays, in many developed countries some small farms are kept in business thanks to generous public support, in particular rural development policies which were introduced partly to counteract the effect of coupled subsidies. Switzerland is no exception to this picture, although the disappearance of small farms has been slowed down lastly, partly by the introduction of payments decoupled from production in 1993.

A large body of research has given interest in the potential survival of small farms by investigating their performance relative to larger farms within a country, some papers being dedicated to the case of dairy farming: e.g. Wieck and Heckelei (2007) in 1989-2000 in the European Union (EU), Tauer and Mishra (2006) in 2000 in the United States (US). Comparison of small dairy farms' performance between countries is however inexistent, and our paper contributes to this topic by pooling data from both countries. A few papers have compared dairy farming performance between countries, but without focusing on the size issue. For example, Haghiri *et al*. (2004) compare dairy farms' efficiency in Canada and in the US during 1992-1998 using a between-model (i.e. pooling both countries' samples) and a within-model (i.e. keeping each country's sample separated). They conclude that New York dairy farmers were more efficient than Ontario farmers, a discrepancy that the authors attribute to the tighter regulations in the Canadian dairy industry. Brümmer *et al*. (2002) investigate total factor productivity (TFP) change for dairy farms in Germany, the Netherlands and Poland between 1991 and 1994. As their data reject the poolability assumption, they analyse the performance for each country separately and find that the Polish farms experienced a decrease in TFP, while there was a growth for German and Dutch farms.

Our objective is to investigate whether small Swiss dairy farms would have a survival potential if they had to compete more directly with farms in the EU. Although Switzerland's entry into the EU is not on the agenda, this competition issue is gaining more importance and realism with the increased openness of markets and the more and more rapid diffusion of technologies and knowledge. More specifically, we compare Swiss dairy farms to France's mountain dairy farms, which are much larger than the Swiss farms. A long period was chosen so as to avoid artefacts that would arise in a specific year only, namely 1990-2004. During the period studied economic conditions were similar for farms in both countries: farms were subject to milk quotas and supported milk price, and farms in the mountainous parts of both countries were smaller and had lower revenue than plains' farms. In both countries the disappearance of mountainous farms to the benefit of farm enlargement in the plains has been limited by regulations regarding milk quota trade: in Switzerland it is forbidden to transfer quotas from mountain areas to plain areas, while in France quotas are transferable within NUTS3 regions ("départements") only. Only mountainous farms in France are chosen for the analysis here, as it is assumed that they would be the ones Swiss farms would have to compete with: they operate under similar agroclimatic conditions and produce similar products, in particular labelled cheese.

Competitiveness is a complex concept that includes many components. For example Jay (2007), studying the case of dairy farming in New Zealand, explains that in order to resist global competition, farmers have to improve "growth, efficiencies of production ('productivity gains'), economies of scale, scientific and technological innovation, and commercial superiority". Here we focus on productivity. As noted by Tauer and Mishra (2006) there may be two constraints to the competitive ability of small farms in terms of productivity: technology and inefficiency. The first constraint implies that the specific technology used by small farms may be less productive than the larger farms' technology, while the second constraint means that small farms may not be able to use appropriately (i.e. efficiently) their technology. In order to investigate both constraints, we use an efficiency approach with respective countries' frontiers and with one metafrontier (that is to say a frontier on the pooled sample). This enables to determine, firstly, whether small dairy farms would be able to use efficiently the hypothetical common technology. We find that Swiss farms would use it less efficiently than French farms. Secondly, the approach allows assess which country, between Switzerland and France, uses the more productive technology, and the extent of productivity gap. We find that France has a more productive technology, but that the technology gap is not substantial. We then investigate the factors behind the efficiency discrepancy and productivity gap. This allows evaluate which changes would be required for Switzerland to close the gaps, that is to say to remain able to compete. Interestingly, we show that, for small Swiss dairy farms to remain competitive with larger French dairy farms, it does not require them to increase their size, but to use a technology appropriate for Switzerland's agroclimatic conditions.

The paper is structured as follows. Section 2 explains in more details the methodology used section 3 presents the data. Section 4 describes the results and Section 5 concludes.

2 METHODOLOGY

2.1. Comparison of the countries' performance

Three main stages are performed to compare countries in terms of technology and productivity. In a first stage, farms' technical efficiency is calculated, under the assumption of separate frontiers between countries, that is to say one frontier is constructed per country and per year. This allows investigate how farms are able to make use of the existing technology in their country: farms with an efficiency score of 1 are those located on the efficient frontier, that is to say making optimal use of the technology; by contrast, farms with a score less than 1 are inefficient, the difference between 1 and their score indicating how much output they could produce more by using the same level of inputs. These technical efficiency scores are however not informative about how performing the country's technology is, in comparison with other countries. Such comparison can be done using the concept of metafrontier and Charnes *et al.*'s (1981) method. The method relies on comparing technical efficiency scores calculated for each farm under its respective country's frontier, with efficiency scores for each farm calculated under a metafrontier, that is to say a hypothetical common frontier constructed with the merged sample of French and Swiss farms. The calculation of the latter scores (under a common frontier) constitutes the second stage. Finally, the third stage consists in computing the ratio of the farm's efficiency score calculated under the metafrontier, to the farm's efficiency score calculated under its respective country's frontier. This is called the farm's technology ratio. Average technology ratios for the Swiss sample and for the French sample are compared, the higher country's average indicating the more productive technology. Technology ratios reveal how far the Swiss frontier would be from the French frontier, or inversely, that is to say potential productivity gaps between countries. The method has been for example applied by Oude Lansink *et al*. (2002) to the comparison of organic and conventional Finish farms' performance in 1994-1997. The authors show that, although organic farms produced more efficiently with respect to their own frontier, they used a less productive technology than conventional farms, and thus that technologies applied on conventional farms had more potential to produce output by using lower levels of production factors.

The non-parametric Data Envelopment Analysis (DEA) approach is used to construct the efficiency frontiers (Charnes *et al*., 1978). This approach does not require distributional or functional form assumptions as it relies on linear programming to build the frontier. The best performing farms of the sample determine the frontier, and other farms' efficiency is calculated according to their distance to the frontier (for more details on the method, see Coelli *et al*., 2005). DEA enables to separate inefficiency that arises from suboptimal production scale from inefficiency that arises from suboptimal farming practices. The latter one is called pure technical efficiency and is calculated under the assumption of variable returns to scale (VRS). The former is called scale efficiency and is calculated as the ratio of efficiency calculated under constant returns to scale (CRS) (also called total technical efficiency) over pure technical efficiency. Total technical efficiency is thus the product of pure technical efficiency and scale efficiency. Moreover, for farms that are not fully scale efficient (i.e. that have a scale efficiency score less than 1), it is possible with DEA to determine whether they operate under decreasing returns to scale (DRS) or under increasing returns to scale (IRS).

Two outputs are used in the DEA model: milk produced in litres, and other output produced in value. Five inputs are included: land proxied by the utilised agricultural area (UAA) in hectares (ha), labour proxied by total annual working days spent on the farm, capital proxied by the value of depreciation and interest, intermediate consumption in euros, and the number of livestock units calculated with the EU standard definition.

2.2. Sources of discrepancy between countries' performance

In order to investigate factors behind farms' inefficiency under the hypothetical common frontier and behind the productivity gap, an Ordinary Least Squares (OLS) regression is performed, firstly on the efficiency scores under CRS obtained with the metafrontier, and secondly on the technology ratios under CRS. Both regressions are carried out on the whole sample (French and Swiss farms merged).

Among the included explanatory variables are: i) UAA as a size proxy, ii) labour per livestock unit as a proxy for the technology used, iii) the share of hired labour in total labour spent on farm, and iv) the ratio of farm's subsidies to total output as a proxy for farm reliance on public support. In addition, all variables are included as cross terms, by multiplying them with a dummy taking the value 1 for French farms and the value 0 for Swiss farms (France dummy).

The dummy is also included as an explanatory variable itself. The cross terms enable to assess whether the effects of the various factors i) to iv) are the same for both countries. Finally, 14 year dummies are included.

3. DATA

Data are extracted from the national Farm Accountancy Data Network (FADN) databases for farms specialised in dairy (European Type of Farming 41) over the period 1990-2004. About 300 farms each year in each country constitute the unbalanced samples (Table 1). For a consistent comparison, only French dairy farms located in hill and mountain areas (NUTS2 regions Alps, Pyrénées, and Massif Central) are selected[1]. Thus, very large farms located in plains (Brittany and Pays de la Loire notably) are excluded.

Table 1: Number of farms used for the analyses in France and in Switzerland in each year

	France	Switzerland
1990	343	269
1991	343	269
1992	341	278
1993	317	286
1994	324	223
1995	334	274
1996	296	224
1997	297	280
1998	307	331
1999	334	305
2000	334	402
2001	346	439
2002	350	307
2003	351	175
2004	337	316

Despite this, the selected French farms are on average three times as large as the Swiss sample's farms in terms of UAA and in terms of livestock units (Table 2): over the period, French farms used 63.6 ha and 63.4 livestock units on average, against 21.2 ha and 22.4 livestock units for Swiss farms. By contrast, Swiss farms used more labour than French farms on average: 500 working days for the Swiss sample over the period, against 452 for the French sample. This suggests that, although livestock density is similar for both samples (1.0 and 1.2 livestock unit per ha on average in France and Switzerland respectively), the amount of labour used per livestock unit per year is much higher in Switzerland: 24.6 working days against 8.2 in France. One reason behind this discrepancy may come from the calculation of labour: Swiss holdings are less specialised in dairy than French farms (milk accounts for 60 percent of the total output produced, against 72 percent for French farms), and a larger part of the total amount of labour spent on farm may be allocated to non-dairy activity in Switzerland than in France. Thus, a simple comparison of the ratio of total labour spent on the farm to livestock units may be misleading. Calculating efficiency scores can address this shortcoming,

[1] Jura mountain farms should have been included in the French sample as well but it was not possible to identify them precisely with the localisation variables available in the French RICA. However, their exclusion from the sample is believed not to affect the findings of the paper.

as all outputs and inputs on farm are considered. Table 2 also presents the countries' averages of the ratio of subsidies to output. The figures indicate that, for every euro of output that Swiss farms produce, they get 0.519 euro of subsidies from the government, the figure being 0.134 euro for French farms. Swiss farms seem therefore to be more subsidised than French farms.

Table 2: Characteristics of farms in each country: averages over 1990-2004

	France	Switzerland
Milk produced (litres)	180,272	75,497
Value of other output than milk (Swiss Francs)	38,511	54,931
Share of milk output in total output value (%)	72.2	60.2
UAA (ha)	63.6	21.2
Number of livestock units	63.4	22.4
Labour (working days)	451.9	500.6
Share of hired labour in total labour (%)	2.2	12.6
Value of depreciation and interest (Swiss Francs)	28,538	35,118
Value of intermediate consumption (Swiss Francs)	65,442	58,061
Ratio of farm's subsidies to total output value	0.134	0.519
Total number of farms	4,954	4,378

4. RESULTS

4.1. Comparison of the countries' performance

Table 3 presents the efficiency results for both countries, firstly when separate frontiers for each country are constructed, and secondly when the metafrontier over the pooled sample is used. Results from the separate frontiers' calculations indicate that the average total efficiency score for the French farms is 0.777, while it is 0.802 for the Swiss farms. This suggests that, over the whole period, Swiss farms were more efficient on average, that is to say a larger part of the Swiss sample could make optimal use of the existing technology than it is the case for the French sample. Breaking down total technical efficiency into pure and scale efficiencies reveals that the superiority of the Swiss sample remains: Swiss farms had, on average over the period studied, higher pure efficiency and higher scale efficiency than French farms. The shares of farms according to their returns to scale are similar for both countries: the larger part (53 percent in France, 45 percent in Switzerland) of farms operated under IRS, indicating that they were too small and could have gained efficiency by increasing their size of operation. Interestingly, this is even more so true in France, where the share under IRS is higher than in Switzerland, despite Swiss farms being smaller on average.

When pooling both countries, the picture is different. Under the assumption of a common hypothetical (meta)frontier, the average total technical efficiency score of French farms is slightly higher than the one for Swiss farms: 0.770 for France *vs*. 0.754 for Switzerland. This suggests that less Swiss farms than French farms form the common frontier. French farms' average pure technical efficiency score is higher than the one for Swiss farms (0.816 for France *vs*. 0.790 for Switzerland), indicating that French farms would have made better use of a hypothetical common technology than Swiss farms. By contrast, more Swiss farms would have had an optimal size than French farms under a common technology, as their scale efficiency score is on average higher than the French farms' score (0.946 for France *vs*. 0.958

for Switzerland). Within both countries, the majority of farms would still be operating under IRS.

The average technology ratios (Table 4) indicate that French farms had a more productive technology than Swiss farms: over the whole period the average productivity calculated under a CRS frontier is 0.992 for the French sample against 0.942 for the Swiss sample, the difference being tested significant at 1 percent. However, these figures indicate that the productivity gap is only of 5 percent. This means that the most efficient (relative to Switzerland's respective frontier) Swiss farm produced 5 percent less than the most efficient French farm (relative to France's respective frontier) which had the same input ratio. The difference is even less when calculating the technology ratios under VRS (0.985 for France *vs*. 0.945 for Switzerland) but still significantly different at 1 percent.

Table 3: Efficiency results in each country: averages over 1990-2004

	France	Switzerland
Under each country's frontiers		
Average scores:		
Total technical efficiency (under CRS)	0.777	0.802
Pure technical efficiency (under VRS)	0.829	0.836
Scale efficiency	0.940	0.961
Share of farms (%):		
Scale efficient	14	17
Under DRS	33	38
Under IRS	53	45
Under the metafrontier		
Average scores:		
Total technical efficiency (under CRS)	0.770	0.754
Pure technical efficiency (under VRS)	0.816	0.790
Scale efficiency	0.946	0.958
Share of farms (%):		
Scale efficient	13	12
Under DRS	36	31
Under IRS	51	57

Table 4: Technology ratios in each country: averages over 1990-2004

	France	Switzerland
Under CRS	0.992	0.942
Under VRS	0.985	0.945

4.2. Sources of discrepancy between countries' performance

Table 5 shows the results of the OLS regression on efficiency scores calculated with a metafrontier under CRS. All explanatory variables have a significant impact on efficiency scores, except for the France dummy, the cross term 'Share of hired labour × France dummy' and three year dummies. This suggests that all factors i) to iv) significantly influence on Swiss and French farms' ability to use optimally the common technology, and that the effect of factors i), ii) and iv) differs across countries. Table 6 compares the effects for both countries.

As shown by Table 6, the size proxy UAA reduces technical efficiency under the metafrontier, even more so for Swiss farms. This finding is shown by the regression coefficient of UAA that is -0.00188 for Swiss farms and the combined coefficient of -0.0004 (-0.00188 + 0.00148) for French farms. This suggests that reducing the farm size by 1 ha would have enabled Swiss farms to increase their technical efficiency by 0.00188 on average, and French farms by 0.0004. The ratio of labour to livestock units positive influences Swiss farms' efficiency (coefficient of 0.0004) and negatively French farms' efficiency (coefficient of 0.0004 - 0.0026 = -0.0022). Regarding the share of hired labour in total labour, it has a similar positive impact on both countries' efficiency, suggesting that both samples could have gained efficiency by using more external labour. As for the ratio of subsidies to output, it has a negative influence on both samples' farms' efficiency, but even stronger in France: coefficient of -0.2324 for Switzerland *vs*. -0.2324 - 0.3509 = -0.5833 for France. In other words, for every 0.10 euro more of subsidy per one euro of output produced, Swiss farms' and French farms' efficiency would have been lowered respectively by 0.02324 and 0.03509 on average.

Table 5: Results of the regression of technical efficiency scores calculated under a metafrontier

Explanatory variables	Estimated coefficient	t-value	Significance
Intercept	0.883	112.4	***
France dummy	-0.011	-1.1	
i) UAA	-0.00188	-10.6	***
UAA × France dummy	0.00148	7.9	***
ii) Labour per livestock unit	0.0004	2.3	**
Labour per livestock unit × France dummy	-0.0026	-4.8	***
iii) Share of hired labour in total labour	0.00033	2.9	***
Share of hired labour × France dummy	-0.000004	-0.0	
iv) Ratio of subsidies to output	-0.2324	-34.3	***
Ratio of subsidies to output × France dummy	-0.3509	-16.6	***
Number of observations		9,330	
R-square		0.187	

Notes:
Dependent variable: efficiency scores calculated with a metafrontier under CRS.
France dummy is a dummy equal to 1 for French farms, and to 0 for Swiss farms.
Estimation results for the 14 year dummies are not shown.
***, **, *: significance at 1, 5, 10 percent respectively.

Table 6: Comparison between France and Switzerland of the influence of factors i) to iv) on technical efficiency scores calculated with a metafrontier

Factors i) to iv)	Regression coefficient for Switzerland	Computed coefficient for France
i) UAA	-0.00188	-0.0004
ii) Labour per livestock unit	0.0004	-0.0022
iii) Share of hired labour in total labour	0.00033	0.00033
iv) Ratio of subsidies to output	-0.2324	-0.5833

Table 7 presents the results of the OLS regression on technology ratios obtained under CRS. All variables present significant estimated coefficients, except for the cross term 'ratio of subsidies to output × France dummy', and for four year dummies. This indicates that all factors i) to iv) play a significant influence on productivity gap, and that factors i) to iii) have a different influence depending on the country. Table 8 compares the effects for both countries.

As shown by Table 8, size (proxied by UAA) has a negative influence on technology ratios, even more so for Swiss farms. The regression coefficient for UAA is indeed -0.00171 for the Swiss sample, and the combined coefficient is -0.00005 (-0.00171 + 0.00166) for the French sample. This indicates that reducing the farm size by 1 ha in Switzerland would have enabled farms to increase their technology factor by 0.00171 on average, that is to say to decrease their productivity gap with France by 0.171 percentage point. The ratio of labour to livestock units has a positive effect for Swiss farms (0.0006) and a negative one for French farms (0.0006 - 0.0011 = -0.0005). The same discrepancy is revealed by the share of hired labour in total labour. This suggests that more labour per animal and more hired labour in total labour would have enabled Swiss farms to reduce the productivity gap, while it would have prevented French farms to attain their leadership. Regarding the effect of farm support, it is similar for both countries as the coefficient for the ratio of subsidies to output is not significant when multiplied by the France dummy. The coefficient of -0.0273 indicates that, in both countries, for every 0.10 euro more of subsidy per one euro of output produced, the technology factor would have decreased by -0.00273.

Table 7: Results of the regression of technology ratios

Explanatory variables	Estimated coefficient	t-value	Significance
Intercept	0.970	342.3	***
France dummy	0.030	8.7	***
i) UAA	-0.00171	-26.5	***
UAA × France dummy	0.00166	24.5	***
ii) Labour per livestock unit	0.0006	11.8	***
Labour per livestock unit × France dummy	-0.0011	-5.7	***
iii) Share of hired labour in total labour	0.00017	3.9	***
Share of hired labour × France dummy	-0.00039	-4.2	***
iv) Ratio of subsidies to output	-0.0273	-11.1	***
Ratio of subsidies to output × France dummy	-0.0075	-1.0	
Number of observations		9,330	
R-square		0.334	

Notes:
Dependent variable: technology ratios obtained under CRS.
France dummy is a dummy equal to 1 for French farms, and to 0 for Swiss farms.
Estimation results for the 14 year dummies are not shown.
***, **, *: significance at 1, 5, 10 percent respectively.

Table 8: Comparison between France and Switzerland of the influence of factors i) to iv) on technology ratios

Factors i) to iv)	Regression coefficient for Switzerland	Computed coefficient for France
i) UAA	-0.00171	-0.00005
ii) Labour per livestock unit	0.0006	-0.0005
iii) Share of hired labour in total labour	0.00017	-0.00022
iv) Ratio of subsidies to output	-0.0273	-0.0273

5. CONCLUSION

We investigated whether Swiss dairy farms, of small size by international standards, would be able to compete with their French counterparts (located in mountainous areas, but larger than Swiss ones) in a future made of increased globalisation and reduced borders. For this we evaluated which country, during the period 1990-2004, would have been more able to use efficiently a common hypothetical technology, and would have had a more productive (own) technology. Efficiency scores and technology ratios were calculated using the concept of metafrontier and the DEA approach.

Results indicated that Swiss farms would have been slightly less efficient on average with respect to the common frontier, and that Swiss farms had a less productive technology, the productivity gap with France being however only 5 percent. Regression results suggested that the efficiency differential and the productivity gap between Swiss farms and French farms were mainly due to Swiss larger farms with lower labour per livestock unit and higher proportion of family labour. It could have been expected that small size and excess labour on Swiss farms would have been a constraint. Our findings suggest, by contrast, that smaller farm size may be more manageable, and spending more time nursing cows may be more necessary, under Swiss agroclimatic conditions than under French ones. In line with previous studies, public support was found to reduce farms' efficiency, in both countries but the effect being stronger for France. Public support however was not found to play a role on the productivity gap between both countries (similar coefficient for both countries in the technology ratio regression), but it would have reduced the hypothetical common technology performance (negative coefficients).

Counter intuitively, our findings suggest that the small Swiss dairy farms may not be able to compete with French holdings if they (Swiss farms) are too large. However, the future of Swiss farms may not be at risk, as structural change in Swiss mountain regions being lower than in plain regions Gazzarin *et al*. (2007). Two reasons may explain the persistence of small farms in this country. Firstly, despite a poor performance, Swiss dairy farmers have a strong preference to stay in dairy production due to non-pecuniary benefits (Lips and Gazzarin, 2008). Secondly, a large part of Swiss farms are part-time holdings, with the Swiss agricultural policy favouring the persistence of such pluriactive small farms, while the agricultural policy applied in France rather favours large productionist farming systems (Latruffe and Mann, 2009).

Despite this survival potential of small dairy Swiss farms, it must be stressed that our findings show, not only a negative effect of subsidization on farm performance as already highlighted in previous studies, but also a negative influence on the technology productivity of the pooled countries. Although this does not advocate a removal of subsidies, it sheds light on the challenge face by governments: keeping the subsidization as it is and facing the risk of Europe's agriculture being less able to compete internationally, or facing the risk of abandonment of Europe's rural areas if subsidies to small farms are removed.

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