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**Technical efficiency, technical progress and productivity change in French agriculture:
Do subsidies and farms' size matter?**

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Technical efficiency, technical progress and productivity change in French agriculture: Do subsidies and farms' size matter?

Introduction

Between 1993 and 2003 the number of farm holdings in France decreased by almost a quarter, and the average farm size increased from 35 ha to 45 ha. What are the likely causes of such a structural evolution of the French farming sector towards larger farms? The usually invoked positive relationship between farm size and farm productivity might be a reason behind this pattern. The less well-known impact of farm subsidies on farm productivity may also be a key element to be considered as regards the French farm enlargement issue. Farmers in Western countries have always been highly subsidised. While it is commonly recognized that subsidies may have an impact on farm productivity, there are surprisingly no studies that investigate this relationship. One reason may be the fact that economic theory provides relatively few guidelines on the shape of this relationship.

Within the existing literature, one may find however some theoretical results regarding the impact of various support policies on farm technical efficiency. For instance, Bergström (1998) argues that subsidies can have a negative impact on technical efficiency for at least two reasons. First, higher profits weaken managers' motivation in the form of slack or lack of effort. Second, subsidies can help managers to avoid bankruptcy and postpone activity reorganisation and performance improving. The same idea arises from the model proposed by Martin and Page (1983). Following Bergsman (1974) and Balassa (1975), arguing that protection increases X-inefficiency, and building on work by Corden (1970) and Martin (1978) showing how to model X-inefficiency effects, Martin and Page develop an analytical framework where each firm's owner-manager maximises his utility that depends positively on firm's profits and negatively on his own work time. The production function, in addition to usual arguments, is specified as an increasing function of efficiency (more precisely X-efficiency). Efficiency is modelled as a positive function of available information stock and total management effort, i.e., the management effort by the manager himself and the "management effort" bought on the market at a given price. Within this modelling framework, Martin and Page show that direct aids have a negative impact on the manager's work time, on total management effort and finally on efficiency. Empirical results based on cross-section data from a survey of firms in Ghana's

logging and sawmilling industries confirm this negative relationship between direct aids and firms' efficiency.

Regarding agriculture, two empirical studies at least confirm this negative relationship. Rezitis et al. (2003) report that subsidies granted to Greek farmers following Greece accession to the European Union had a negative impact on Greek farms' technical efficiency. Similarly, Giannakas et al. (2001) find that subsidies had a negative effect on technical efficiency of farms in the Province of Saskatchewan, Canada, over the period 1987 to 1995. More precisely, they show that technical efficiency is negatively related to the share of income stemming from government support in total farm income.

When panel data are available, total factor productivity change can easily be decomposed into technical change (progress or regress) and change in technical efficiency (Nishimizu and Page, 1982). Although a negative impact of subsidisation on yearly technical efficiency can be hypothesised from the above literature, the impact of subsidies on the change in technical efficiency from year to year is not straightforward. On the other hand, one can suspect a positive relationship between subsidisation and technical change as higher profits help to advance the technological development of firms, for example by relaxing credit constraints and improving access to expensive new technologies. Therefore the influence of subsidisation on productivity change is ambiguous.

This paper aims at investigating the influence of income support direct aids on productivity change for French crop, beef and dairy farms, based on individual farm data over the period 1995 to 2002.

The paper is organised as follows. We first describe the methodology and the data used. The empirical results are then discussed. The paper ends with some concluding remarks.

Methodology and data

The input-oriented Malmquist index

In order to investigate the impact of subsidies on French farms' productivity changes, Malmquist indices have been calculated. Malmquist productivity indices present the advantage of a possible decomposition of productivity change into efficiency change and technological change. Efficiency change measures the change in the ability of making the best use of the available

technology, while technological change refers to an improvement or worsening of the state of technology. In addition, Malmquist indices do not require data about prices, by contrast with other productivity indices.

Conventionally, Malmquist indices are calculated as the geometrical mean of the index of period t against period $t+1$ and the index of period $t+1$ against period t . The input-orientated Malmquist index between period t and period $t+1$ is:

$$M_I^{t,t+1} = \left[\frac{D_I^t(X_{t+1}, Y_{t+1})}{D_I^t(X_t, Y_t)} \frac{D_I^{t+1}(X_{t+1}, Y_{t+1})}{D_I^{t+1}(X_t, Y_t)} \right]^{\frac{1}{2}} \quad (1)$$

where X_t and Y_t are the inputs and outputs in period t , respectively. $D_I^t(X_{t+1}, Y_{t+1})$ is the distance between observation at period $t+1$ and the frontier technology at period t , and is defined by:

$$D_I^t(X_{t+1}, Y_{t+1}) = \max\{I : (X_t / I) \in L_t(Y_t)\} \quad (2)$$

where I measures the maximum contraction of the inputs and $L_t(Y_t)$ is the input set.

The decomposition into efficiency change (first ratio of the right hand side of equation (3)) and technological change (term in brackets of the right hand side of (3)) is as follows (Färe *et al.*, 1992):

$$M_I^{t,t+1} = \frac{D_I^{t+1}(X_{t+1}, Y_{t+1})}{D_I^t(X_t, Y_t)} \left[\frac{D_I^{t+1}(X_{t+1}, Y_{t+1})}{D_I^{t+1}(X_{t+1}, Y_{t+1})} \frac{D_I^t(X_t, Y_t)}{D_I^{t+1}(X_t, Y_t)} \right]^{\frac{1}{2}}. \quad (3)$$

In this study, Malmquist indices have been computed with DEA under constant returns to scale (CRS). DEA is a non-parametric method creating the efficient frontier with the best observations in the sample (Charnes *et al.*, 1978). Based on linear programming, DEA avoids misspecification and distribution errors, which might arise with parametric methods.

Influence of subsidies

The influence of subsidies is investigated in a second-stage regression. Technical efficiency scores, indices of technical efficiency change, of technological change and of productivity change, respectively have been regressed over a set of explanatory variables, including variables representing the subsidisation.

In a general way, variables that are tested as main determinants of the abovementioned dependent variables are chosen on the basis of intuition or past empirical studies as there is no unified

theoretical framework upon which this selection could rely. Several groups of variables are commonly considered: human capital variables, farm characteristics, farm technology, and on- and off-farm structural factors (such as security of land ownership rights, farms' financial situation, credit access, institutional environment, etc.). We retained two human capital variables, the managers' age and whether the latter has a secondary education in agriculture (dummy equal to 1). Three variables were chosen as characteristics of the farm: legal status (dummy equal to 1 if the farm is of individual type), specialisation type for the crop sample only (dummy equal to 1 if the farm is specialised in cereals rather than protein and oilseeds), and farm size (in European Size Units). Regarding the technology employed, two variables were selected, the capital to labour ratio and the share of hired labour in total farm labour. Finally, as part of on and off-farm structural factors, we retained only location and subsidy variables. Location is proxied by three main region dummies for crop and dairy farms (Eastern France, Western France and Northern France-Paris area) and two main region dummies for beef farms (Western France and Eastern France-Northern France-Paris area), the reference for all sample being Southern France. The subsidy variable accounts for the CAP direct payments received by the farm. This variable covers the area payments for crops (including set-aside payments) and the headage payments for livestock. It is specified either as a proportion of the revenue of the farm or per hectare of utilised agricultural area (in which case, the payments were deflated).

In this second stage the panel data specification accounting for individual effects was rejected. Accordingly, the equations finally retained include only time dummies.

Data

Data are extracted from the French FADN (RICA) for the period 1995 to 2002. Three categories of farms are considered corresponding to farms specialised in crop, beef meat and dairy production, respectively. After creating balanced samples over the whole period, and cleaning for missing and inconsistent data, the sample sizes are of 725 for crop farms, 102 for beef meat farms and 268 for dairy farms.

Input-orientated Malmquist indices have been calculated with DEA, based on a multi-output multi-input model. Three aggregate outputs have been considered: crop output (mainly cereals, oilseeds and protein crops), livestock output (meats, milk, eggs, etc.), and other output (live animals and manufactured products such as processed fruit, vegetable and oil products for

instance). Four inputs have been distinguished: agricultural area in hectares, labour in annual working units (AWU), the depreciated value of total assets for the capital factor and intermediate inputs. The three outputs and intermediate inputs are in value and have been deflated by relevant price indices (base 1995).

Table 1 displays descriptive statistics for the outputs and inputs used for Malmquist calculation, for the three samples, and for the first (1995) and last (2002) year of the period. Table 1 shows that crop farms are in average greater than beef meat or dairy farms. In 2002, the average product was of 111.1 K euros for crop farms, 44.8 K euros for beef meat farms and 89.8 K euros for dairy farms. At the same date, the average size was 126 hectares for crop farms, 77.2 hectares for beef meat farms and 56.0 hectares for dairy farms. Table 1 also shows that the three categories of farms have grown over the period 1995 to 2002. By 2002, the average output volume has increased by 10.4 % for crop farms, 14.5 % for beef meat farms and 10.5 % for dairy farms. By the same date, land and intermediate inputs have also increased but by lower percentages, and capital is remained practically constant. Labour shows contrasted patterns, an increase for the average crop farm (+2.4 %), a decrease for the average dairy farm (-2.6 %) and no change for the average beef meat farm.

Table 1. Descriptive statistics of the data used for productivity change calculation; averages in first (1995) and last (2002) years

		Crop output (ths euros)	Livestock output (ths euros)	Other output (ths euros)	Land (ha)	Labour (AWU)	Capital (ths euros)	Intermediate inputs (ths euros)
Crop farms	(725 farms)							
1995	Mean	101.9	5.9	3.3	120.3	160.6	260.5	66.4
	Std deviation	78.0	16.4	13.2	69.6	89.7	166.8	42.0
	Minimum	6.37	0	0	12.37	75.5	17.8	7.1
	Maximum	928.4	218.0	150.7	445.6	1,068.2	1,129.5	305.9
2002	Mean	113.8	5.4	3.5	126.0	164.9	260.2	72.3
	Std deviation	87.1	20.6	14.2	72.3	97.9	189.7	49.6
	Minimum	2.6	0	0	12.56	76.0	8.7	4.5
	Maximum	768.0	345.4	151.3	480.8	1,266.0	1,521.1	406.8
Beef farms	(102 farms)							
1995	Mean	1.7	37.2	0.2	72.8	131.6	224.4	23.1
	Std deviation	3.3	17.7	0.5	43.0	36.7	93.0	13.2
	Minimum	0	3.1	0	22.1	90.9	57.6	5.3
	Maximum	20.0	94.2	3.0	281.4	242.0	494.6	85.0
2002	Mean	1.9	42.6	0.3	77.2	130.5	233.4	27.0
	Std deviation	3.3	24.1	0.9	43.3	44.5	109.5	16.2
	Minimum	0	7.4	0	18.1	78.0	43.7	6.2
	Maximum	17.1	134.1	7.7	281.4	300.0	622.3	74.8
Dairy farms	(268 farms)							
1995	Mean	3.0	16.7	61.6	52.3	156.5	185.1	42.4
	Std deviation	5.2	13.2	34.7	27.8	54.5	92.4	28.3
	Minimum	0	0	10.7	11.0	90.9	35.7	8.0
	Maximum	29.0	87.0	235.0	210.0	352.3	610.6	257.1
2002	Mean	4.6	13.4	71.8	56.0	152.4	186.9	44.9
	Std deviation	7.5	11.6	43.0	31.8	67.2	117.4	30.8
	Minimum	0	0	10.5	12.0	100.0	27.3	7.4
	Maximum	62.6	86.5	273.1	208.9	600.0	845.7	211.7

Note: The values of the aggregate crop output (respectively the aggregate livestock output) have been deflated by the French index of producer prices of crop products (respectively livestock products). The values of the aggregate other output have been deflated by the French index of producer prices of agricultural products. The capital values have been deflated by the French index of purchase prices of total goods and services contributing to agricultural investment. The values of intermediate inputs have been deflated by the French index of purchase prices of goods currently consumed in agriculture. Price indices are in base 1995 and from Eurostat New Cronos.

Table 2 reports descriptive statistics for the direct payments (total amount, as a proportion of revenue and per hectare) received by farmers, in average over the 1995-2002 period. Table 2 indicates that in average crop farms received more direct payments than both beef meat and dairy farms. The total amount of direct payments granted to crop farms reached 37.5 K euros while beef meat farms received, in average, 15 K euros and dairy farms only 5.6 K euros. One obtains the same ranking when considering direct payments per hectare, crop farms receiving in average 302.4 euros per hectare of UAA, beef meat farms 221.8 euros per hectare and dairy farms 104.1 euros per hectare. Despite observed differences in direct payments received, Table 2 suggests that direct payments accounted for a similar proportion in revenue of both crop farms and beef meat farms (nearly 40%). By contrast, dairy farms seem significantly less dependant on direct payments, these latter accounting for less than 7% of their revenue.

Table 2. Direct payments received by farmers, average across farms

	Average over the whole period		
	Amount of direct payments (th's euros)	Direct payments per 100 euros of revenue (euros)	Direct payments per hectare of UAA (euros)
Crop farms (725 farms)			
Mean	37.5	39.4	302.4
Std deviation	23.7	33.3	71.5
Minimum	0	0	0
Maximum	224.5	1166.8	977.4
Beef farms (102 farms)			
Mean	15.0	39.7	221.8
Std deviation	7.0	16.1	83.3
Minimum	2.9	6.6	46.8
Maximum	50.8	169.3	679.9
Dairy farms (268 farms)			
Mean	5.6	6.6	104.1
Std deviation	6.0	5.4	87.0
Minimum	0	0	0
Maximum	117.4	144.1	1982.1

Note: Direct payments are measured in real terms. They have been deflated by the French consumer price index (based 1995) provided by the French Statistical Office (INSEE).

Results

Technical efficiency

Table 3 reports the average total technical efficiency scores obtained for the three types of farms, from 1995 to 2002 and in average over the whole period. Average technical efficiency amounts to 0.604 for crop farms, 0.777 for beef meat farms and 0.791 for dairy farms. It thus

appears significantly greater for the two categories of animal farms relative to crop farms, even if sample sizes (much larger for crop farms) may explain part of this result. From 1995 to 2002, the evolution of average technical efficiency scores for the three types of farms does not show any clear upward or downward trend.

Table 3. Total technical efficiency scores of French farms (calculated under constant return to scale)

	1995	1996	1997	1998	1999	2000	2001	2002	Average 1995-2002 (*)
Crop farms (725 farms)	0.597	0.551	0.639	0.587	0.628	0.629	0.579	0.624	0.604
Beef farms (102 farms)	0.791	0.779	0.777	0.822	0.770	0.752	0.759	0.765	0.777
Dairy farms (268 farms)	0.829	0.800	0.802	0.789	0.755	0.802	0.772	0.779	0.791

(*) Arithmetic mean over the period

A comparison of the characteristics of the top one-fourth of farms with the rest of units provides the following results. Let us first consider crop farms for which labour, area, economic dimension unit, output, output per hectare, intermediate consumption per hectare and subsidies are all significantly higher in the 25% more technically efficient farms. By contrast, labour per hectare, capital per hectare, subsidies per hectare and subsidies in total revenue are significantly lower in the top 25% of technical efficiency ratings. Similar results are obtained for the two other categories of farms except for subsidies per hectare, which are lower in the more efficient crop farms but higher in the more efficient beef meat and dairy farms. One also may notice that labour per hectare is not statistically different in the more efficient farms compared with other farms. Although the direction of causation cannot really be inferred from this analysis, the main conclusion that emerges is that the more efficient farms are larger than the rest of farms. They also have more output per hectare as well as more intermediate inputs per hectare. But subsidies in total revenue are lower for the farms ranked in the top 25% of technical efficiency ratings.

Efficiency change, technical change and total factor productivity change

The Malmquist productivity indices and their decomposition between technical efficiency and technological change are displayed in Table 4. The first picture that emerges is that annual average growth rates of efficiency, technological change and productivity are low for the three categories of farms. They are always lower than to 1% per year. The rate of productivity

growth is significantly greater for crop farms (0.524% per year) than for the two other categories of farms (0.041% for beef meat farms and 0.141% for dairy farms). The decomposition of productivity into its two components shows that technological progress is the dominant force for the three categories of farms, notably for dairy farms (0.881% per year). Average technical efficiency improves for crops farms (0.213% per year) but deteriorates for the two classes of animal farms (-0.216% per year for beef meat farms and -0.700% per year for dairy farms).

The change rates vary substantially from one year to another. Let us consider crop farms to illustrate this point. In 1996, technological change increased by 15.2% and technical efficiency decreased by -8.2% resulting in a 5.7% productivity growth. By contrast, in 1999, technological change decreased by -11.1% and technical efficiency increased by 7.9% resulting in a productivity decrease of -4.1 %. A similar pattern is obtained for beef meat farms (compare, for example, changes in years 1996 and 2002) and, but in a lesser extent, for dairy farms. For crop farms, when technological change regresses (respectively progresses), technical efficiency improves (respectively deteriorates). This occurs six years over a total of seven years considered. A similar conclusion does not arise for dairy farms as technological change and efficiency move in the same direction four times over the study period. And beef farms tend to exhibit an inverse pattern as technological change and technical efficiency move in the same direction for six years. A technological regress makes it easier for farmers to reach a point closer to the (new) frontier. The greater the number of farmers close to the frontier, the higher the average technical efficiency, other things being equal (Brümmer et al., 2002). What our results show is that in the case of beef meat producers, this simplified (and intuitive) explanation is clearly not the full story as technological progress (regress) is accompanied by technical efficiency improvement (deterioration). A third picture that emerges from Table 4 is that annual changes are generally higher for crop and beef meat producers than for dairy farmers. This observation can be related to policy instruments used in these three sectors, notably the fact that milk production is directly controlled by individual production quotas which are binding while production control is much more weaker in the two other sectors (there is no production control at farm level in the crop sector, only the definition of a base area for area payments at aggregate level, and premium quotas were not binding for most beef meat farms in the 1995-2002 period). Finally, one may notice that for crop farms, annual rates of changes are much higher for the two components of productivity (technical efficiency and technological change) than for the productivity itself. This is not the case for the two other categories of farms. For crop farms, such a result is not surprising since

most often technological change and technical efficiency show opposite patterns from one year to another (see above). This result however should be interpreted with caution. Our DEA model does not include climatic variables which very likely exercise a stronger influence on behaviours and production results of crop producers relative to beef meat or dairy producers.

Table 4. Productivity, technical efficiency and technological changes (1995 = 100)

Panel a. Crop farms (725 farms)

	1995- 1996	1996- 1997	1997- 1998	1998- 1999	1999- 2000	2000- 2001	2001- 2002	Average 1995- 2002 (*)	Annual growth rate over 1995-2002
Productivity change	105.7	109.0	104.9	100.6	102.7	98.0	105.2	103.67	0.524%
Technical efficiency change	91.8	108.0	98.0	105.8	106.4	96.6	105.0	101.49	0.213%
Technological change	115.2	101.0	107.2	95.3	96.6	101.7	100.3	102.28	0.325%

Panel b. Beef farms (102 farms)

	1995- 1996	1996- 1997	1997- 1998	1998- 1999	1999- 2000	2000- 2001	2001- 2002	Average 1995- 2002 (*)	Annual growth rate over 1995-2002
Productivity change	87.1	104.2	112.0	112.1	100.6	87.2	102.1	100.29	0.041
Technical efficiency change	98.4	99.4	105.5	98.8	96.0	94.8	96.9	98.49	-0.216
Technological change	88.5	104.8	106.0	113.4	104.6	91.9	105.2	101.46	0.209

Panel c. Dairy farms (268 farms)

	1995- 1996	1996- 1997	1997- 1998	1998- 1999	1999- 2000	2000- 2001	2001- 2002	Average 1995- 2002 (*)	Annual growth rate over 1995-2002
Productivity change	95.2	103.0	103.4	101.8	101.5	97.4	105.0	100.99	0.141%
Technical efficiency change	96.5	96.6	94.9	90.5	96.1	92.5	98.9	95.11	-0.699%
Technological change	98.7	106.7	109.0	112.4	105.6	105.2	106.1	106.17	0.882%

(*) Geometric mean over the period.

Do subsidies and farms' size matter?

Table 5 presents the regression results of the technical efficiency scores, indices of technical efficiency change, of technological change and of productivity change, for all three samples.¹ Higher scores/indices indicate greater efficiency/change, therefore parameters with positive (negative) sign reveal a positive (negative) influence of the corresponding explanatory variable on the dependent variable.

For all samples CAP direct payments expressed as a share of the farm revenue have a negative impact on technical efficiency, as expected from the literature. However, they have a positive influence on technical efficiency change, that is to say they help farmers getting closer to the frontier over time.

CAP direct payments as a share of revenue favour technological progress for crop farms only. They have no significant impact on technological change for beef meat and dairy farms. Finally, for all three samples, CAP direct payments as a share of revenue contribute significantly to enhance productivity growth.

For all samples larger farms are more technically efficient than smaller farms. In the crop sample, larger farms reduced their efficiency and productivity over time while smaller farms increased it, as shown by the negative parameter for the size variable. For beef meat and dairy farms, the size variable has no significant impact on productivity change, neither on its two components, technical efficiency change and technological change.

As far as other explanatory variables are concerned, one must distinguish between regression results of the technical efficiency scores and those of indices of technical efficiency change, technological change and productivity change. Most of these explanatory variables have a significant and conform to expectation impact on technical efficiency scores, especially for crop and to a lesser extent dairy farms. At reverse, except for the case of crop farms, most or even none of these explanatory variables influence significantly the indices of technical efficiency change, technological change and productivity change.

¹ Standard OLS are used for each regression, even for the regression with technical efficiency as dependent variable, since only a few farms are on the frontier each year (between 3 and 5 percent).

At this stage, one may acknowledge that regression results for these three indices are quite unsatisfactory for beef meat and dairy farms with the subsidy variable appearing as the only significant determinant of the technical efficiency, technological and productivity changes experienced by these farms over the 1995-2002 period. Such results are quite surprising and clearly need further investigations.

Table 5. Determinants of technical efficiency, and of technical efficiency, technological and TFP changes during 1995-2002

Panel a. Crop farms (725 farms)

	Estimated parameters and significance from regression on:			
	Technical efficiency (under CRS)	Technical efficiency change	Technological change	Productivity change
Constant	0.693 ***	1.144 ***	0.999 ***	1.141 ***
Age	-1.779 E-3 ***	-0.438 E-3	-0.112 E-3	-0.760 E-3 *
D=1 if agricultural education	2.898 E-3	-0.177 E-3	0.196 E-3	-0.237 E-3
Size (ESU)	1.523 E-3 ***	-0.447 E-3 ***	-0.012 E-3	-0.329 E-3 **
Capital to labour ratio	0.152 E-5	0.514 E-7	-0.688 E-5 ***	-0.634 E-5 *
Share of hired labour	-0.855 E-3 ***	0.452 E-3 *	0.057 E-3	0.379 E-3 **
D=1 if individual farm status	-0.041 ***	-0.011	0.003	-0.008
D=1 if cereals specialisation	-0.029 ***	-0.025 ***	0.004	-0.022 ***
D=1 if in Eastern France	0.040 ***	0.010	-0.0019	0.011
D=1 if in Western France	0.024 ***	0.023 **	-0.0023	0.021 *
D=1 if in Northern France-Paris area	0.044 ***	0.006	-0.0023	0.008
Direct payments per 100 euros of revenue	-1.298 E-3 ***	0.755 E-3 ***	0.110 E-3 **	0.935 E-3 ***
R-squared	0.24	0.15	0.42	0.06
Number of observations	5,800	5,075	5,075	5,075

Panel b. Beef farms (102 farms)

	Estimated parameters and significance from regression on:			
	Technical efficiency (under CRS)	Technical efficiency change	Technological change	Productivity change
Constant	0.841 ***	1.015 ***	0.906 ***	0.884 ***
Age	-0.2666 E-3	-3.178 E-3	-0.170 E-3	-3.853 E-3
D=1 if agricultural education	5.294 E-3	34.128 E-3	-3.133 E-3	39.394 E-3
Size (ESU)	2.246 E-3 ***	1.407 E-3	0.045 E-3	1.668 E-3
Capital to labour ratio	0.190 E-7	0.173 E-4	0.062 E-4	0.261 E-4
Share of hired labour	-0.977 E-3	0.098 E-3	0.255 E-3	0.274 E-3
D=1 if individual farm status	-0.029	-0.050	-0.001	-0.051
D=1 if in Western France	0.084 ***	0.028	-0.009	0.044
D=1 if in Eastern France-Northern France-Paris area	0.049 **	0.015	-0.002	0.027
Direct payments per 100 euros of revenue	-2.786 E-3 ***	5.656 E-3 ***	-0.131 E-3	6.728 E-3 ***
R-squared	0.14	0.04	0.13	0.04
Number of observations	816	714	714	714

Panel c. Dairy farms (268 farms)

	Estimated parameters and significance from regression on:			
	Technical efficiency (under CRS)	Technical efficiency change	Technological change	Productivity change
Constant	0.629 ***	1.022 ***	1.074 ***	1.089 ***
Age	1.847 E-3 ***	0.184 E-3	0.127 E-3	0.351 E-3
D=1 if agricultural education	18.197 E-3 ***	8.135 E-3	0.640 E-3	-6.450 E-3
Size (ESU)	1.779 E-3 ***	-0.087 E-3	0.092 E-3	0.067 E-3
Capital to labour ratio	0.431 E-5	-0.584 E-5	-1.315 E-5 ***	-1.750 E-5 **
Share of hired labour	-0.414 E-3	0.372 E-3	0.193 E-3	-0.179 E-3
D=1 if individual farm status	-0.033 ***	0.002	0.001	-0.004
D=1 if in Eastern France	0.031 ***	-0.012	0.001	-0.010
D=1 if in Western France	0.063 ***	-0.012	0.002	-0.009
D=1 if in Northern France-Paris area	0.094 ***	-0.014	0.007	-0.004
Direct payments per 100 euros of revenue	-3.977 E-3 ***	2.193 E-3 **	0.606 E-3	2.805 E-3 ***
R-squared	0.18	0.05	0.28	0.08
Number of observations	2,144	1,876	1,876	1,876

Note: Parameters for time dummies are not shown.

Concluding remarks

This paper first investigated productivity changes experienced by French farms over the period 1995 to 2002. Using FADN data for crop, beef meat and dairy farms, Malmquist productivity indices were calculated using DEA and decomposed into technical efficiency change and technological change.

Results suggest that over the 1995-2002 period, annual average growth rates of efficiency, technological change and productivity are low for the three categories of farms. The decomposition of productivity into its two components shows that technological progress is the dominant force for the three categories of farms, notably for dairy farms. Average technical efficiency improves for crop farms but deteriorates for the two classes of animal farms.

In a second-stage regression, we investigated whether there are significant influence of farms' subsidies on technical efficiency and on changes in productivity, technical efficiency and technology experienced by French farmers from 1995 to 2002. Our results interestingly show that CAP direct payments expressed as a share of farm revenue have similar impacts for all three types of farms: they influence negatively technical efficiency scores but positively changes in both technical efficiency and in productivity. Moreover, they favour technological progress for crop farms. In other words, our empirical results indicate that French farms that are more supported are less efficient, conform to expectations and to empirical results obtained in other studies. However, more supported farms would have experienced higher improvements in technical efficiency and higher productivity growth over the 1995-2002 period.

These results are only preliminary and must be considered cautiously. In fact, regression results of indices of technical efficiency change, technological change and productivity change are quite unsatisfactory, especially for beef meat and dairy farms. It is clear that these results, although providing interesting insights as regard the effects of CAP direct payments, clearly need further investigations. To this respect, one may underline that the three equations of the technical efficiency, technological change and productivity indices have been estimated separately using standard OLS. One must acknowledge that such an estimation technique may be inappropriate and lead to biased and inconsistent empirical results since the three indices are clearly interrelated. Hence in the next step, the system of the three equations, including the explicit relation between the three indices, will be consistently estimated using the appropriate estimation technique.

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