Impact of CAP direct payments on French farms' managerial efficiency

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Impact of CAP Direct Payments on French Farms' Managerial Efficiency

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Abstract— **This paper investigates the relationship between CAP direct payments and managerial efficiency for French crop and beef farms. Managerial efficiency scores are calculated using a four-step approach that allows to disentangle managerial inefficiency from other technical inefficiency components, notably what is due to unfavourable environment conditions. Then managerial efficiency scores are regressed over a set of explanatory variables, including CAP direct payments. Our empirical application, based on individual farm data and meteorological data at the municipality level for the year 2000, shows that there is a substantial component of inefficiency that is due to unfavourable conditions. Moreover, there is a significant negative relationship between managerial efficiency and CAP direct payments for crop farms, but a positive relationship for livestock farms. The type of payments also matter, with area-based and Less Favoured Area payments reducing crop farms' efficiency but headage and agri-environmental payments increasing beef farms' efficiency.**

Keywords— **technical efficiency, managerial efficiency, subsidies, crop farms, beef farms, France**

I. INTRODUCTION

Farmers in Western countries have always been highly subsidised. While it is commonly recognized that subsidies may have an impact on farm technical efficiency, there are surprisingly very few 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 at the "extensive margin". In a model with free entry and exit, Leathers [1] and Guyomard et al. [2] show that direct aids to farmers are likely to negatively affect the average technical efficiency of the farming sector as a whole by allowing relatively less efficient farms to stay in business. In these models however, the technical efficiency of a given farm is modelled as an exogenous variable entering the production, the cost or the profit function. As a result, this kind of studies cannot account for the potential impact of farm subsidies on the technical efficiency of each farm (i.e., at the intensive margin).

In this respect, Bergström [3] 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 [4]. Following Bergsman [5] and Balassa [6], arguing that protection increases X-inefficiency, and building on work by Corden [7] and Martin [8] 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 the negative relationship between aids and efficiency. Rezitis et al. [9] 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. [10] 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.

However, these agricultural studies consider the overall technical efficiency of farms, while the notion of X-efficiency upon which the Martin and Page's model is built on as well as the first reason invoked by Bergström for an expected negative relationship between subsidies and efficiency rather relate to managerial efficiency only. The managerial efficiency indeed represents the ability and the effort of farmers-managers. It is thus a more suitable variable on which subsidies may impact relative to other inefficiency components, notably those related to climatic or location characteristics.

Hence, this paper aims at investigating the relationship between income support direct aids and managerial efficiency for French crop and beef farms. Based on individual farm data for 2000, we use the four-step approach initially developed by Fried et al. [11] in so far as this approach seeks to disentangle managerial inefficiency from other technical inefficiency components, notably what is due to unfavourable environment conditions.

The paper is organised as follows. We first describe the four-step approach that has been implemented. In the following sections, we present the empirical model, the data and the empirical results. The paper ends with some concluding remarks.

II. METHODOLOGY

Managerial efficiency is the part of technical efficiency that is not due to environmental conditions. The Data Envelopment Analysis (DEA) approach is used to measure technical efficiency. This non-parametric method presents the advantages of not relying on a particular functional form for the frontier and of considering several outputs and inputs simultaneously.

Studies using DEA for investigating the effects of explanatory factors on technical efficiency resort to a two-stage approach in which the technical efficiency scores calculated with DEA in a first stage are regressed over the set of retained factors in a second stage. Our objective in this study is to investigate the impact of CAP direct payments on the managerial efficiency of French crop and beef farmers. For this reason, we use the four-stage approach proposed by Fried et al. [11] that allows adjusting the technical efficiency scores for the operating environment.

Fried et al.'s procedure is proposed for an input-orientated framework. In the first stage, technical efficiency (*TE*) is estimated with DEA including standard inputs and outputs. This gives, for each observation (i.e., each firm or farm), the total potential reduction of each input calculated as the radial reduction given by the efficiency score plus the non radial reduction given by input slacks. In the second stage, the total potential reduction for each input is regressed over a set of variables characterising the operating environment. The predicted input reductions are then used to adjust the primary input data in a third stage. Finally, in a fourth stage, new technical efficiency scores are calculated again using DEA but with the adjusted inputs. This final stage provides the managerial efficiency, that is to say the technical efficiency disentangled from environmental conditions.

In this paper we adapt the Fried et al.'s four-stage procedure to the output-orientated framework as we consider that this choice is more suitable for French crop and beef farms, which are not constrained on their output expansion. The four stages are defined as follows.

A. Calculation of technical efficiency and total potential output augmentations

DEA uses linear programming to construct the efficient frontier with the best performing farms of the sample so that all farms lie on or below the frontier. In the output-oriented framework, distance from a farm to the frontier on its output-ratio ray represents the extent of its radial (i.e. proportional) potential output augmentation; this distance defines the technical efficiency score. A firm might however have the potential to augment further some of its outputs:

"radial" efficiency increase does not exhaust improvement possibilities as firms may also extend output "non radially". Such non-radial output augmentations, also called slacks, are inherent to the DEA method. The distinction between radial and non-radial proportions is explained on Figure 1 in the two output technology, *ABCD* is the efficient frontier constructed with DEA. Point *F* represents a non-efficient farm. Its projection on the frontier along the output-ratio is *E*. Its efficiency score is thus *OF*/*OE* calculated as the radial potential augmentation of each output that the farm could implement without changing its input use. Additionally, farm *F* could increase its first output Y_1 by *EB* and still use the same level of input. Distance *EB* represents the non-radial potential augmentation of the first output.

Running several linear programming models gives for each farm *i*, firstly the output-oriented technical efficiency score, TE_i, secondly the non-radial potential augmentation for each output *k*, $NRA_{i,k}$. Then for each output *k* and each farm *i*, the total potential augmentation $OTA_{i,k}$ is calculated as:

$$OTA_{i,k} = (TE_i - 1) * 100 + NRA_{i,k} \quad (1)$$

B. Regression of each output total potential augmentation on environmental variables

A total of *K* equations are estimated, where *K* is the number of outputs. For the *k*-th output, the equation to estimate is:

$$OTA_{i,k} = g(Z_{i,k}) + u_{i,k} \qquad \text{for } i=1,\ldots,N \text{ farms} \quad (2)$$

where $Z_{i,k}$ is a vector of environmental variables for the *k*-th output, *g* is a function and $u_{i,k}$ is the error term

The predicted total augmentations of output, $\hat{OTA}_{i,k}$, represent the output loss that can be attributed to the external environment.

C. Adjustment of primary output levels

These predicted output total augmentations are then used to adjust the primary output data. The adjustment is realised using a base for comparison. The base we retained corresponds to the most favourable environmental conditions: for a farm operating in the best environment, the adjusted output is thus equal to the initial output; for the other farms, the adjustment formula increases the initial levels of outputs as the underlying assumption is to compensate the farm that produces proportionally less output because it operates in an unfavourable environment. Therefore, the primary output data are adjusted using the difference between the predicted total augmentation in outputs for the farm considered and the minimum predicted total augmentation in the sample. For the *k*-th output, the computation is as follows:

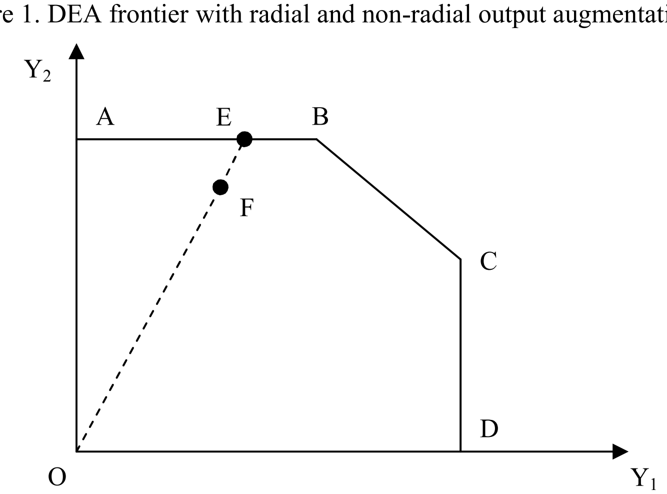
$$Y_{i,k}^{adj} = Y_{i,k} + \left[OT\hat{A}_{i,k} - \min\left(OT\hat{A}_{i,k}\right)\right] \qquad \text{for } i=1,\ldots,N \text{ farms} \quad (3)$$

with $Y_{i,k}^{adj}$ is the adjusted *k*-th output and $Y_{i,k}$ is the *k*-th primary output of the *i*-th farm.

D. Calculation of the managerial efficiency and analysis of the impact of CAP direct payments

The adjusted outputs are finally used in a second DEA linear programming model. The technical efficiency scores obtained are interpreted as measures of managerial efficiency. The managerial efficiency scores are regressed over a set of variables that are not characteristics of the environment. These explanatory variables include CAP direct payments.

Figure 1. DEA frontier with radial and non-radial output augmentations



III. DATA AND EMPIRICAL MODEL

Data are extracted from the French FADN for the year 2000 for farms specialised in crop production (European Type of Farming 13 and 14) and farms specialised in beef production (European Type of Farming 42). After cleaning for missing and inconsistent data, the sample size is of 2,045 crop farms and 569 beef farms.

Technical efficiency is calculated with DEA based on a multi-output multi-input model under variable returns to scale. Two aggregate outputs are considered: for crop farms, crop output (mainly cereals, oilseeds and protein crops) and other output (livestock output, live animals and manufactured products such as processed fruit, vegetable and oil products for instance); for beef farms, livestock output and other output. Four inputs are distinguished for crop farms, agricultural area in hectares, labour in Annual Working Units (AWU), the depreciated value of total assets for the capital factor, and intermediate inputs. The same inputs are used for beef farms, with the total livestock units as an additional input.

Table 1 displays descriptive characteristics for outputs and inputs used in the first DEA model. Input data are identical in the second DEA model while output data are initial data adjusted for accounting for environmental conditions.

Unfortunately but unsurprisingly, the FADN does not provide detailed information about the specific operating environment facing each farm. However, meteorological data from Météo France were available for the year considered at the municipality level. They include, as averages in the municipality where the farm operates, altitude, slope, minimal and maximal temperatures, rain level, evaporation, sunshine period and the water stock capacity. Additional FADN data proxying the environmental conditions where the farm operates were included: NUTS2 regional dummies, two dummies indicating whether the farm is situated in Less Favoured Area (LFA) and whether in mountainous LFA, respectively, and the value of subsidies received for farms situated in remote mountainous areas and for farms that have experienced a natural disaster the year before. It is expected that these Météo France and FADN variables characterise the main features of the operating environment faced by farms such as, for instance, land quality and climate conditions.

Finally, managerial efficiency scores obtained as output of the second DEA model are regressed over a set of explanatory variables, including CAP direct payments. In a general way, variables that are tested as main determinants of technical efficiency 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 they have a university education (dummy equal to 1). To proxy the farm legal status, a dummy equal to 1 if the farm is of individual type, was included (other statuses include mainly various forms of partnership). Regarding the technology employed, five variables were selected: the share of rented land in total utilised area, the share of hired labour in total farm labour, the capital to labour ratio, the land to labour ratio and the share of irrigated land. The debt to asset level was also included to represent the use of external financing.

Finally, the CAP direct payments received by the farm were considered. They include area-based payments (crop and set-aside payments), headage premiums for livestock, LFA payments and agri-environmental aids. In order to account for size effects, they are not specified as the total value per farm, but as the amount per hectare of utilised agricultural area; then the four various components are included in turn in separate regressions in order to assess their specific impact. Thus, five regressions are estimated for each sample. Table 2 reports descriptive statistics for these CAP direct payments. Crop farms received more CAP direct payments than beef farms in 2000 as a total amount; however, when compared per hectare, the amount received was fairly similar (around 330 euros/ha). As expected, crop farms received mainly area-based payments, and beef farms mainly headage premiums. Crop farms benefited almost from no LFA or agri-environmental payments.

Table 1. Descriptive statistics of the data used for the first DEA model

	Crop output (ths euros)	Livestock output (ths euros)	Other output (ths euros)	Land (ha)	Livestock units	Labour (AWU)	Capital (ths euros)	Intermediate inputs (ths euros)
	Crop farms (2,045 farms)							
Mean	104.7	Not used	79.9	131.1	Not used	1.75	203.1	82.6
Std deviation	79.5		67.7	78.8		1.17	154.0	53.1
Minimum	0.6		5.2	6.9		0.75	1.0	7.3
Maximum	890.6		743.7	655.7		14	1,669.2	500.5
	Beef farms (569 farms)							
Mean	Not used	56.3	38.9	96.8	114.9	1.50	229.6	40.2
Std deviation		34.3	25.8	55.6	61.6	0.61	127.2	27.6
Minimum		8.3	2.8	11.5	18.3	0.82	23.4	4.2
Maximum		262.9	196.8	391.9	428.7	5	922.0	195.8

Table 2. CAP direct payments received by farms

	Crop farms (2,045 farms)				Beef farms (569 farms)			
	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max
Amount per total output value	0.26	0.10	0	0.70	0.34	0.09	0.05	0.71
Amount per farm (ths euros)								
All payments	43.9	26.6	0	227.8	30.6	16.1	1.9	111.2
Amount per hectare of agricultural area (euros)								
All payments	337.0	77.4	0	1,090.1	330.7	83.6	81.7	845.3
Area-based payments only	322.7	79.9	0	676.4	39.4	42.0	0	346.8
Headage premiums only	11.6	32.3	0	627.6	233.1	73.6	0	675.0
LFA payments only	0.7	5.1	0	344.0	35.3	37.2	0	228.5
Agri-environmental aids only	2.0	13.6	0	125.1	22.8	22.8	0	153.8

Note: CAP direct payments include area-based payments, headage premiums, LFA payments and agri-environmental aids.

IV. RESULTS

A. Technical and managerial efficiency

Descriptive statistics of technical efficiency scores (first DEA model) and of managerial efficiency scores (second DEA model) are given in Table 3. Conventionally, the inverse of the scores given by the output-orientated models is used. As expected, the managerial efficiency is greater than the technical efficiency as it has been disentangled from unfavourable environmental effects. On average, there is a substantial difference between managerial efficiency scores and technical efficiency scores: efficiency scores are higher by 0.4 for crop farms and 0.6 for beef farms. This suggests that, although managerial inefficiency is the main source of technical inefficiency, inefficiency could be reduced if the farms were located in better environmental conditions.

B. Impact of direct payments on managerial efficiency

Table 4 presents results of the regression of the managerial efficiency scores. As only a few farms are on the frontier (3% in the crop sample, 6% in the beef sample), a standard OLS regression is performed. The dependent variable is the inverse of the output-oriented managerial efficiency score. It ranges between 0 and 1, and the higher its value, the higher the efficiency.

Regarding the effect of subsidies, results show that the amount of CAP direct payments per hectare of utilised agricultural area has a significant negative impact on managerial efficiency for crop farms but a positive impact for beef farms. This indicates that French crop farms that are more supported are less efficient, conform to the expectations based on previous studies. By contrast, CAP direct payments enable beef farms to increase their efficiency. The effects are however very small: one more euro of payment per hectare decreases, respectively increases, managerial efficiency by 0.0002 and 0.0003 unit for crop and beef farms respectively. Including each type of CAP direct payments in turn in the regression enables to capture the specific effects of the various types. Table 5 shows that the significant negative, respectively positive, impact of CAP direct payments is confirmed for crop farms when area-based payments, headage payments or LFA payments are considered. For beef farms, the positive impact is confirmed by headage payments, LFA payments and agri-environmental payments. By contrast, argi-environmental payments have no significant influence the crop sample's managerial efficiency, while LFA payments have no significant impact on the beef sample's managerial efficiency.

Regarding the effect of other variables, the impact of age is negative for crop farms. A higher age may imply reduced ability to work and/or reluctance to change and adopt technological innovations and/or less effort and less concern in optimising production. The university education dummy has an insignificant impact. We tried various educational variables in the model (including variables representing agricultural education), but none of them were significant. Individual farmers perform better than those farming in partnership. The share of rented land in total land has a positive impact and the share of hired labour in total labour has a negative impact for crop farms (no significant impact for beef farms). As expected, the higher the capital to labour on the farm, the more efficient a crop farm, while the more livestock units per hectare, the more efficiency a beef farm. As for the land to labour ratio, it has a positively impact for both crop and beef farms. The share of irrigated land has no significance influence, even for crop farm; this is consistent with the fact that disentangling from environmental conditions has increased farms' efficiency: irrigation thus plays no more role on efficiency. Finally, debts allow both crop and beef farms to perform better, may be by allowing them to purchase high quality inputs.

V. CONCLUDING REMARKS

This paper investigates the relationship between CAP direct payments and managerial efficiency for French crop and beef farms. Managerial efficiency scores are calculated using the four-step approach initially developed by Fried et al. (1999). This approach allows disentangling managerial inefficiency from other technical inefficiency components, notably what is due to unfavourable environment conditions. Then managerial efficiency scores are regressed over a set of explanatory variables, including the CAP direct payments.

Two main findings emerge. First, using meteorological variables at the municipality to characterise farms' operating environment enabled to disentangle inefficiency due to bad external conditions from managerial inefficiency. Second, there is a negative relationship between managerial efficiency and CAP direct payments for crop farms only. This indicates that French crop farms that are more supported are less efficient, conform to expectations and to empirical results obtained in other studies. However, the opposite is found for beef farms: more supported farms are more efficient. Investigating the relationship between managerial efficiency and CAP direct payments depending on the type of payments, showed that this (negative for crop farms, positive for beef farms) effect is to be found not only in the area-based or headage payments, but there is also a negative effect of LFA payments (for crop farms) and a positive effect of agri-environmental payments (for beef farms).

Table 3: Descriptive statistics of technical and managerial efficiency scores

	Technical efficiency score (first DEA)	Managerial efficiency score (second DEA)
Crop farms (2,045 farms)		
Mean	0.661	0.703
Standard deviation	0.131	0.116
Minimum	0.296	0.372
Maximum	1	1
Beef farms (569 farms)		
Mean	0.702	0.761
Standard deviation	0.133	0.118
Minimum	0.359	0.426
Maximum	1	1

Note: These descriptive statistics are for the inverses of the output-oriented efficiency scores.

Table 4: Results of the regression of managerial efficiency scores including the total CAP direct payments per hectare

	Marginal effects and significance for crop farms	Marginal effects and significance for beef farms
Constant	0.693 ***	0.512 ***
Age	-0.508 E-03 *	-0.164 E-03
Dummy = 1 if university education	0.011	0.006
Dummy = 1 if individual farm status	0.013 **	0.044 ***
Share of rented land	0.634 E-03 ***	0.117 E-03
Share of hired labour	-0.338 E-03 ***	0.519 E-03
Capital to labour ratio	1.72 E-07 **	-0.56 E-07
Livestock units per hectare of land	Not included	0.027 ***
Land to labour ratio	0.269 E-03 ***	1.011 E-03 ***
Share of irrigated land	-7.66 E-07	0.314 E-03
Debt to asset ratio	0.009 ***	0.035 **
CAP direct payments per hectare of land	-0.182 E-03 ***	0.313 E-03 ***
R-squared	0.071	0.136
Number of observations	2,045	569

Note: *, **, *** denotes significance at 10, 5, 1 percent level. E-*n* means $x10^{-n}$.

Table 5: Results of the separate regressions of managerial efficiency including various CAP direct payments in turn

	Marginal effects and significance for crop farms	Marginal effects and significance for beef farms
Area-based payments per hectare of land	-0.072 E-03 **	-.0005 E-03
Headage payments per hectare of land	-0.485 E-03 ***	0.254 E-03 ***
LFA payments per hectare of land	-1.237 E-03 ***	0.267 E-03 **
Agri-environmental payments per hectare of land	0.009 E-03	0.420 E-03 **

Note: *, **, *** denotes significance at 10, 5, 1 percent level. E-*n* means $x10^{-n}$.

Hence, caution should be made when drawing policy recommendations regarding the impact of direct payments on farms' efficiency. Although the literature agrees on a negative impact, due to a reduced effort, the conclusions may not be clear-cut: farms' production type and payment's type matter.

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