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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 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 the CAP direct payments. Our empirical application, based on individual farm data over the period 1995-2002, shows that for French crop farms, there is a strongly significant negative relationship between managerial efficiency and CAP direct payments. This indicates that French crop farms that are more supported are less efficient, conform to expectations and to empirical results obtained in other studies

**Keywords:** technical efficiency, managerial efficiency, subsidies, crop farms, France

**JEL Classification**: D24, Q12, Q18

## Impact of CAP direct payments on French farms' managerial efficiency

### 1. 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 (1992) and Guyomard et al. (2001) 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 such 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).

To this regards, Bergström (2000) 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.

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. 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.

Hence, this paper aims at investigating the relationship between income support direct aids and managerial efficiency for French crop farms. Based on individual crop farm data over the period 1995 to 2002, we use the four-step approach initially developed by Fried et al. (1999) 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.

## 2. 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 specific impact of CAP direct payments on the managerial efficiency of French crop farmers. For this reason, we use the four-stage approach proposed by Fried et al. (1999) that allows to adjust the technical efficiency scores for the operating environment.

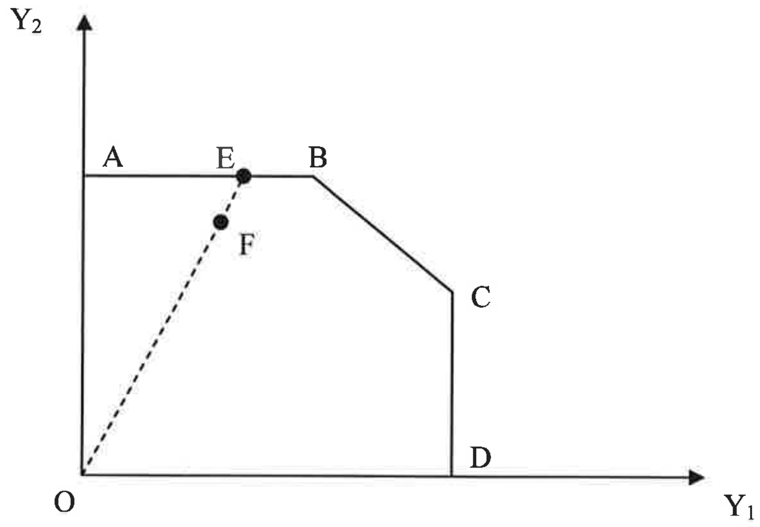
Fried et al.'s procedure is proposed for an input-orientated framework. In the first stage, technical efficiency (TE) is estimated with DEA including standard inputs and outputs. This gives, for each observation (i.e., each firm or farm), the total potential reduction of each input calculated as the radial reduction given by the efficiency score plus the non radial reduction given by inputs slacks. In the second stage, the total reduction for each input is regressed over a set of variables characterising the operating environment. The predicted total 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 using DEA 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 (1999) four-stage procedure to the output-orientated framework, we consider that such framework is more suitable for French crop farms who are not constrained on their output expansion. The four stages are defined as follows.

*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, which is its technical efficiency score. A firm might however have the potential to augment further some of its outputs. 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 below, representing a two-output space. ABCE is the efficient frontier constructed with DEA and F is a non-efficient farm. Its projection on the frontier along the output-ratio is E, and its efficiency score is OF/OE, which is the radial potential augmentation of each output that the farm could implement without changing its input use. Additionally, farm F could increase its output $Y_1$ by EB and still use the same level of input, therefore EB represents the non-radial potential augmentation of the first output.

Figure 1: DEA frontier with radial and non radial output augmentations




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 $k$-th output, $NRA_{i,k}$. Then for each $k$-th output and each $i$-th farm, the total potential augmentation $OTA_{i,k}$ is calculated as:

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

*Regression of each output's total potential augmentation on environmental variables*

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

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

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

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

*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 level of output 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 of the farm considered and the minimum predicted total augmentation in the sample. For the $k$-th output, the computation is as follows:

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

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

*Calculation of the managerial efficiency*

The adjusted outputs are used in a second DEA linear programming model. The technical efficiency scores obtained are interpreted as measures of managerial efficiency.

*Impact of direct payments*

The managerial efficiency scores are finally regressed over a set of variables that are not characteristics of the environment. These explanatory variables include CAP direct payments.

## 3. Data and empirical model

Data are extracted from the French FADN (RICA) for the years 1995 to 2002 for farms specialised in crop production. After creating a balanced sample over the whole period and cleaning for missing and inconsistent data, the sample size is of 725 farms for each of the eight years.

Technical efficiency is calculated with DEA based on a multi-output multi-input model under variable returns to scale. Two aggregate outputs are considered, 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). Four inputs are distinguished, agricultural area in hectares, labour in Annual Working Units (AWU), the depreciated value of total assets for the capital factor, and intermediate inputs. Outputs and intermediate inputs are in value and have been deflated by relevant price indices (base 1995).

Table 1 displays descriptive characteristics (calculated over the pooled sample) 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.

Table 1: Descriptive statistics (calculated over the pooled sample) of the data used for the first DEA model

| | Crop output (ths euros) | Other output (ths euros) | Land (ha) | Labour (AWU) | Capital (ths euros) | Intermediate inputs (ths euros) |
|---|---|---|---|---|---|---|
| Mean | 110.6 | 8.9 | 124.0 | 1.61 | 266.1 | 70.8 |
| Std deviation | 84.5 | 23.4 | 71.3 | 0.90 | 184.0 | 45.8 |
| Minimum | 0.1 | 0.0 | 12.4 | 0.75 | 8.7 | 4.5 |
| Maximum | 1,189.3 | 345.4 | 482.5 | 12.66 | 1,717.3 | 406.8 |

Note: The values of the aggregate crop output have been deflated by the French index of producer prices of crop 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.

Unfortunately but unsurprisingly, the FADN does not provide detailed information about the specific operating environment facing each farm. However, The FADN data base includes several location and subsidy variables that can be used as proxies for characterising this operating environment. Hence, the environmental variables used in the second stage consist of three main region dummies (Eastern France, Western France and Northern-Paris area), a dummy indicating whether the farm is situated in less favoured area, a dummy indicating whether the farm altitude is greater than 300 metres, and the (deflated) 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 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 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 (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-farm structural factors, only one variable was considered, that is 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). Table 2 reports descriptive statistics for the direct payments (total amount per farm, as a proportion of revenue and per hectare).

In the second stage, regressions of the first DEA scores over the retained environmental variables (region dummies, less favoured area dummy, altitude dummy and subsidies for location in remote mountainous areas and for natural disasters) are estimated with panel data, accounting for individual and time effects. However, statistical results indicate that the specification including both individual and time effects is rejected. Accordingly, the equations finally retained include only time dummies. Similarly, in the fourth stage, the regression of the managerial efficiency scores account for individual and time effects. Here, statistical tests suggest that both effects should be retained in estimated equations.

Table 2: CAP direct payments received by farmers (calculated over the pooled sample)

| | Total amount per farm (ths euros) | Direct payments per 100 euros of revenue (euros) | Direct payments per hectare of agricultural area (euros) |
|---|---|---|---|
| Mean | 37.5 | 39.4 | 302.4 |
| Std deviation | 23.7 | 33.3 | 71.5 |
| Minimum | 0.0 | 0.0 | 0.0 |
| Maximum | 224.5 | 1,166.8 | 977.4 |

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).

## 4. Results

*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.

Table 3: Descriptive statistics (calculated over the pooled sample) of technical and managerial efficiency scores

| | Technical efficiency score (first DEA) | Managerial efficiency score (second DEA) |
|---|---|---|
| Mean | 0.649 | 0.651 |
| Standard deviation | 0.190 | 0.188 |
| Minimum | 0.043 | 0.045 |
| Maximum | 1 | 1 |

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

The managerial efficiency is greater than the technical efficiency as it has been disentangled from unfavourable environmental effects. However, results reported in Table 3 show that, in average, there is not much difference between managerial efficiency scores and technical efficiency scores. This suggests that managerial inefficiency is the main source of technical inefficiency for French crop farms.

*Impact of direct payments on managerial efficiency*

Table 4 presents regression results of the managerial efficiency scores. As only a few farms are on the frontier (about 6 percent), 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. The higher the value, the higher the efficiency.

Table 4: Results of the regression of managerial efficiency (panel data, 725 farms over 8 years)

| | Parameter | t-test |
|---|---|---|
| Constant | 0.698 | 22.63 *** |
| Age | -0.940 E-3 | -1.84 * |
| Dummy = 1 if agricultural education | 4.934 E-3 | 0.50 |
| Size (ESU) | -0.125 | -1.15 |
| Capital to labour ratio | 0.013 E-3 | 3.82 *** |
| Share of hired labour | -0.001 | -5.06 *** |
| Dummy = 1 if individual farm status | 0.014 | 0.83 |
| Dummy = 1 if cereals specialisation | -0.004 | -0.52 |
| Direct payments per 100 euros of revenue | -0.40 E-3 | -6.91 *** |
| R-squared | 0.74 | |
| Number of observations | 5,800 | |

Note: *, **, *** denotes significance at 10, 5, 1 percent level.

The parameter associated with the variable Age is negative and significant. In fact, there is no agreement about the effect of the manager's age on technical efficiency in existing literature. On the one hand, higher age may be hypothesised to lead to reduced ability to work and/or reluctance to change and adopt technological innovations and/or less effort and less concern in optimising production. In such a case, a negative impact is expected (our result supports this hypothesis). On the other hand however, the manager's age may be considered as a measure of farming experience and management skills. Under this alternative assumption, a positive relationship between the manager's age and technical efficiency is expected. In view of both these possible interpretations of the effect of the farmer's age, it is common practice to introduce both the age and the squared age in regressions in order to figure a positive (due to increased farming experience) but declining (due to reduced ability to work, reluctance to change and decreasing effort as the farmer becomes older) effect of age on technical efficiency. In this study, we also tried such a specification of the age variable but no significant results emerged.

The agricultural education dummy has a positive but insignificant impact. The positive sign, which suggests that better agriculturally educated farmers run their farm more efficiently, is consistent with many other existing studies.

The impact of farm size on farm technical efficiency has been widely examined leading to rather controversial findings (see, e.g., Alvarez and Arias, 2004, for a recent review). Indeed, conclusions vary widely according to studies ranging from negative to positive or U-shape relationships as well as a number of inconclusive results. As far as this study is concerned, results belong to the inconclusive category since the parameter of the farm size variable is not significant. We also tested for a U-shape relationship by including both the farm size and the squared farm size in the regression. Both estimated parameters were still insignificant. Therefore, our results suggest that for French crop farms, over the 1995-2002 period, there is no empirical evidence of a clear relationship between farm size and managerial efficiency.

Usually, it is considered that farms using more capital-intensive technologies and relying more on family labour are more technically efficient. Our results are consistent with these expectations since the capital to labour ratio has a significant positive parameter while the share of hired to total labour has a significant negative parameter.

The dummy characterising the legal status has a positive but insignificant parameter, suggesting that individual farms perform as well as partnerships or other forms of farm organisation. As for the specialisation, cereal farms are as efficient as protein and oilseeds farms, as indicated by the insignificant parameter of the cereal specialisation dummy variable.

Finally, regarding the effect of subsidies, results show that the amount of direct payments per 100 euros of revenue has a significant negative impact on managerial efficiency. This indicates that French crop farms that are more supported are less efficient, conform to the expectations. When using the amount of direct payments per hectare, the influence is also negative and significant at the 1% level.

## 5. Concluding remarks

This paper investigates the relationship between CAP direct payments and managerial efficiency for French crop farms. Managerial efficiency scores are calculated using the four-step approach initially developed by Fried et al. (1999). This approach 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 the CAP direct payments.

Four findings emerge. First, differences between total and managerial efficiency scores are low. This suggests that managerial inefficiency is the main source of technical inefficiency for French crop farms. Second, there is a negative relationship between managerial efficiency and CAP direct payments. This indicates that French crop farms that are more supported are less efficient, conform to expectations and to empirical results obtained in other studies. Third, the main factors that significantly contribute to increase managerial efficiency of French crop farms are the use of capital-intensive technologies and the use of production practices based on family labour. Inversely, there is evidence of a negative relationship between farmers' age and managerial efficiency. Finally, farm size has no significant impact on managerial efficiency. As shown by the existing literature, the relationship between farm size and technical efficiency is complex and our result clearly needs further investigations.

In this paper, we have investigated the relationship between managerial efficiency and CAP direct payments, which constitute one form of agricultural support policy. It would be interesting to generalise the analysis to other kinds of income support policies, particularly price support, in order to examine whether alternative forms of support impact differently on farm managerial efficiency.

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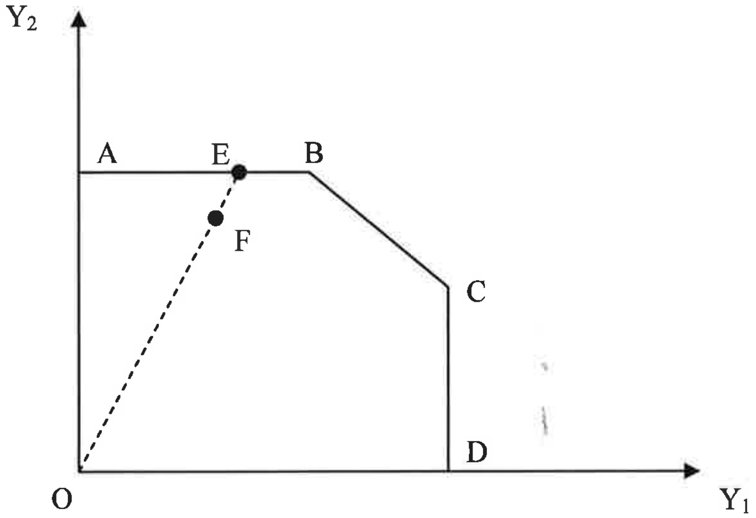
Figure 1: DEA frontier with radial and non radial output augmentations




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 $k$-th output, $NRA_{i,k}$. Then for each $k$-th output and each $i$-th farm, the total potential augmentation $OTA_{i,k}$ is calculated as:

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

*Regression of each output's total potential augmentation on environmental variables*

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

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

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

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

*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 level of output 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 of the farm considered and the minimum predicted total augmentation in the sample. For the $k$-th output, the computation is as follows:

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

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

*Calculation of the managerial efficiency*

The adjusted outputs are used in a second DEA linear programming model. The technical efficiency scores obtained are interpreted as measures of managerial efficiency.

*Impact of direct payments*

The managerial efficiency scores are finally regressed over a set of variables that are not characteristics of the environment. These explanatory variables include CAP direct payments.

## 3. Data and empirical model

Data are extracted from the French FADN (RICA) for the years 1995 to 2002 for farms specialised in crop production. After creating a balanced sample over the whole period and cleaning for missing and inconsistent data, the sample size is of 725 farms for each of the eight years.

Technical efficiency is calculated with DEA based on a multi-output multi-input model under variable returns to scale. Two aggregate outputs are considered, 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). Four inputs are distinguished, agricultural area in hectares, labour in Annual Working Units (AWU), the depreciated value of total assets for the capital factor, and intermediate inputs. Outputs and intermediate inputs are in value and have been deflated by relevant price indices (base 1995).

Table 1 displays descriptive characteristics (calculated over the pooled sample) 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.

Table 1: Descriptive statistics (calculated over the pooled sample) of the data used for the first DEA model

| | Crop output (ths euros) | Other output (ths euros) | Land (ha) | Labour (AWU) | Capital (ths euros) | Intermediate inputs (ths euros) |
|---|---|---|---|---|---|---|
| Mean | 110.6 | 8.9 | 124.0 | 1.61 | 266.1 | 70.8 |
| Std deviation | 84.5 | 23.4 | 71.3 | 0.90 | 184.0 | 45.8 |
| Minimum | 0.1 | 0.0 | 12.4 | 0.75 | 8.7 | 4.5 |
| Maximum | 1,189.3 | 345.4 | 482.5 | 12.66 | 1,717.3 | 406.8 |

Note: The values of the aggregate crop output have been deflated by the French index of producer prices of crop 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.

Unfortunately but unsurprisingly, the FADN does not provide detailed information about the specific operating environment facing each farm. However, The FADN data base includes several location and subsidy variables that can be used as proxies for characterising this operating environment. Hence, the environmental variables used in the second stage consist of three main region dummies (Eastern France, Western France and Northern-Paris area), a dummy indicating whether the farm is situated in less favoured area, a dummy indicating whether the farm altitude is greater than 300 metres, and the (deflated) 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 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 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 (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-farm structural factors, only one variable was considered, that is 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). Table 2 reports descriptive statistics for the direct payments (total amount per farm, as a proportion of revenue and per hectare).

In the second stage, regressions of the first DEA scores over the retained environmental variables (region dummies, less favoured area dummy, altitude dummy and subsidies for location in remote mountainous areas and for natural disasters) are estimated with panel data, accounting for individual and time effects. However, statistical results indicate that the specification including both individual and time effects is rejected. Accordingly, the equations finally retained include only time dummies. Similarly, in the fourth stage, the regression of the managerial efficiency scores account for individual and time effects. Here, statistical tests suggest that both effects should be retained in estimated equations.

Table 2: CAP direct payments received by farmers (calculated over the pooled sample)

| | Total amount per farm (ths euros) | Direct payments per 100 euros of revenue (euros) | Direct payments per hectare of agricultural area (euros) |
|---|---|---|---|
| Mean | 37.5 | 39.4 | 302.4 |
| Std deviation | 23.7 | 33.3 | 71.5 |
| Minimum | 0.0 | 0.0 | 0.0 |
| Maximum | 224.5 | 1,166.8 | 977.4 |

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).

## 4. Results

*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.

Table 3: Descriptive statistics (calculated over the pooled sample) of technical and managerial efficiency scores

| | Technical efficiency score (first DEA) | Managerial efficiency score (second DEA) |
|---|---|---|
| Mean | 0.649 | 0.651 |
| Standard deviation | 0.190 | 0.188 |
| Minimum | 0.043 | 0.045 |
| Maximum | 1 | 1 |

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

The managerial efficiency is greater than the technical efficiency as it has been disentangled from unfavourable environmental effects. However, results reported in Table 3 show that, in average, there is not much difference between managerial efficiency scores and technical efficiency scores. This suggests that managerial inefficiency is the main source of technical inefficiency for French crop farms.

*Impact of direct payments on managerial efficiency*

Table 4 presents regression results of the managerial efficiency scores. As only a few farms are on the frontier (about 6 percent), 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. The higher the value, the higher the efficiency.

Table 4: Results of the regression of managerial efficiency (panel data, 725 farms over 8 years)

| | Parameter | t-test |
|---|---|---|
| Constant | 0.698 | 22.63 *** |
| Age | -0.940 E-3 | -1.84 * |
| Dummy = 1 if agricultural education | 4.934 E-3 | 0.50 |
| Size (ESU) | -0.125 | -1.15 |
| Capital to labour ratio | 0.013 E-3 | 3.82 *** |
| Share of hired labour | -0.001 | -5.06 *** |
| Dummy = 1 if individual farm status | 0.014 | 0.83 |
| Dummy = 1 if cereals specialisation | -0.004 | -0.52 |
| Direct payments per 100 euros of revenue | -0.40 E-3 | -6.91 *** |
| R-squared | 0.74 | |
| Number of observations | 5,800 | |

Note: *, **, *** denotes significance at 10, 5, 1 percent level.

The parameter associated with the variable Age is negative and significant. In fact, there is no agreement about the effect of the manager's age on technical efficiency in existing literature. On the one hand, higher age may be hypothesised to lead to reduced ability to work and/or reluctance to change and adopt technological innovations and/or less effort and less concern in optimising production. In such a case, a negative impact is expected (our result supports this hypothesis). On the other hand however, the manager's age may be considered as a measure of farming experience and management skills. Under this alternative assumption, a positive relationship between the manager's age and technical efficiency is expected. In view of both these possible interpretations of the effect of the farmer's age, it is common practice to introduce both the age and the squared age in regressions in order to figure a positive (due to increased farming experience) but declining (due to reduced ability to work, reluctance to change and decreasing effort as the farmer becomes older) effect of age on technical efficiency. In this study, we also tried such a specification of the age variable but no significant results emerged.

The agricultural education dummy has a positive but insignificant impact. The positive sign, which suggests that better agriculturally educated farmers run their farm more efficiently, is consistent with many other existing studies.

The impact of farm size on farm technical efficiency has been widely examined leading to rather controversial findings (see, e.g., Alvarez and Arias, 2004, for a recent review). Indeed, conclusions vary widely according to studies ranging from negative to positive or U-shape relationships as well as a number of inconclusive results. As far as this study is concerned, results belong to the inconclusive category since the parameter of the farm size variable is not significant. We also tested for a U-shape relationship by including both the farm size and the squared farm size in the regression. Both estimated parameters were still insignificant. Therefore, our results suggest that for French crop farms, over the 1995-2002 period, there is no empirical evidence of a clear relationship between farm size and managerial efficiency.

Usually, it is considered that farms using more capital-intensive technologies and relying more on family labour are more technically efficient. Our results are consistent with these expectations since the capital to labour ratio has a significant positive parameter while the share of hired to total labour has a significant negative parameter.

The dummy characterising the legal status has a positive but insignificant parameter, suggesting that individual farms perform as well as partnerships or other forms of farm organisation. As for the specialisation, cereal farms are as efficient as protein and oilseeds farms, as indicated by the insignificant parameter of the cereal specialisation dummy variable.

Finally, regarding the effect of subsidies, results show that the amount of direct payments per 100 euros of revenue has a significant negative impact on managerial efficiency. This indicates that French crop farms that are more supported are less efficient, conform to the expectations. When using the amount of direct payments per hectare, the influence is also negative and significant at the 1% level.

## 5. Concluding remarks

This paper investigates the relationship between CAP direct payments and managerial efficiency for French crop farms. Managerial efficiency scores are calculated using the four-step approach initially developed by Fried et al. (1999). This approach 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 the CAP direct payments.

Four findings emerge. First, differences between total and managerial efficiency scores are low. This suggests that managerial inefficiency is the main source of technical inefficiency for French crop farms. Second, there is a negative relationship between managerial efficiency and CAP direct payments. This indicates that French crop farms that are more supported are less efficient, conform to expectations and to empirical results obtained in other studies. Third, the main factors that significantly contribute to increase managerial efficiency of French crop farms are the use of capital-intensive technologies and the use of production practices based on family labour. Inversely, there is evidence of a negative relationship between farmers' age and managerial efficiency. Finally, farm size has no significant impact on managerial efficiency. As shown by the existing literature, the relationship between farm size and technical efficiency is complex and our result clearly needs further investigations.

In this paper, we have investigated the relationship between managerial efficiency and CAP direct payments, which constitute one form of agricultural support policy. It would be interesting to generalise the analysis to other kinds of income support policies, particularly price support, in order to examine whether alternative forms of support impact differently on farm managerial efficiency.

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