

# The Role of Technical Efficiency in Takeovers: Evidence From the French Cheese Industry, 1985-2000<sup>†</sup>

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## **Abstract**

The paper aims to identify whether production characteristics, such as technical efficiency and returns to scale, affect takeovers. Applying a two-stage procedure on original panel data on French cheese manufacturers, the paper first estimates firm-specific productive efficiency and scale economies using Data Envelopment Analysis. The paper then uses the findings of the first stage to evaluate a random effects logit model of the determinants of takeover in the French cheese industry for the period 1985-2000. The paper finds that technical efficiency is not a significant determinant of takeovers, whereas the nature of scale economies is. Firms with Decreasing Returns to Scale (i.e. an over-sized production capacity) face a higher risk of takeover. This suggests that cheese manufacturers have been seeking to expand their milk processing capacities by acquiring large firms. This proves to be an indirect consequence of the non-transferable milk quota regime affecting the scarce milk input commodity.

**Key Words:** Technical Efficiency, Takeovers, Market Structure, Data Envelopment Analysis, Panel Data, Cheese Industry.

**Journal of Economic Literature Classifications:** C81, D24, L11, L25, L66, O1.

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<sup>†</sup> This work benefited from the very helpful and encouraging comments of Prof. John Sutton. Previous versions of this paper also benefited from insightful suggestions at CNIEL (French Dairy Industry Institute) presentations in Paris. We are also grateful to H el ene Raynal for her help in data handling. All views expressed and any errors are solely our own.

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# **The Role of Technical Efficiency in Takeovers: Evidence From the French Cheese Industry, 1985-2000<sup>†</sup>**

## **1. Introduction**

The dairy industry in the European Union exhibits a low rate of concentration, particularly the French dairy industry. According to a recent survey by the French ministry of agriculture, in 2000, 673 firms were producing cheese, and the Hirshman-Herfindhal (HH) concentration index was lower than 1000 (Onilait, 2004). This has prompted many analysts to think that the French dairy industry needs to be restructured, both in terms of product positioning and the number and size of firms. Thus, if some ‘waves’ of mergers are going to take place in the dairy industry, a key question becomes: what would the likely targets be?

There are several reasons why a company might be the acquisition target of another. As detailed in Gort (1969), horizontal or vertical takeovers can occur in order to benefit from potential operating or financial synergies. Operating synergies can be revenue-enhancing, when, for instance, a company with a strong distribution network acquires a multi-product firm. Operating synergies can also be cost-reducing, and aim at benefiting from economies of scale. For example, a company may expand through the horizontal acquisition of a competitor, thus increasing the size of its operation and lowering per unit costs. On the other hand, financial synergies occur when a larger firm is created through the combination of two or more smaller firms, and has better access to capital markets (Mueller, 1969). Gort (1969) also argues that mergers and acquisitions can take place as a result of economic disturbances affecting the industry, in order to restructure it and attain an optimal industry size.<sup>1</sup>

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<sup>1</sup> In the case of the dairy sector, the recent reform of the Common Agricultural Policy, which leads to significant decreases in intervention prices of butter and skimmed milk powder, is an example of economic disturbance that may provoke restructuring.

The literature also recognizes the role of agency costs as an important determinant of takeovers. As detailed in Shleifer and Vishny (1988) and Dickerson *et al.* (1998), agency costs materialize as a result of the separation of management and ownership. Managers could pursue personal goals and fail to maximize profits, thus the market for corporate control could act to discipline such poorly performing managers. Takeovers can thus be seen as a good tool to dismiss managers that are not acting in the shareholders' best interest.

It is difficult to draw the main determinants of takeovers from the empirical literature. For example, whereas Dickerson *et al.* (1998) finds a negative effect of profitability on the probability of takeover, Agrawal and Jaffe (2003) concludes that there is little evidence that supports the idea that takeover targets are those performing poorly, based on a review of the financial literature.

This paper uses data from 1985 to 2000, to analyze the main determinants of takeovers in the French cheese industry. We use a two-stage strategy. In the first stage, we estimate technical efficiency and the nature of scale economies for each firm. In the second stage, we use the results of the first stage, as well as other firm characteristics, to explain the probability of takeover of firms. Our results suggest that scale economies rather than productive efficiency are a significant determinant of takeovers, in the context of the cheese industry in France.

The structure of the paper is as follows. The following section provides some specific information about the dairy industry in France, and discusses the role of public intervention. In the third section, the method used to estimate the technical and scale efficiency of firms is detailed. The fourth section presents the data set Section five provides the estimation results, and section six concludes.

## **2. An Overview of the French Cheese Industry**

### **2.1 Some important facts**

The French cheese sector is quite unique. With almost 400 cheese varieties, and an overall production reaching 1.8 million tons in 2001, it stands as a major agro-food industry both on a European and an international level. Two factors contribute to the uniqueness of this industry. First, on the demand side, cheese is the main dairy product consumed in France. Cheese consumption reaches 24 kg/year/person, ranking the French second behind the Greeks as the world's top cheese consumers (Chausson, 2002). Second, on the supply side, cheese production uses up to 40% of the available raw material (milk), and accounts for almost 45% of sales in the dairy industry (Chausson, 2002).

The significant size of the cheese industry and the high diversity of cheese products have allowed the coexistence of two types of firms. On one side, there are large firms that possess the major cheese brands. Such firms either belong to the private sector (can be family-owned firms that are very common) – such as Lactalis, Bongrain and Fromageries Bel – or form parts of big cooperatives, such as Sodiaal or Eurial Poitouaine. On the other side, there is a myriad of small cheese manufacturing plants that produce local cheese products (Xerfi, 2002). Although the large firms dominate the cheese market (in 2000, the 11 biggest cheese groups accounted for more than 40% of market sales), yet a unique feature of the French cheese industry remains the fact that small manufacturers are still able to survive.<sup>2</sup> This may be due to three reasons. First, niche markets have formed around the traditional cheese varieties, due to the very high preference of French consumers for cheese variety. Second, massive public intervention in the dairy sector has allowed a slower rate of exit for cheese manufacturers, and

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<sup>2</sup> There are two main ways to explain small firms survival. One refers to niche market and the second one refers to innovation. As suggested by Agarwal and Audretsch (1999) both views are correct but are related to different phases of the industry life-cycle. The first one applies to a mature industry while the second one applies to a more recent industry. In the case of the cheese industry we thus refer to the niche market explanation.

helped maintain small firms in their areas. Finally, as shown by Chaaban (2004) for the soft cheese industry, two coexisting production technologies can be distinguished. Each technology has a particular efficient scale. One technology corresponds to small-scale production, with the product frequently benefiting from some label, and the other corresponds to more industrialized large-scale production. Therefore, the survival of small cheese manufacturers may also be due to the fact that an optimal production scale also exists for small and medium-size manufacturing firms.

Figure 1 below confirms these facts. In 2000, among the firms with more than 20 employees, almost 90% of those operating in the cheese industry had less than 50 employees each. Yet, these firms only accounted for about 8% of industry sales.

[FIGURE 1 ABOUT HERE]

[FIGURE 2 ABOUT HERE]

Figure 2 shows the evolution of the number of cheese-producing firms in France between the years 1985 and 2000.<sup>3</sup> Notice that this number declines over time, as in most manufacturing industries, yet the rate of decline is somewhat slow. More importantly, a significant number of firms are very small. In 2000, out of total of more than 600 firms, only 200 have more than 20 employees (Fig. 1).

This slow decline in the number of cheese manufacturers is further confirmed by looking at turnover statistics. Table 1 below shows that a large proportion of firms have remained in the industry over the years, and that turnover has been quite low (total dairy industry turnover was about 10% over the period).

[TABLE 1 ABOUT HERE]

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<sup>3</sup> Contrary to Figure 1 which refers to firms with more than 20 employees, Figure 2 presents the number of firms whatever their size.

Moreover, as shown in Figure 3, over the period 1985-2000, and contrary to other sectors in the dairy industry, the number of firms in the cheese sector remained quite stable (the dairy industry has four sectors: fluid milk and fresh products, butter, cheese and other dairy products).<sup>4</sup>

[FIGURE 3 ABOUT HERE]

However, this apparent stability of cheese firms hides takeover activity over the period. As will be shown below, about 21% of cheese firms were acquired by others between 1985 and 2000.

## **2.2 The importance of public intervention**

As for most agricultural commodities, dairy product markets are regulated in the European Union. The basic objective of this regulation is to guarantee to farm producers a minimum price for their commodities. In the case of dairy products, the regulation consists in intervention measures both at the supply side (milk production) and at the demand side (dairy product markets). At the supply side, the main regulation is the quota regime established in April 1984 (European Economic Council (EEC) Regulation No 856/84). Quotas are distributed among individual producers. In France, quota mobility is restricted. A quota cannot be traded freely and remains linked to the land. The direct consequence of such a policy is to maintain milk production in many areas, even in regions where milk production costs are high (see for example Guyomard *et al.*, 1996). Production in high cost areas is possible due to the guaranteed price policy that accompanies the quota policy. As a consequence, milk is produced in numerous farms and regions in France. Because milk is

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<sup>4</sup> Note that the decrease in the number of firms in 1998 is due to the change in the base of the survey (more than 10 persons until 1997, and more than 20 employees as of 1998). Also note that some firms produce more than one category of dairy product which explains why the total number of dairy firms is lower than the sum of dairy firms involved in each sector of the industry. Finally the figure refers to consolidated groups, where we aggregated individual subsidiaries into their mother groups.

costly to transport, milk-processing activities are needed in all regions in France. The European Commission supply-side dairy policy favours the existence of processing activities in all regions.

The guaranteed milk price policy is a consequence of the 'intervention' price policy designed for some dairy products (butter and Skimmed Milk Powder (SMP)). In other words, through different instruments (such as export subsidies, domestic consumption subsidies, public and private storage policy), the European Commission maintains the price of butter and SMP at minimum levels. This allows processors to pay milk at the 'recommended' price. As shown by the ONILAIT survey, every milk processor faces roughly the same milk price.<sup>5</sup>

What is true at the level of France is also true at the level of the European Union. While milk production costs vary across the European member states, quotas cannot be traded among countries. Thus, according to a recent study (Consortium INRA-Wageningen, 2002), the marginal costs of milk production vary between 0.14 €/kg in Ireland to 0.28 €/kg in Sweden. As explained for the French market, the farm milk price does not reflect these cost disparities. In the main producing countries, farm milk price is almost identical (0.31 €/kg in France, 0.31 €/kg in Germany and 0.32 €/kg in the Netherlands). This means that cheese manufacturers face a similar price for milk, independently of the degree of competitiveness of the upstream sector. Thus, firms do not benefit from low costs of milk production. Knowing that the main production cost is milk for most kinds of cheese, many cheese manufacturers have similar costs of production.

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<sup>5</sup> For example, in 2003-2004, according to the survey by ONILAIT (2004), the average price of milk in France was 0.256 €/l. The lowest regional price was 0.247 and the highest was 0.260 (excluding Franche-Comté where milk price is significantly higher (0.291 €/l) because of the specificity of production; thus, Comté, a PDO cheese (Protected Designation of Origin), is the main production of the area and milk used for Comté production needs to be produced according to special requirements, which excludes in particular the use of silage, which increases the production costs). Thus the difference of average milk price is lower than 5% across regions while the difference in average production cost was roughly estimated to 25 to 30% by Guyomard, Delache, Irz and Mahé (1996).

Thus, the public regulation of the industry is likely to limit the possibility of takeover. In another context, Masson and DeBrock (1980) showed that the regulation of fluid milk prices in the US had a significant impact on the number of dairy plants in the US.

Moreover, according to CNIEL (Centre National Interprofessionnel de l'Economie Laitière), more than 400 cheese varieties are produced in France. Among them, 45 have obtained the Protected Designation of Origin (PDO) label, which is a signal of specificity and quality. Thus, French cheese production is highly differentiated. This also explains why the number of cheese producers remains high. By definition, PDO production cannot be delocalised. Indeed, the label says that the product has specific characteristics because it is produced in a given area according to given requirements. Even though PDO production only represents 10% of the French cheese production, numerous firms produce PDO cheese. Only one firm, Lactalis, is significantly present in the production of the main PDO cheese in France.

### **3. Method and estimated models**

The most commonly employed determinants of takeover include profitability, growth, size, leverage and liquidity. As reviewed in Dickerson *et al.* (1998), 'most studies find that profitability has a negative effect on the probability of takeover, confirming the fact that the market for corporate control acts to discipline poorly performing managers' (p. 284). This is what Hannan and Rhoades (1987) refer to as the "driving out bad management hypothesis". However, Agrawal and Jaffe (2003) argue that there is little evidence to support the idea that takeover targets perform poorly.

Wheelock and Wilson (2000) and Cebenoyan *et al.* (2002) have taken an interesting approach to test the relationship between managerial efficiency and the risk of takeover. Both studies employ a two-stage methodology to examine the banking industry. First, they estimate cost

inefficiency by employing econometric and linear programming techniques. Then, they use the inefficiency estimates as an explanatory variable, along with other firm-specific and market variables. This methodology relies on the assumption that managers may have greater control over cost efficiency versus profitability, and therefore that the evaluation of cost efficiency may be a better test of the bad management hypothesis. In the first stage, Wheelock and Wilson estimate both a parametric stochastic frontier model to estimate cost inefficiency, as well as nonparametric distance functions to estimate input and output technical inefficiency. On the other hand, Cebenoyan *et al.* estimate inefficiency scores for individual thrifts for each year using a stochastic cost-frontier methodology.

The empirical literature on the determinants of takeovers has used different modeling strategies (see for example Cebenoyan *et al.* (2002) and Dickerson *et al.* (1998)). Two techniques have mostly been used. The first has been cross-sectional logit/probit analysis, which explores the ex-post correlates of takeovers. The second has been a proportional takeover hazard model to predict the time to takeover<sup>6</sup>. Logit models are simpler and require fewer restrictive assumptions, such as constant proportionality. Yet, as argued by Dickerson, Gibson and Tsakalotos (1998), cross-sectional logit/probit analyses cannot measure the impact of a company's changing age on its risk of takeover, and nor can they incorporate other time-varying covariates.

In this paper, we follow the approach developed by the above-mentioned studies. We first evaluate firm-specific yearly productive efficiency and scale economies performance, and then use these results as possible determinants of firm takeover.

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<sup>6</sup> The standard proportional continuous time hazard function (Cox, 1972) can be written as:

$$g_i(t) = g_0(t) \exp[X_i(t) * \beta]$$

where  $g_i(t)$  is the instantaneous probability of takeover for company  $i$  conditional on survival to time  $t$ ,  $g_0(t)$  is the underlying or baseline hazard at time  $t$ ,  $X_i(t)$  is a vector of explanatory variables and  $\beta$  is a vector of unknown parameters.

As explained below, we evaluate efficiency using Data Envelopment Analysis. In the second stage, we develop a panel data modeling approach, in order to overcome the limits of cross-sectional analysis. This is made possible by our data set, which consists of a panel of unbalanced cheese firms that allows us to track the time and individual-specific covariates over the period under study. We use a random effects logit modeling approach, which allows us to take into account, for the first time to our knowledge, firm heterogeneity in the analysis of takeovers.

### **3.1 Technical efficiency estimation: Data Envelopment Analysis (DEA)**

In this paper we use the widely known Data Envelopment Analysis (DEA) tool in order to evaluate the technical or productive efficiency of cheese firms. This technique falls into the broader category of efficiency evaluation methods, which seek to benchmark a firm or an operating unit's performance against a common estimated best-practice frontier. DEA uses a non-parametric linear programming methodology in order to calculate a sample's technology frontier, and then provides firm-specific (in)-efficiency and scale economies measures relative to this frontier.

The reason we only employ DEA and not parametric techniques, such as regression analysis or Stochastic Frontier Analysis (SFA), is that these parametric methods typically involve the specification of a Translog production or cost function. This function entails difficulties in estimation, especially when one seeks to identify a multi-product efficiency frontier. In our present setting, cheese firms are of a multi-product nature. We don't have firm-level data on input and output prices, as the Annual Firm survey only contains income statement variables. These input/output prices are essential if one needs to estimate a parametric Translog function (see for instance Christensen and Greene (1976) and Ferrier and Lovell (1990) for more details). DEA provides a simple treatment of multiple input/output settings, and has the

advantage of not imposing an *a priori* functional form on the production technology. More importantly, the DEA method is able to provide firm-specific efficiency scores, along with an indication into the nature of scale economies achieved at the firm level. DEA is thus more versatile than other parametric methods.

With this in mind, a major drawback of this non-parametric method is the fact that it attributes all deviations from the frontier to inefficiency. This deterministic nature of the DEA model has to be borne in mind when interpreting efficiency measures. Detailed discussions concerning DEA and its widespread applications can be found in Ali and Seiford (1993), Banker *et al.* (1984), Bowlin (1998) and Seiford and Thrall (1990).

In this paper, an input-oriented DEA model is used, and only technical efficiency is evaluated. The absence of information on input prices makes the evaluation of allocative efficiency impossible.

In Appendix 1, the theoretical model underlying the estimation procedure is discussed, based on the axiomatic approach to modeling the production technology detailed in Färe *et al.* (1994).

In our yearly DEA estimations, we use a multi-output/multi-input cheese technology specification. We consider three inputs: labor (measured by the total wages paid), raw materials (measured as the sum of total purchases of raw materials and the variation in inventories), and capital (proxied by the sum of interest paid and asset depreciation). These input definitions have now become standard in the literature on productivity analysis (see Scully (1999) for a brief review)<sup>7</sup>. The output vector we retain contains 7 types of cheese outputs, in addition to the sales realized by the firm outside the cheese sector. The inclusion of this last variable is intended to correct any bias in productivity measurement<sup>8</sup>.

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<sup>7</sup> It is assumed that firms face the same input prices. This is a reasonable assumption in France because of a high degree of public intervention in the milk sector, making the price of milk, the main input used by cheese firms, relatively given for all firms (Onilait 2004).

<sup>8</sup> The details of the sampling methodology are detailed in Trevisiol (2003).

### 3.2 The determinants of takeovers: the Random Effects Logit model

Having estimated technical efficiency and evaluated the nature of scale economies for each firm, we use these results as possible determinants of a cheese firm being taken over, along with some other firm characteristics. For this, we use the maximum likelihood logit model, defining a binary dependent variable of a firm being taken over or continuing to operate.

The structural model for our unbalanced panel data can be written as<sup>9</sup>:

$$y_{it}^* = \mathbf{x}'_{it-1}\beta + \varepsilon_{it}, i = 1, \dots, n, t = 1, \dots, T_i,$$

$$y_{it} = 1 \text{ if } y_{it}^* > 0, \text{ and } 0 \text{ otherwise.}$$

$y$  is the takeover binary dependent variable, which takes the value of one if the firm has been taken over at time  $t$ , and 0 otherwise.  $\mathbf{x}$  is a vector of explanatory variables, including the efficiency or scale economies estimates. As in Hannan and Rhoades (1987), these explanatory variables are lagged one year in order to allow for a time lag between a firm's specific conditions and its takeover activity.

The availability of an unbalanced panel data allows accounting for unobserved firm heterogeneity when estimating the above model. Typically, an effects model is written:

$$y_{it}^* = \mathbf{x}'_{it-1}\beta + v_{it} + u_i, i = 1, \dots, n, t = 1, \dots, T_i,$$

$$y_{it} = 1 \text{ if } y_{it}^* > 0, \text{ and } 0 \text{ otherwise.}$$

Where  $u_i$  is the unobserved firm specific heterogeneity. Random and fixed effects models thus arise, depending on the assumptions one imposes on the relationship between  $u_i$  and  $\mathbf{x}_{it-1}$ . If  $u_i$  is assumed to be unrelated to  $\mathbf{x}_{it-1}$ , then we get the *random effects model*. If the conditional distribution  $f(u_i|\mathbf{x}_{it-1})$  is unrestricted, so that  $u_i$  and  $\mathbf{x}_{it-1}$  may be correlated, then we get the *fixed effects model*. In this paper, we only focus on the random effects logit model.

The regression to be estimated is written as:

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<sup>9</sup> This presentation follows Greene (2003), chapter 21.

$$P_{i,t} = \alpha + \beta_1 AGE_{i,t-1} + \beta_2 FIN_{i,t-1} + \beta_3 COOP_{i,t-1} + \beta_4 \mathbf{D}'_{i,t-1} + v_{it} + u_i$$

where:

$P_i$ : takeover binary variable (equal to 1 if the cheese firm is acquired during the period 1985-2000, 0 otherwise),

$AGE_i$ : logarithm of the age of the firm (taking into account the censoring effect at the beginning of the period)

$FIN_i$ : the total financial expenditures (measured in logs)

$COOP_i$ : a dummy variable equal to 1 if the cheese firm is a cooperative, 0 otherwise.

$\mathbf{D}_i$ : a vector of efficiency/scale economies measures. We use three different setups with different variables included in  $\mathbf{D}_i$ . In Model 1, we only include the firm-specific efficiency score under a constant return to scale frontier assumption ( $EFF\_CRS_i$ ). In Model 2, we use the efficiency score under a variable return to scale technology assumption ( $EFF\_VRS_i$ ). In Model 3, we include two dummy variables indicating increasing returns to scale ( $IRS_i$ ) or constant returns to scale ( $CRS_i$ ). These dummy variables are intended to capture the effects of the nature of scale economies on the probability a cheese firm is taken over.

Given this, the estimated variance of the random effect  $u$  can be used to assess the importance of this effect with:

$$\rho = \frac{\sigma_u^2}{\sigma_u^2 + 1}$$

This statistic gives the correlation between the composite errors across any two time periods. If  $\rho$  is not significantly different from zero (using a standard  $t$ -test), then we cannot reject the null hypothesis that unit effects are zero.

We can also compute the predicted probability of an average firm being taken over. This probability is given by:

$$\hat{p} = \frac{1}{1 + \exp(-(\hat{\alpha} + \hat{\beta}\bar{\mathbf{x}}'))}$$

Where  $\bar{\mathbf{x}}$  is the vector of the mean of explanatory variables, excluding dummy variables.

### 3.3 Anticipated effects of the explanatory variables

There are two conflicting theories linking efficiency to the risk of takeover. Under the ‘bad management hypothesis’ introduced by Hannan and Rhoades (1987), inefficient or poorly managed firms are swept out of the industry, as acquirers seek to gain from turning these firms around. A low technical efficiency would therefore lead to a higher takeover probability, implying that the coefficient of *EFF\_CRIS* or *EFF\_VRS* is expected to be significant and negative (remember that we are using an input oriented measure). An alternative view is that inefficiency can be unattractive, as it signals to potential acquirers problems with the target firms. As noted by Wheelock and Wilson (2000) in the context of the banking sector, “the costs of reorganizing an inefficient bank and the potential for hidden problems that inefficiency might signal tend to discourage the acquisition of inefficient banks.” Under this view, the coefficient associated with our efficiency measure is expected to be significant and positive. We have no *a priori* expectation over the signs of the coefficients associated with the nature of scale economies.

Regarding the remaining variables, we expect the coefficient of *AGE* to be significant and negative, with older and therefore well-established firms facing a lower risk of acquisition. We also expect the coefficient of *FIN* to be significant and positive, as firms facing a bad financial position are more prone to being acquired. The coefficient of *COOP* is expected to be negative, because cooperatives are not easily acquired due to the many legal problems associated with this process. Moreover, the cooperative structure in agro-food industries is often very complex, and therefore not an easy target for restructuring.

#### **4. The Data**

Data on the cheese industry was obtained by merging two statistical sources. The first is the Annual Firm Survey conducted by the French Ministry of Agriculture, which compiles accounting and firm specific data. The second is the Annual Dairy Production Survey also conducted by the Ministry of Agriculture, surveying dairy production by all firms operating on the French territory. This survey contains detailed information about the quantities produced by each firm, according to a very narrow product definition. Merging these two datasets has allowed the construction of a detailed firm-specific production process database (inputs, outputs, cost, plus other firm characteristics), made available for the first time in studies concerning French industries. We thus get an unbalanced panel data set, where cheese firms can be observed throughout the period from 1985 to 2000. It is an unbalanced panel because not all firms are operating in all the years under consideration.

In this paper, we concentrate on cheese firms, and we take into account the multiple sub cheese outputs produced by these firms. We therefore select in the unbalanced panel at hand firms that were only active in the cheese market, or firms that had a cheese output exceeding 1% of industry production. In addition, a second level of firm selection is applied, where we only keep companies for which we have the necessary input and output information to estimate technical efficiency scores. Table 2 below presents the annual number of firms in the selected sample, as well as its relative significance. On average, our sample represented about 80% of industry sales and 64% of industry production over the period.

[TABLE 2 ABOUT HERE]

We particularly focus in this paper on exploring the determinants of takeovers of cheese producers. Table 3 details the number of takeovers that occurred with regards to all firms that operated in the cheese industry during the 1985-2000 period.

[TABLE 3 ABOUT HERE]

In the overall population, about 21% of firms were acquired. In the sample under study, 25% of firms were acquired, and these takeovers constitute about 1/3 of the overall observed ones.

## **5. Results**

### **5.1 Technical efficiency estimation results**

The DEA estimation of technical efficiency was conducted on a yearly basis over the sample at hand<sup>10</sup>. Table 4 below shows the mean efficiency scores obtained for the period, according to different assumptions on the production technology (constant or variable returns to scale). Results show that firms, on average, should have decreased their input use by 18% over the period, in order to operate on the estimated best practice frontier, under a variable returns to scale assumption.

[TABLE 4 ABOUT HERE]

### **5.2 Logit model estimation results**

We can now test two key questions:

- Is technical efficiency a significant determinant of takeovers (having either a positive or a negative relationship)?
- Is the nature of scale economies at the firm level a significant determinant of takeovers?

Table 5 below summarizes the logit estimation results, for the three models highlighted above.

[TABLE 5 ABOUT HERE]

All three models have their parameters jointly significant (Likelihood Ratio (LR) tests on the three models indicate a good fit).

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<sup>10</sup> The ONFRONT<sup>®</sup> software, developed by Färe and Grosskopf (2000), was used to obtain efficiency estimates.

Considering models 1 and 2, we find that the technical efficiency variable (*EFF\_CRS* and *EFF\_VRS*) has a positive but insignificant coefficient. Inefficient firms have a lower probability of being acquired, yet this effect is not statistically significant. This result reflects the findings of Hannan and Rhoades (1987), who find an insignificant relationship between takeovers and firm profitability (their proxy for management efficiency). We are therefore led to reject the role of technical efficiency on the probability of takeover.

The coefficients associated with increasing and constant returns to scale (*IRS* and *CRS*) in model 3 are both negative and statistically significant. Firms with increasing or constant returns to scale face a lower risk of being acquired than those with decreasing returns to scale (*DRS*). This means that the nature of scale economies at the firm level plays an important role in the takeover activity. Acquiring firms seem to prefer targets with *DRS* properties. These targets are typically large firms with a large production capacity (see Table 6 and Appendix 2). Therefore, the takeover motive could be more expansionary than restructuring, through the acquisition of (scale) optimal firms. Milk regulation, particularly the milk quota system in place, may also explain this result. Because of the quota management in France (non tradable quota that is linked to the land), it is difficult for a firm to increase its milk procurement. Because milk cannot be substituted by other inputs to produce the final dairy product, a firm can increase its production by taking over other firms in order to have an increased access to raw material.

Table 6 confirms that firms possessing a Decreasing Returns to Scale *DRS* production are large structures. The assets (measured in book value, *KF*, *ASSETS* variable) and the production level (*Q* variable, measured in tons) of *DRS* firms are much larger on average than their *IRS* and *CRS* counterparts. Figures A.2.1 and A.2.2 in Appendix 2 confirm these findings, by constructing Box-Whiskers plots of our two size variables: assets and the production level.

[TABLE 6 ABOUT HERE]

With respect to the other variables, we find first that older firms have a lower probability of being taken over, as the coefficient of *AGE* is negative and significant in all three models. Two reasons could be behind this finding. First, older cheese manufacturers could be well-established and sufficiently strong to face any takeover threat. Second, younger firms might present stronger growth opportunities than older ones, making them a more attractive acquisition target.

Second, the coefficient of the financial expenditures variable *FIN* is significantly positive in all three models. Firms with high financial expenditures, and therefore high debt, face a greater risk of being acquired than firms with less financial stress. This finding echoes a commonly known fact in the takeover literature, where financially well-positioned firms can defend themselves more aggressively against takeovers, while firms with bad financials make easy targets.

Lastly, the coefficient of the *COOP* variable is significantly negative in the three estimated models, indicating a lower risk for cooperatives of being acquired. This result is in line with our prediction that firms with a cooperative structure make a difficult target for acquirers, because the acquisition of a cooperative is often hampered by legal problems and cooperative members' opposition, who often are strong farmers unions.

Another central finding in the estimation above is the statistical importance of firm heterogeneity  $\rho$ . The statistic gives the correlation between the composite errors across any two time periods, and is not significantly different from zero in all three models. Therefore, we cannot reject the null hypothesis that unit firm effects are zero. This indicates that one needs to incorporate individual firm specific effects when modeling the takeover probability of cheese firms. This also fully justifies the panel approach we choose in this paper.

Table 7 below gives the predicted probability in model 3 that a cheese firm is the target of a takeover, given the nature of scale economies and whether or not it is a cooperative.

[TABLE 7 ABOUT HERE]

As expected, the highest predicted probability of takeover occurs for a non cooperative firm having decreasing returns to scale, with mean age and financial charges.

An interesting question that one could also raise is: Did the acquired cheese firms improve their technical efficiency after being taken over? To answer this question, we look at the evolution of the main estimated productivity characteristics of these acquired firms, between 1985 and 1997. We present in Appendix 3 the evolution of efficiency ranking with respect to other firms (Rank, under a Constant Returns to Scale CRS or a Variable Returns to Scale VRS estimation procedure).<sup>11</sup>

As reported in Table 8, the efficiency of firms taken over during the period is not improved. Under the CRS assumption, a firm that is taken over has the same probability of improving its ranking as a firm that has not been taken over. Whereas under VRS, a firm taken over has a lower probability of improving its ranking than a firm that has not been acquired during the period. This is coherent with the fact that we do not find a significant role for technical efficiency in the probability of a firm being taken over.

[TABLE 8 ABOUT HERE]

## **6. Conclusions**

In this paper, we used a two-stage procedure to identify whether production characteristics such as technical efficiency and returns to scale affect takeovers. Using original panel data on French cheese manufacturers, we first estimate firm-specific productive efficiency and scale economies using Data Envelopment Analysis. In the second stage, we evaluate a random effects logit model of the determinants of takeover in the French cheese industry for the

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<sup>11</sup> We have a sample of 81 firms that were present both in 1985 and 1997. The efficiency ranking of the 14 firms that were acquired during this period is measured with respect to the other non-acquired cheese firms.

period 1985-2000. We use the results of the first stage, as well as other firm characteristics such as financial expenditures and the nature of ownership, as explanatory variables. We find that technical efficiency is not a significant determinant of takeovers, while the nature of scale economies is. Firms with Decreasing Returns to Scale (i.e. an over-sized production capacity) face a higher risk of takeover. This suggests that French cheese manufacturers have sought to expand their milk processing capacities by acquiring large firms. This may have been an indirect consequence of the non-transferable milk quota regime. By acquiring a competitor, a firm would be seeking an increased access to a scarce input that is absolutely needed to increase its production.

We also find that firm-specific effects are significant. This indicates that one needs to incorporate individual firm-specific effects when modeling the takeover probability of cheese firms. This fully justifies the panel approach we chose in this paper.

## List of tables

**Table 1: Yearly turnover -1985-2000**

Year	Remaining (in %)	Entering (in %)	Exiting (in %)
1985-1986	90,9	3,3	5,9
1986-1987	90,8	2,1	7,1
1987-1988	90,0	2,9	7,1
1988-1989	90,0	2,3	7,7
1989-1990	85,7	4,3	10,1
1990-1991	87,7	4,0	8,3
1991-1992	85,1	4,4	10,5
1992-1993	88,3	3,7	8,1
1993-1994	87,6	4,4	8,1
1994-1995	78,5	8,7	12,8
1995-1996	86,8	4,9	8,4
1996-1997	88,5	2,9	8,6
1997-1998	72,2	12,1	15,8
1998-1999	88,1	7,0	4,9
1999-2000	88,4	5,4	6,1
<b>Average 1985-2000</b>	87,5	4,0	8,5

Source: Dairy Products Survey (PRODCOM), French Ministry of Agriculture

*Note:* Before 1998, the survey considers firms with more than 10 employees, while after 1998, the survey only covers firms employing more than 20 employees, which explains the sudden change in the statistics between 1997 and 1998.

**Table 2: Number of firms (Eff), Quantity share (SQ) and sales share (SCA) for the sample under consideration**

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Eff	183	180	171	172	159	154	143	161	185	180	177	194	170	178	177	178
SQ	55.2	52.6	50.2	52.8	45.6	44.7	42.8	49.5	66.6	61.0	73.7	77.6	76.8	86.0	86.4	89.2
SCA	76.5	72.8	69.0	72.9	74.3	70.3	69.8	77.0	86.4	89.2	81.5	81.9	84.3	92.4	85.2	90.4

**Table 3: Number of takeovers in the cheese industry**

	<i>Sample</i>	<i>Overall</i>
<b>Total Number of firms</b>	410	1806
<b>Number of takeovers</b>	116	383

**Table 4: Input oriented technical efficiency scores 1985-2000**

Score	<i>EFF_CRS</i>	<i>EFF_VRS</i>	<i>SE</i>
Mean	0.71	0.82	0.86
Sd.	0.23	0.20	0.17

*EFF\_CRS*: Mean technical efficiency score, constant returns to scale assumption.  
*EFF\_VRS*: Mean technical efficiency score, variable returns to scale assumption.  
*SE*: Mean scale efficiency score.

**Table 5: Logit Estimation Results**<sup>12</sup>

	Model 1	Model 2	Model 3
<b>cons.</b>	-5.54116 ** (1.062287)	-5.502653 ** (1.121776)	-4.418904 ** (0.4975106)
<b>AGE</b>	-0.7184375 * (0.2892532)	-0.7331546 * (0.2880535)	-0.342382 * (0.1574009)
<b>FIN</b>	0.4192229 ** (0.0914839)	0.4091049 ** (0.0909026)	0.3246779 ** (0.0613245)
<b>COOP</b>	-2.340896 ** (0.8314578)	-2.313064 ** (0.8248674)	-1.320931 ** (0.4045297)
<b>EFF_CRS</b>	0.9321012 (0.7845558)		
<b>EFF_VRS</b>		0.8841911 (0.8878595)	
<b>Returns to Scale:</b>			
<b>Increasing IRS</b>			-0.9598654 ** (0.347287)
<b>Constant CRS</b>			-0.655251 * (0.3295568)
<b>Log likelihood</b>	-214.78561	-215.00474	-456.65954
<b>LR test</b>	$\chi^2(4)=30.89$ pr=0	$\chi^2(4)=30.94$ pr=0	$\chi^2(5)=53.99$ pr=0
$\rho$	0.3456946 (0.1030121)	0.3436526 (0.1022583)	0.3122331 (0.0787693)
<b>LR test of <math>\rho</math></b>	$\chi^2(1)=14.5$ pr=0	$\chi^2(1)=14.44$ pr=0	$\chi^2(1)=18.97$ pr=0
<b>No. of observations</b>	1390	1390	2448
<b>No. of firms</b>	297	297	457

- Standard errors in parentheses.  
- \* Significant at 5%, \*\* Significant at 1%.

<sup>12</sup> The xtlogit procedure in STATA<sup>®</sup> was used to obtain the models' estimates.

Table 6: Some characteristics of firms with respect to scale economies

	n	Mean	SD	SE	95% CI of Mean	
ASSETS IRS	50	14,798	16,735	2,367	10,042	to 19,554
ASSETS CRS	64	52,103	102,279	12,785	26,554	to 77,651
ASSETS DRS	60	240,433	417,075	53,844	132,691	to 348,175
ALL	6017	72,703	187,959	2,423	67,953	to 77,454
	n	Mean	SD	SE	95% CI of Mean	
Q IRS	45	1,559	1,832	273	1,009	to 2,109
Q CRS	60	5,948	6,573	848	4,250	to 7,646
Q DRS	56	17,792	27,418	3,663	10,450	to 25,135
ALL	5545	4,502	12,834	172	4,164	to 4,840

Table 7: Probability of firm being taken over (Model 3)

Characteristic	IRS	CRS	DRS
Cooperative	0.5 %	0.7 %	1.3 %
Non cooperative	1.9 %	2.5 %	4.8 %

Table 8: Joint and conditional probabilities of rank evolution, 1985-1997

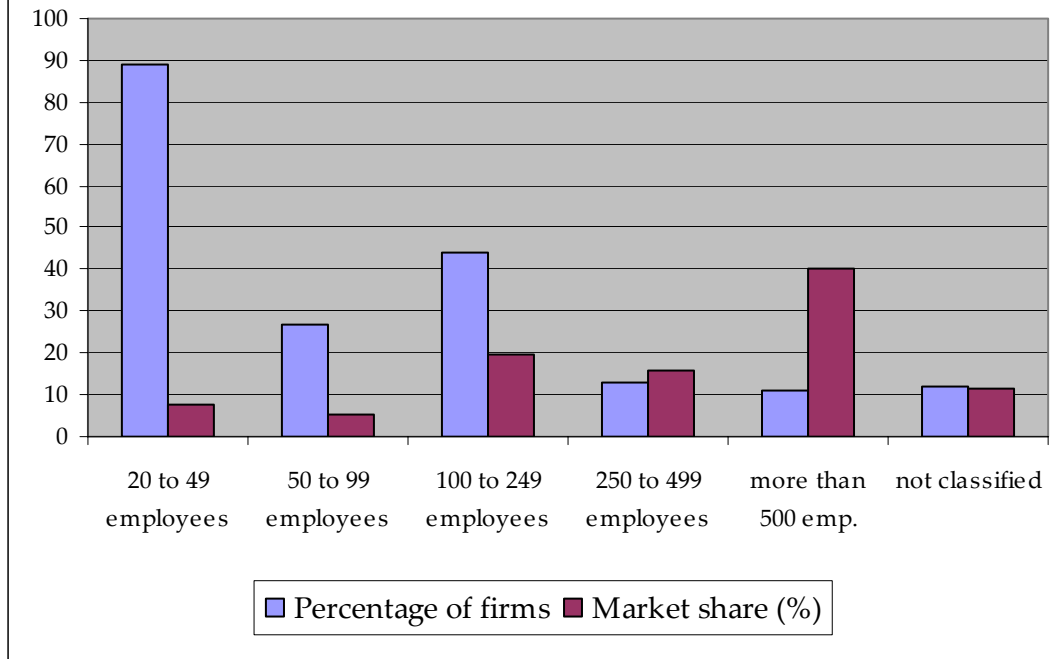
Joint probability table:				
VRS	A	R	S	Total
CONS	0.074	0.111	0.075	0.26
UNCONS	0.407	0.210	0.123	0.74
Total	0.481	0.321	0.198	1
A: Advanced in rank R: Regressed in rank S: no change CONS : Acquired UNCONS : Not acquired				
Conditional Prob. :				
Under VRS:				
Pr(A/CONS) = 0.285				
Pr(A/UNCONS) = 0.551				

Joint probability table:				
CRS	A	R	S	Total
CONS	0.136	0.123	0	0.26
UNCONS	0.383	0.346	0.012	0.74
Total	0.519	0.469	0.012	1
Conditional Prob. :				
Under CRS:				
Pr(A/CONS) = 0.538				
Pr(A/UNCONS) = 0.513				

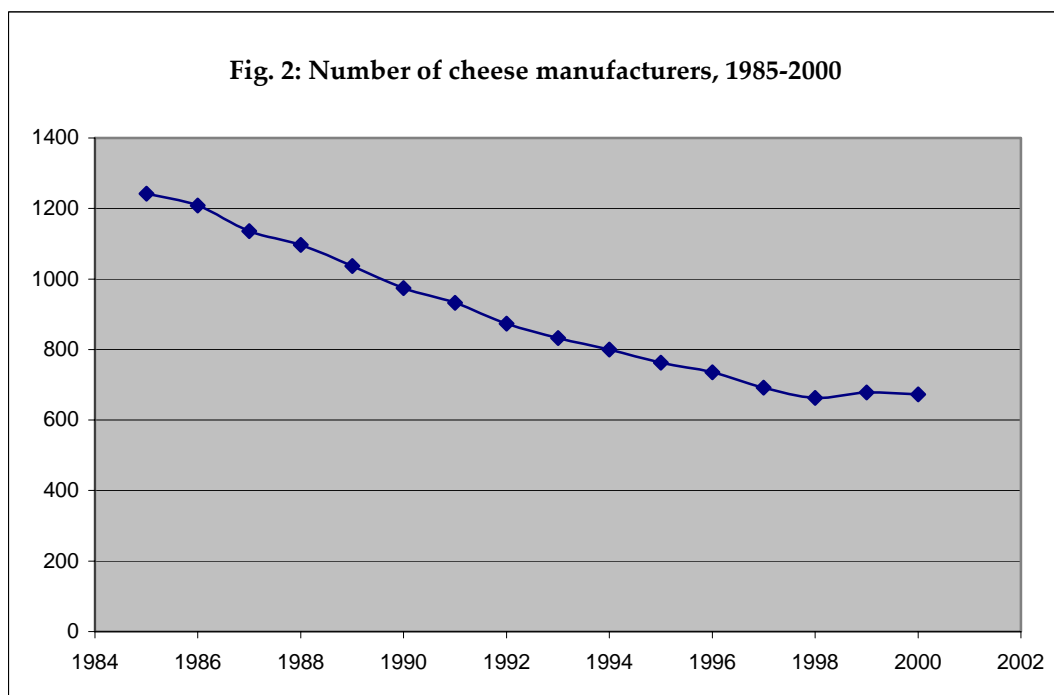
**List of figures**

**Fig.1: Size distribution of cheese firms in 2000**

Source: Agreste, French Ministry of Agriculture

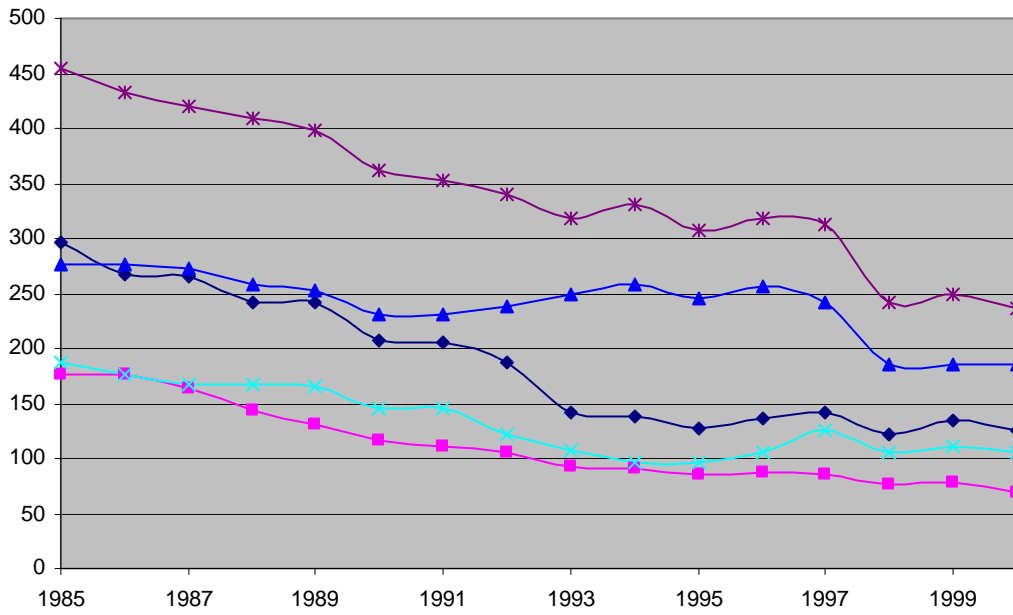


**Fig. 2: Number of cheese manufacturers, 1985-2000**



Source: Dairy Products Survey (PRODCOM), French Ministry of Agriculture

Fig. 3 Comparative number of dairy firms, 1985-2000



◆ Fluid milk & fresh dairy    ■ Butter    ▲ Cheese    ✕ Other dairy    \* All industry

## Appendix 1: The input-oriented DEA method

Let  $x \in \mathfrak{R}_+^N$  denote a vector of inputs and  $y \in \mathfrak{R}_+^M$  the resulting output vector. Assume that there are  $k = 1, \dots, K$  firms, so that the data is given by:  $(x^k, y^k)$ ,  $k = 1, \dots, K$ .

We define the *Input Requirement Set*  $L(y)$ , which shows all the combinations of inputs that can be used to produce the output vector  $y$ .

The *Farrell Input-Oriented Measure of Technical Efficiency* under constant returns to scale  $C$  and strong input disposability  $S$ <sup>13</sup> is formally defined by:

$$F_i(y, x|C, S) = \min\{\lambda : \lambda x \in L(y|C, S)\}$$

Where  $L(y|C, S)$  is the output possibility set defined by:

$$L(y|C, S) = \left\{ (x_1, \dots, x_N) : \begin{array}{l} \sum_{k=1}^K z^k y_m^k \geq y_m, m = 1, \dots, M \\ \sum_{k=1}^K z^k x_n^k \leq x_n, n = 1, \dots, N \\ z^k \geq 0, k = 1, \dots, K \end{array} \right\}$$

Input-oriented models typically seek to answer the following question: “By how much can input usage be proportionally reduced without changing the output quantities produced?”<sup>14</sup>

The  $z$  variables are commonly referred to as intensity variables. They define through linear combinations the frontier points of the benchmark technology. Input oriented DEA calculations are designed to minimize the relative efficiency score of each firm, subject to the constraint that the set of intensity variables obtained in this manner for each firm must also be feasible for all the others included in the sample. In order to determine the efficiency score of each unit, each type of input is scaled down by  $\lambda$  until the frontier is reached, with a simultaneous selection of optimal  $z$  variables. Firms with positive  $z$  variables are called the “peers”, and they constitute frontier units with which the firm under investigation is being compared to. Notice that, in order to obtain an efficiency measure for each unit, the above linear programming problem must be solved  $K$  times, once for each firm in the sample.

Inefficient firms have input efficiency scores less than one and efficient firms have scores equal to one. Therefore, a firm is technically input efficient if:

$$F_i(y, x|C, S) = 1,$$

and inefficient otherwise. A firm with a score of 0.70 for example could decrease its inputs by 30% if it were operating on the best practice frontier.

In this paper, only strong input disposability  $S$  is considered. This implies that, if inputs are held the same or increased, then output will not decrease. This assumption is common in efficiency studies, and is opposed to weak disposability of inputs  $W$  that can also be introduced in DEA frameworks (see Färe *et al.* (1994) for more details).

Given this, various types of returns to scale can be imposed on the reference technology by changing the restrictions on the intensity variables  $z$  in the definition of the input possibility set. Namely, adding the restriction

<sup>13</sup> Strong Input Disposability indicates that an increase in inputs cannot decrease or congest output. This assumption is equivalent to the ‘free disposal’ property of production technologies. The use of the Weak Disposability assumption allows evaluating a congestion component.

<sup>14</sup> Coelli and Perelman (1999) show that the choice of orientation does not significantly alter efficiency estimation results.

$$\sum_{k=1}^K z^k \leq 1$$

defines non-increasing returns to scale  $N$ ; and

$$\sum_{k=1}^K z^k = 1$$

defines variable returns to scale  $V$  (which allows for increasing, constant and decreasing returns to scale). Banker *et al.* (1984) and Seiford and Thrall (1990) provide proofs for these correspondences based on duality theory.

Input-oriented technical efficiency under variable returns to scale can thus be defined by:

$$F_i(y, x|V, S) = \min\{\lambda : \lambda x \in L(y|V, S)\}$$

Moreover, *Output Scale Efficiency* is defined by the following ratio:

$$S_i(y, x|S) = F_i(y, x|C, S) / F_i(y, x|V, S),$$

Which is a measure of the deviation from constant returns to scale in the input direction. A firm is scale efficient if its input scale efficiency is equal to one, and scale inefficient otherwise. To identify the nature of this scale inefficiency, the following rule is used:

If  $S_i(y, x|S) < 1$ , then scale inefficiency is due to:

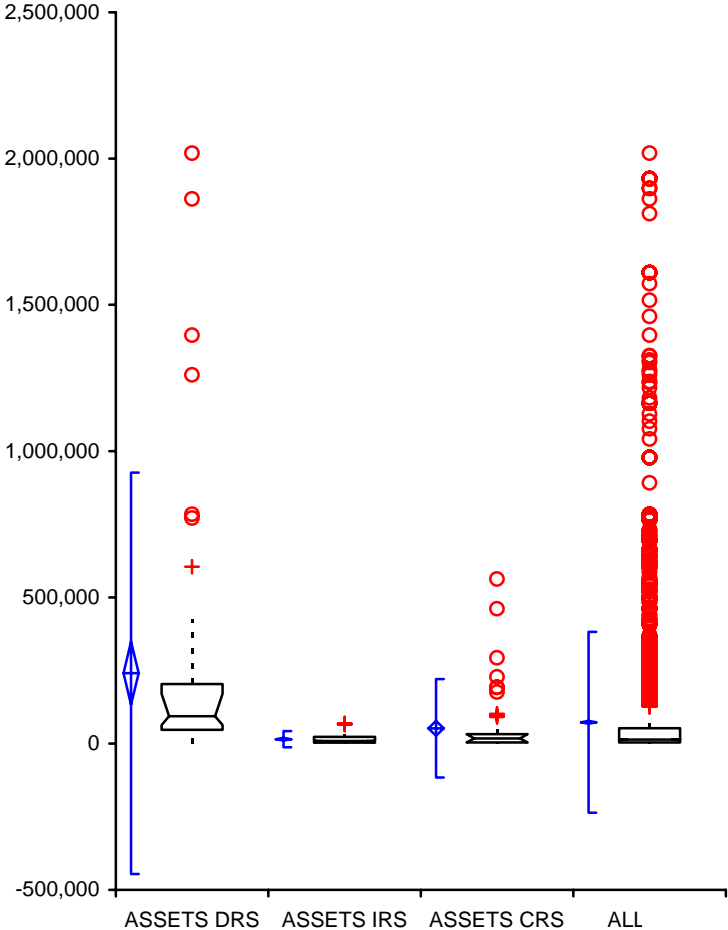
Increasing Returns to Scale (IRS) if  $F_i(y, x|N, S) = F_i(y, x|C, S)$ ;

Decreasing Returns to Scale (DRS) if  $F_i(y, x|N, S) > F_i(y, x|C, S)$ ; where

$F_i(y, x|N, S) = \min\{\lambda : \lambda x \in L(y|N, S)\}$  is technical efficiency relative to a non-increasing returns to scale technology  $N$ . The proof of these results is detailed in Färe *et al.* (1994).

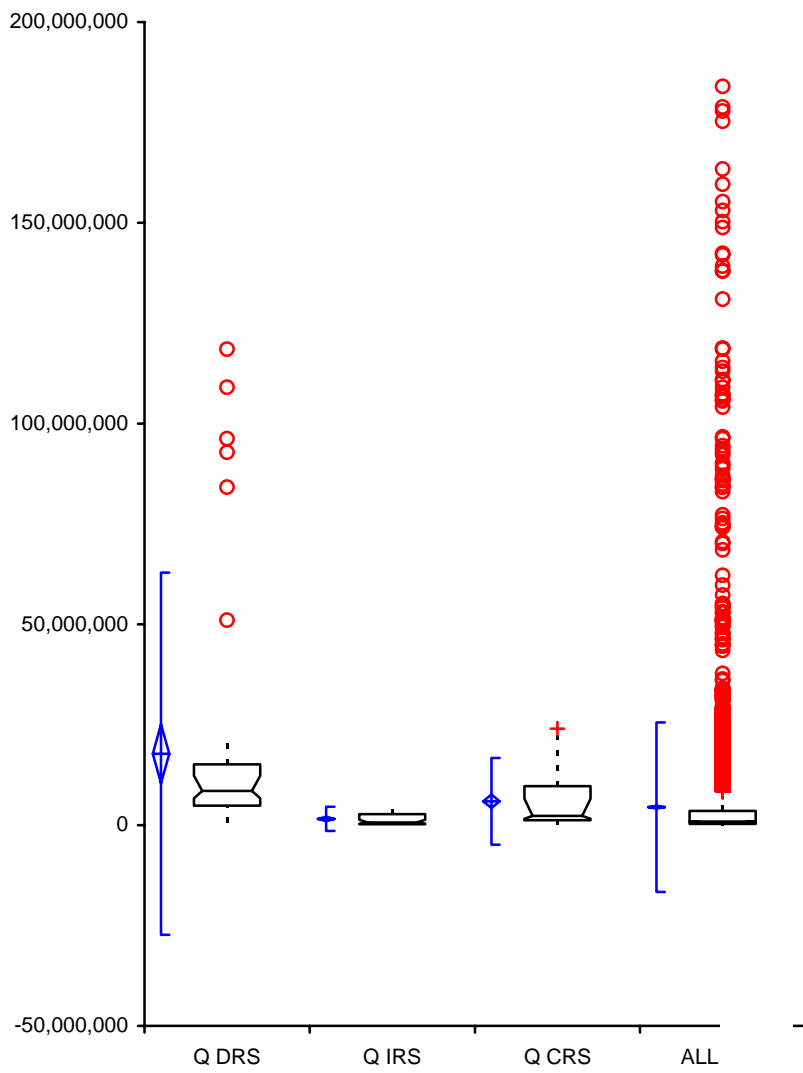
**Appendix 2: Box-Whiskers Plots for the ASSETS and Q variables**

**Fig. A.2.1: Box-Whiskers plot for the ASSETS variable<sup>15</sup>**



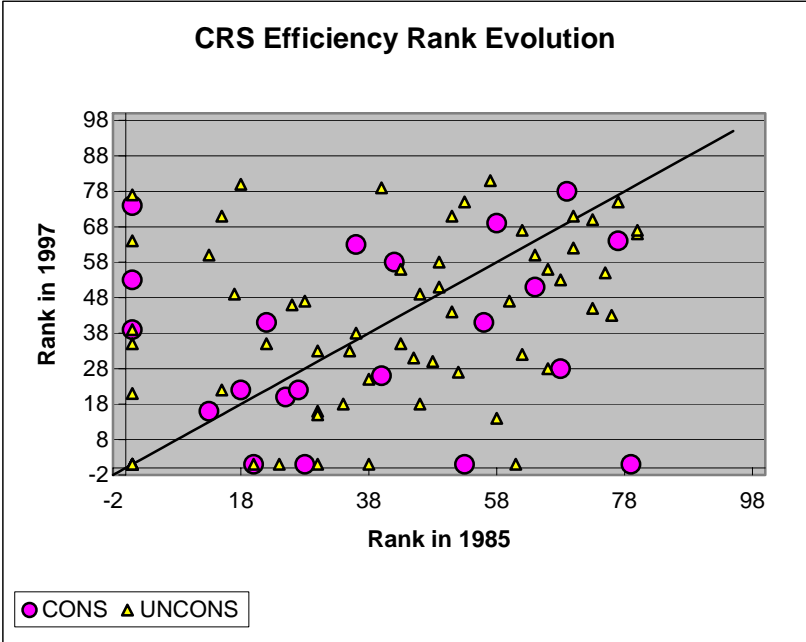
<sup>15</sup> The line series shows parametric statistics: the diamond shows the mean and the requested confidence interval around the mean. The notched lines show the requested parametric percentile range. The notched box and whiskers show non-parametric statistics: the notched box shows the median, lower and upper quartiles, and confidence interval around the median. The dotted-line connects the nearest observations within 1.5 IQRs (inter-quartile ranges) of the lower and upper quartiles. Crosses (+) and circles (o) indicate possible outliers - observations more than 1.5 IQRs (near outliers) and 3.0 IQRs (far outliers) from the quartiles. The vertical lines show the requested non-parametric percentile range.

**Fig. A.2.2:** Box-Whiskers plot for the Q variable

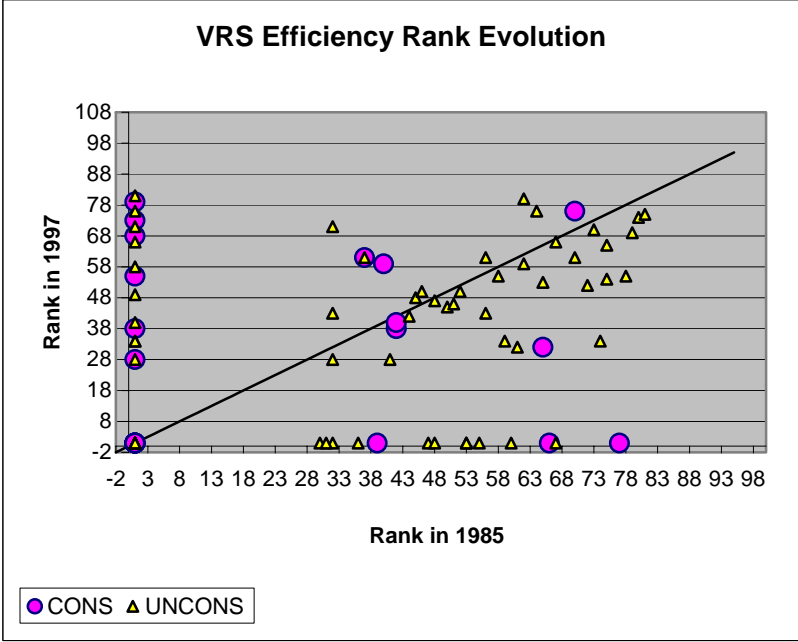


**Appendix 3: Fig A.3 Evolution of efficiency score ranks of cheese firms**

Under CRS assumption



Under VRS assumption



CONS: firms which were taken over during the period.  
 UNCONS: firms which were not taken over during the period.

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