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Abstract: This paper analyses technical efficiency of football clubs in the Spanish Football League Division 1 (Primera Liga) from the seasons, 1995/96-2004/05 with an unbalanced panel data. The random frontier model is used, allowing the identification of random variables in the cost frontier. It is concluded that the price of capital-investment, the number of points won and attendance are heterogeneous variables. Therefore, no common publicpolicy aiming to improve efficiency can embrace all of the clubs, so that policies by clusters are required.

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1. Introduction

Economic efficiency in sports is a theme that has attracted some research in recent decades. Two traditions are observed, the DEA - data envelopment analysis, which has been applied by Barros and Leach, 2006A; Haas, 2003A, 2004B, Barros and Santos 2005, 2003; Espitia-Escuer and García-Cebrian, 2004; Fizel and D'Itry, 1996,1997; and Porter and Scully (1982) and the stochastic frontier models, which have been applied by Barros and Leach, 2006B, 2006C; Kahane, 2005; Gerrard (2005); Hoeffler and Payne, 1997; Dawson, Dobson and Gerrard, 2000; Carmichael, Thomas and Ward, 2001; Scully, 1994; and Zak, Huang and Siegfried (1979). The aim of this research is to combine sports and financial variables in the evaluation of the clubs' efficiency.

This paper uses the stochastic framework approach, but innovates in relation to previous research by adopting a random stochastic frontier model (Greene, 2004, 2005). This model enables the separation of the covariates in the cost function into homogenous and heterogeneous variables. The identification of heterogeneous variables is of prime importance for policy purposes, since heterogeneity in the cost function of the Spanish football league would result in generic policy procedures that would affect the different clubs asymmetrically.

Homogenous stochastic frontier models are common in many research fields, for example, Haghiri et al. (2004) apply this type of model to the dairy industry; in Cullinane and Song (2003), it is applied to seaports; Mahadevan (2000) applies it to manaufacturing in Singapore; Lothgreen (2000) applies it to the health services sector; and Street and Jacobs (2002) apply it to hospitals. However, in the sports context, the random frontier model has not previously been applied.

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The motivation for our research stems from the fact that while efficiency in sporting terms is observable on the field of play, the financial efficiency of clubs is far less transparent, being accessible for observation only in the club's financial report. Thus, the comparison of sporting and financial results is of value when evaluating the efficiency of a football league club. Moreover, whilst Deloitte & Touche publish an annual financial report on Spanish football, among other leagues, reports are not compiled for every European country. Without the publication of a pan-European standardised report, researchers encounter difficulties in gathering the data sets needed to compare sporting performance with its financial underpinning.

The contribution of this paper to sports research is based on two aspects: first, it adopts an innovative stochastic frontier approach, the random frontier model, which to the authors' knowledge, has not previously been applied to sports. The random frontier model assumes that the variables are possibly heterogeneous, overcoming the hypothesis of homogeneity of the variables applied to earlier frontier models. Secondly, this is the first time that a stochastic frontier model has been applied to the Spanish Football League First Division, in relation to which prior analysis had been carried out with a DEA model (Espitia-Escuer and García-Cebrian, 2004).

The paper is organised as follows: In Section 2, the contextual setting is described; Section 3 presents the literature survey; in Section 4, the model is explained; in Section 5, the data and results are presented; Section 6 discusses the results, and in Section 7, the concluding remarks are made.

2. Contextual Setting

The first division (known as the *Primera Liga*) of the Spanish National Football League is renowned as one of the strongest leagues in the world, since many of the best players, in particular the Latin Americans, are contracted by Spanish clubs. As a result, the top Spanish teams are frequently successful in the lucrative European competitions[2]. Another consequence is that various scientific studies have used data from the Spanish *Primera Liga*, for instance, García and Rodríguez (2002) study the determinants of attendance of the Spanish league; Espitia-Escuer and García-Cebrian (2004) study the efficiency of the *Primera Liga* teams using DEA (Data Envelopment Analysis), which is a non-parametric technique, while Ascari and Gagnepain (2006) analyse the financial crisis of Spanish professional football as a whole.

On the other hand, the main characteristic of the *Primera Liga* is that two teams, Real Madrid and F.C. Barcelona, are global brand giants, with the means to buy many of the top players, boast the largest numbers of supporters (Barcelona regularly play at home in front of a maximum capacity 110,000 spectators) and usually achieve the first two positions in the league, as in the 2004-2005 season.

Table 1 below presents information on the financial situation of the *Primera Liga* (in millions of Euros). In Table 2, we compute the average league position, revenues and wages for each club that played in the *Primera Liga* during the period analysed.

Table 1. Summary of financial information in the Spanish PLF

Spanish PLF	1996	1997	1998	1999	2000	2001	2002	2003	2004
Match	24,0	24,2	23,4	22,3	23,0	21,3	26,1	28,5	28,8
Wages	175	230	303	342	390	491	559	607	608
Income	366	524	569	612	683*	713*	776	847	953
Profits	-23	19	-124	-170					
Profits*	-21	17	-101	-150	-159	-369	-682	-402	-105

Sources: Deloitte&Touche Annual Review of Football Finance (2003, 2005) and authors' calculations from clubs' accounts.

[2] F.C.Barcelona won the European Champions League, while Sevilla C.F. won the UEFA Cup at the end of the 2005/06 season. These are the two European-level club competitions.

Table 2. Clubs' Statistics for the *Primera Liga* (Averages for seasons 1995/96-2004/05)

Teams	N	Average Position	Average Wages	Average Revenues
		(1)	(2)	(3)
Barcelona	9	2.8	58,464	107,197
Real Madrid	9	3.0	89,627	138,318
Valencia	8	4.9	31,810	52,683
Depor Coruña	6	6.0	21,920	32,207
Celta	8	7.5	7,563	19,761
Mallorca	6	7.7	14,456	20,515
Athletic Bilbao	9	8.4	21,148	30,123
Betis	8	9.0	7,385	22,079
Atletico Madrid	7	9.0	25,198	40,316
Real Sociedad	9	9.3	13,707	24,177
Malaga	5	10.4	15,161	16,263
Valladolid	5	10.8	8,696	10,601
Español	9	11.4	12,386	20,399
Alavés	5	11.6	12,308	15,704
Zaragoza	9	12.1	13,221	18,467
Compostela	3	12.7	4,938	7,655
Rayo Vallecano	3	13.0	5,198	8,825
Sevilla	6	13.2	12,696	20,571
Tenerife	5	13.6	10,667	19,137
Villarreal	4	13.8	8,472	19,276
Osasuna	2	14.0	14,488	19,047
Racing Santander	7	15.0	8,475	9,849
Oviedo	7	15.3	5,824	9,916
Sporting Gijon	2	16.5	6,699	10,906
Salamanca	2	17.5	5,666	9,752
Numancia	2	18.5	4,528	6,921
Albacete	2	19.0	3,747	5,105

3. Literature Survey

Sports efficiency is commonly analysed as an aspect of sports economics and management (Slack, T., 1997). There are two contemporary approaches to measure efficiency: firstly, the econometric or parametric approach and second, the non-parametric. Besides these two approaches, we observe other papers relying on ratio analysis to address the same issue.

Among the papers which have used the econometric frontier, which is of particular relevance to the present research, Zak, Huang and Siegfried (1979) analysed production efficiency in the basketball market with a Cobb-Douglas deterministic frontier. Scully (1994) analysed measures of managerial efficiency for professional baseball, basketball and American football coaches, with a deterministic and a stochastic econometric frontier. A survival analysis was used to measure the coaching tenure probability in these sports. Extending the analysis of efficiency in sports, Ruggiero, Hadley and Gustafson (1996) analysed the efficiency of baseball teams with panel data. Hoeffler and Payne (1997) analysed the stochastic frontier of American basketball with cross-section data. Audas, Dobson and Goddard (2000) analysed involuntary and voluntary managerial job-termination, with hazard functions for English professional football. Hadley, Poitras, Ruggiero and Knowles (2000) analysed the performance of the American NFL, using a Poisson regression model. Dawson, Dobson and Gerrard (2000) analysed the managerial efficiency of English football managers with an econometric stochastic frontier and Carmichael, Thomas and Ward (2001) analysed the efficiency of the English Premiership clubs with residuals. Gerrard (2001) analysed the production function of coaches working in the English Premier League with win-ratios for the period of 1992 to1998. Kahane (2005) investigated the efficiency of the USA Hockey League's discriminatory hiring practices with a stochastic frontier model.

Among the papers which have taken the non-parametric approach, we mention Fizel and D' Itri (1996, 1997), who applied the DEA analysis to measure the managerial efficiency of college basketball teams to assess the conflicting theses concerning the impact of managerial succession on organisational performance, and Porter and Scully (1982), who analysed the managerial efficiency of baseball managers with a non-parametric approach. Barros (2003) analysed the incentive regulation on sports organisational training activities, disentangling technical and allocative efficiency with DEA. Haas (2003A) analysed the efficiency of the USA Major Soccer League with plain DEA and Barros and Santos (2003) estimated a Malmquist index for Portuguese sports organisational training activities. In summary, we find no published paper adopting the approach of this paper.

4. Theoretical Framework

Our framework is based on two strands of literature: models of industry efficiency and stochastic frontier models.

4.1 Models of Industry Efficiency

Two competing models of industry efficiency exist in the literature. Firstly, the strategic-group theory (Caves and Porter, 1977), which justifies differences in efficiency scores as being due to differences in the structural characteristics of units within an industry, which in turn lead to differences in performance. In the case of Spanish football clubs, units with similar asset configurations pursue similar strategies with similar results in terms of performance (Porter, 1979). While there are different strategic options to be found among the different sectors of an industry, not all options are available to each club, due to mobility impediments, causing a spread in the efficiency scores of the industry.

The second model is the resource-based theory (Barney, 1991; Rumelt, 1991; Wernerfelt, 1984), which justifies different efficiency scores on the grounds of heterogeneity in relation to the resources and capabilities on which the clubs base their strategies. These resources and capabilities may not be perfectly mobile across the industry, resulting in a competitive advantage for the best-performing clubs.

Purchasable assets cannot be considered to represent sources of sustainable profits. Indeed, critical resources are not available in the market. Rather, they are built up and accumulated on the club's premises, their non-imitability and non-substitutability being dependent on the specific traits of their accumulation process. The difference in resources thus results in barriers to imitation (Rumelt, 1991) and in the football managers'/club executive managements' inability to alter their accumulated stock of resources over time. In this context, unique assets are seen as exhibiting inherently differentiated levels of efficiency; sustainable profits are ultimately a return on the unique assets owned and controlled by the football clubs (Teece et al., 1997).

4.2 Random Frontier Models

In this paper, we adopt the stochastic cost econometric frontier approach. This approach, first proposed by Farrell (1957), came to prominence in the late 1970s as a result of the work of Aigner, Lovell and Schmidt (1977), Battese and Corra (1977) and Meeusen and Van den Broeck (1977).

The frontier is estimated econometrically and measures the difference between the inefficient units and the frontier by the residuals. This is an intuitive approach based on traditional econometrics. However, when we assume that the residuals have two components (noise and inefficiency), we have the stochastic frontier model. Therefore, the main issue is the decomposition of the error terms. The general frontier cost function proposed by Aigner et al. (1977) and Meeusen and van den Broeck (1977) is the following:

$$C_{it} = C(X_{it}).e^{v_{it}+u_{it}} \; ; \quad \mathrm{i}=1,2,\ldots\mathrm{N}, \mathrm{t}=1,2,\ldots T \qquad (1)$$

Where C_{it} represents a scalar cost of the decision-unit i under analysis in the t-th period; X_{it} is a vector of variables including the input prices and the output descriptors present in the cost function, Varian (1987).

The error term v_{it} is the one that is traditional of the econometric models, assumed to be independently and identically distributed, that represents the effect of random shocks (noise) and is independent of u_{it}.

The inefficient term u_{it} represents the technical inefficiencies and is assumed to be positive and distributed normally with zero mean and variance σ_u^2. The positive disturbance u_{it} is reflected in a half-normal independent distribution truncated at zero, signifying that each club cost must lie on or above its cost frontier. This implies that any deviation from the frontier is caused by management factors controlled by the football clubs.

The total variance is defined as $\sigma^2 = \sigma_v^2 + \sigma_u^2$. The contribution of the error term to the total variation is as follows: $\sigma_v^2 = \sigma^2 /(1+\lambda^2)$. The contribution of the inefficient term is: $\sigma_u^2 = \sigma^2 \lambda^2 /(1+\lambda^2)$. Where σ_v^2 is the variance of the error term v, σ_u^2 is the variance of the inefficient term u and λ is defined as $\lambda = \frac{\sigma_u}{\sigma_v}$, providing an indication of the relative contribution of u and v to ε=u+v.

Because estimation procedures of equation (1) yield merely the residual ε, rather than the inefficiency term u, this term in the model must be calculated indirectly (Greene, 2003). In the case of panel data, such as that used in this paper, Battese and Coelli (1988) used the conditional expectation of u_{it}, conditioned on the realized value of the error term $\varepsilon_{it} = (v_{it} + u_{it})$, as an estimator of u_{it}. In other words, $E[u_{it} / \varepsilon_{it}]$ is the mean productive inefficiency for the i the sport club at any time t.

However, the inefficiency can also be due to the heterogeneity of the clubs. In order to take this heterogeneity into account, we consider the following random effects model:

$$c_{it} = (\beta_0 + w_i) + \boldsymbol{\beta}'\mathbf{x}_{it} + v_{it} + u_{it} \qquad (2)$$

where the variables are in logs and w_i is a time invariant, firm-specific random term that captures firm heterogeneity.

To estimate the model, the random coefficient model requires the identification condition that the random components of the coefficients be uncorrelated with the explanatory variables. A second issue concerns the stochastic specification of the inefficiency term *u*. For the latter, we assume the half-normal distribution.

For the estimation of the parameters of this model, we construct the likelihood function using the approach proposed by Greene (2005). With the previous assumptions, the conditional density of c_{it} given w_i is:

$$f(c_{it} \mid w_i) = \frac{2}{\sigma}\phi\left(\frac{\varepsilon_{it}}{\sigma}\right)\Phi\left(\frac{\lambda\varepsilon_{it}}{\sigma}\right), \quad \varepsilon_{it} = c_{it} - (\beta_0 + w_i) - \boldsymbol{\beta}'\mathbf{x}_{it} \qquad (3)$$

Where ϕ is the standard normal distribution and Φ the respective cumulative distribution function. The parameters λ and σ^2 were defined before. Conditioned on w_i, the *T* observations for enterprise *i* are independent and therefore, the joint-density for the *T* observations is:

$$f(c_{i1},\ldots,c_{iT} \mid w_i) = \prod_{t=1}^{T}\frac{2}{\sigma}\phi\left(\frac{\varepsilon_{it}}{\sigma}\right)\Phi\left(\frac{\lambda\varepsilon_{it}}{\sigma}\right) \qquad (4)$$

The unconditional joint density is obtained by integrating the heterogeneity out of the density:

$$L_i = f(c_{i1},\ldots,c_{iT}) = \int_{w_i}\prod_{t=1}^{T}\frac{2}{\sigma}\phi\left(\frac{\varepsilon_{it}}{\sigma}\right)\Phi\left(\frac{\lambda\varepsilon_{it}}{\sigma}\right)g(w_i)dw_i \qquad (5)$$

The log likelihood, $\sum_i \log L_i$, is then maximised with respect to the parameters β_0, $\boldsymbol{\beta}$, σ, λ and any parameters appearing in the distribution of w_i . The integral in (5) will be intractable. However, if we consider that equation (5) can be rewritten in the equivalent form:

$$L_i = f(c_{i1},...,c_{iT}) = E_{w_{i_i}}\left[\prod_{t=1}^{T}\frac{2}{\sigma}\phi\left(\frac{\varepsilon_{it}}{\sigma}\right)\Phi\left(\frac{\lambda\varepsilon_{it}}{\sigma}\right)\right] \qquad (6)$$

we propose to compute the log likelihood by simulation. Averaging the function in (6) over sufficient draws from the distribution of w_i will produce a sufficiently accurate estimate of the integral in (5) to allow estimation of the parameters (see, Greene, 2004, 2005). The simulated log likelihood is:

$$\log L_s(\beta_0,\boldsymbol{\beta},\lambda,\sigma,\theta) = \sum_{i=1}^{N}\log\frac{1}{R}\sum_{r=1}^{R}\left[\prod_{t=1}^{T}\frac{2}{\sigma}\phi\left(\frac{\varepsilon_{it}\mid w_{ir}}{\sigma}\right)\Phi\left(\frac{\lambda\varepsilon_{it}\mid w_{ir}}{\sigma}\right)\right] \qquad (7)$$

where θ includes the parameters of the distribution of w_i and w_{ir} is the rth draw for observation *i*. Based on the panel data, Table 3 presents the maximum likelihood estimators of model (1) as found in other authors' recent studies Greene (2004,2005)

5. Data and Results

Since the early 1990s, most of the Spanish clubs have adopted corporate status, thereby being enforced to publish their financial accounts regularly. Yet, the task of gathering our panel was not an easy one. Some clubs do not publish the information punctually, while another four clubs (Barcelona, Real Madrid, Athletic de Bilbao and Osasuna) have retained club status. Hence, given these limitations of data availability, we have restricted our analysis to the period 1995/96-2004/05. In almost all the cases, the data was obtained directly from the clubs' financial reports.

To estimate the cost frontier, we used an unbalanced panel data on the *Primera Liga* for the years from 1995/96 to 2004/05 (159 observations). Frontier models require the identification of inputs (resources) and outputs (transformation of resources). Several criteria can be used. First, one empirical criterion is availability of data. Second, the literature survey is a way to ensure the validity of the research and therefore, another criterion to take into account. The last criterion for measurement selection is the professional opinions of managers in the industry. In this paper, we follow these three criteria. Based on the data span available, we estimate a stochastic generalised Cobb-Douglas cost function. We have transformed the variables according to the description column in Table 3. We adopt the traditional log-log specification to allow for the possible non-linearity of the frontier.

Table 3: Descriptive Statistics of the Data

Variable	Description	Minimum	Maximum	Mean	Standard deviation
Log Cost	Logarithm of operational cost in Euros at constant prices 2000=100	6.6685	8.9475	7.4633	0.4104
Log PL	Logarithm of price of workers, measured by dividing total wages by the number of employees	4.61378	6.8152	5.7316	0.3782
Log PK1-premises	Logarithm of price of capital-premises, measured by dividing the amortisations by the value of the total assets	0.00453	0.3959	0.0689	0.0486
Log PK2-investment	Logarithm of price capital-investment, measured by dividing the cost of long-term investment by the value of the long term debt	3.07E-06	2.1188	0.2438	0.3603
Log Sales	Logarithm of the sales in Euros at constant prices 2000=100	5.6367	8.3703	7.2507	0.4537
Log points	Logarithm of the number of points obtained in the league	1.4313	1.9542	1.7216	0.0988
Log Atten	Logarithm of the total attendences	3.9469	4.9410	4.4003	0.2302

The rationale for using capital-premises and capital-investment requires justification. Financial resources and premises are needed to develop their activity. Therefore, in order to capture the specificity of this activity, we must disentangle these two types of capital

5.1 Results

In this study, we estimate a stochastic generalised Cobb-Douglas cost function with three input prices (one price of labour and two prices of capital), and three outputs (sales, points and attendance). Linear homogeneity in input prices is imposed, restricting the parameters in the estimated function. The model is as follows:

$$LogCost_{it} = \beta_0 + \beta_1 Trend + \beta_2 LogPL_{it} + \beta_3 LogPK1_{it} + \beta_4 LogPK2_{it}$$
$$+ \beta_5 LogSales_{it} + \beta_6 LogPoints_{it} + \beta_7 LogAtten_{it} + (V_{it} + U_{it}) \quad (7)$$

where PL, PK1 and PK2 are the prices of labor, capital-premises and capital-investment, respectively. This is the cost frontier model, known as the Error Components Model in Coelli, Rao and Battese (1998), because it accounts for causes of efficiency controlled by the club management. The variables have been defined and characterised in Table 3. Table 4 presents the results obtained for the stochastic frontier, using the Gauss program.

The regularity conditions require that the cost function be linearly homogeneous, non-decreasing and concave in input prices (Cornes, 1992). Considering the number of observations and exogenous variables, the Cobb Douglas model with a half-normal distribution was chosen and statistically supported by the data. The error components model is then adopted (Coelli et al., 1998). Table 4 presents the results obtained for the stochastic frontier adopting a half-normal distribution specification for the costs function frontier.

Table 4: Stochastic Cobb-Douglas panel cost frontier (dependent variable: Log Cost)

Variables	Random Frontier model	Non Random Frontier Model
Non-random parameters	Coefficients (t-ratio)	Coefficients (t-ratio)
Constant (β_0)	1.0380 (5.480)	1.194 (1.442)
Trend (β_1)	0.0269 (5.709)	0.0270 (2.680)
Log PL(β_2)	0.6993 (19.610)	0.6809 (5.232)
Log PK1 (β_3)	0.5401 (5.141)	0.5513 (2.248)
Log PK2(β_4)	–	0.0490 (0.409)
Log Sales(β_5)	0.0540 (2.018)	0.0521 (0.461)
Log Point (β_6)	–	0.2350 (0.793)
Log Atten(β_7)	–	0.2881 (1.694)
Mean for Random Parameters		
LogPK2 (β_2)	0.6022 (3.957)	–
LogPoints(β_6)	0.1975 (2.219)	–
LogAtten (β_7)	0.3388 (6.256)	–
Scale Parameters for Dists. Of Random Parameter		
LogPK2 (β_2)	1.4281 (10.414)	–
LogPoints(β_6)	0.0202 (4.459)	–
LogAtten (β_7)	0.0115 (6.453)	–
Statistics of the model		
Sigma of u	0.1362 (29.032)	0.1225 (1.079)
Lambda	0.2532 (2.706)	0.8094 (2.132)
Log likelihood	75.169	72.010
Chi Square Degrees of freedom Probability	144.338 3 0.0002	132.214 3 0.0005
Observations	159	159

t Statistics in parentheses are below the parameters, those followed by * are significant at 1% level.

Having estimated two competing Cobb-Douglas models, the homogeneous Cobb-Douglas frontier model and the heterogeneous Cobb-Douglas frontier model, the likelihood test enables the selection of the most appropriate functional form, which, in the present case, is the heterogeneous frontier model. The likelihood test is a statistical test of goodness-of-fit between two competing models. It compares models with different numbers of parameters. On comparison, the likelihood test has a chi-square distribution higher for the heterogeneous frontier than the standard frontier. Therefore, it is concluded that the heterogeneous frontier model describes better the data set than the Cobb-Douglas model.

We also compute the Chi-square statistic that serves as a general specification test of adding variables to the model. Therefore, it is concluded that the addition of variables by the heterogeneous frontier model is supported by the test, signifying that the heterogeneous frontier better describes the data set. Finally, in order to decide if the frontier model is better than the cost function, the Sigma square and lambda variables of the cost frontier model are statistically significant, which means that a traditional cost function is unable to capture adequately all the dimensions of the data set.

Moreover, the random cost function specified above fits the data well, since both the R-squared value and the overall F-statistic from the initial ordinary least-squares estimation used to obtain the starting values for the maximum-likelihood estimation are higher than the standard cost function, presented for comparative purposes.

The value of parameter lambda is positive and statistically significant in the stochastic inefficiency effects. We also verify that the coefficients of the variables have the expected signs, with the cost increasing with the trend, signifying that there was no technological improvement to drive costs down in this market during the period studied. Furthermore, the cost increases with the price of labour, price of capital-premises and attendance. These are statistically significant coefficients. However, the price of capital-investment and sales, despite being positive, are statistically insignificant in the standard frontier, but become statistically significant in the random frontier models. This signifies that the random frontier better captures the dynamics in this data set. The significant random parameters vary along the sample. The identification of the mean values of random parameters means that the price of capital-finance, points and attendance are heterogeneous and therefore, a strategy to control costs must take into account this heterogeneous characteristic of the sample. Hence, a common policy can be defined for the sample based on the average values of the homogeneous variables, but no common policy can cater for all of the clusters identified in the heterogeneous variables. Different policies for the different segments among the Spanish clubs by heterogeneous variables are required. The model does not identify how many clusters exist in the sample and only identifies their heterogeneous nature. However, market knowledge and other techniques can be applied to identify the clusters. The scale parameters of the heterogeneous variables are statistically significant, meaning that the heterogeneity of the variables is statistically supported.

6. Discussion

How do we interpret these results? First, we conclude that random frontier models describe the Spanish football league more accurately than homogenous frontier models. This is the main result of the present paper. The implication of this result is that a common (+government?) policy is unable to embrace all of the clubs, since heterogeneity exists relative to the price of capital-finance, points won and attendance. Therefore, any policy targeting any of these heterogeneous variables has to be tailored by clusters. What is the explanation for these findings? This is an intuitive result, since football clubs are not homogenous. There are small and large clubs, located in large cities and small towns, and so on. These visible characteristics translate into the variations in points gained in the league, wide variations in stadium attendances and different dimensions of financial debts, resulting in different clusters among the clubs. In the *Primera Liga*, at least three clusters can be identified: the top group comprises Real Madrid and Barcelona; The middle group includes the clubs that challenge for qualification for the lucrative European competitions, or survive in the top flight; and the last cluster that consists of the weakest clubs which are destined to battle against relegation. These clusters can be distinguished from each other on the basis of the price of capital-investment, points and attendance. This finding also signifies that the Spanish clubs are relatively homogenous in terms of the price of labour, price of capital-premises and sales. Relative to labour, we observe that competition by resources drives the market and translates into homogenous dynamics. In addition, relative to capital-premises, a certain level of investment is found to be a pre-requisite in this market, translating into homogenous behaviour. Relative to sales, it is unexpected homogenous. What differs substantially is the price of capital-investment, points and attendance. Why are sales homogenous, in this context? Probably because there are other factor in action in this market that forces the sales to be homogenous, despite attendance. This factor can be the municipal funds allocated to Spanish clubs, which are not taken into account in the present research, since this information is not displayed in the club accounts.

Second, the trend is positive which signifies that costs increase along the time. This is an expected result for football. Football is not driven by technology improvements; therefore a negative sign is not expected for the cost frontier. However, this result is problematic since it signifies that costs are always increasing in this activity, which results in financial distress (Ascagni and Gagnepain, 2006).

Third, the lambda inefficient parameter signifies that on average 80% of the costs are imputable to inefficiency, according to the homogenous frontier. However, this value translates into 0.25 within the heterogeneous frontier, signifying that the heterogeneity translates into inefficiency in the homogenous frontier models (Greene, 2005). Furthermore, the sigma is similar in both models, signifying that the average inefficiency changes little between homogenous and heterogeneous frontier models.

Finally, in this context, unique assets are seen as exhibiting inherently differentiated levels of efficiency; sustainable profits are ultimately a return on the unique assets owned and controlled by the football clubs (Teece et al., 1997). In addition, the strategic-groups theory (Caves and Porter, 1977), which justifies different efficiency scores on the grounds of differences in the structural characteristics of units within an industry, explains part of the efficiency differences observed in the *Primera Liga* football clubs.

With regard to comparisons between this paper and similar research undertaken in other research fields, there are several models that estimate a parameters model, allowing for heterogeneity. Traditional models include the heterogeneity as an individual effect ((Mundlak, 1961; Farsi et al., 2005). Other Models that are continuous in the sense that they allow each club to have a different technology, estimate the model parameters allowing for heterogeneity, as does the random parameter model (Greene, 2005, 2006) which is adopted in the present paper, and the local maximum likelihood estimation (Kumbhakar et al., 2006). Other methods are discrete, in the sense that they create several groups and that estimate as many technologies as there are groups, such as the latent frontier model (Orea and Kumbhakar, 2004). Therefore this paper is only comparable to Greene (2005, 2006).

7. Conclusion

This article has proposed a simple framework for the comparative evaluation of Spanish *Primera Liga* football clubs and the rationalisation of their operational activities. The analysis is based on a stochastic frontier model that allows for the incorporation of multiple inputs and outputs in determining the relative efficiencies and the inclusion of heterogeneity observed in the data. Several interesting and useful managerial insights and implications from the study are discussed. The general conclusion is that, on average, the heterogeneous frontier model better captures the dynamics observed in the data.

The result suggests that resources, scale economies and organisational structure are major factors in determining a unit's efficiency. More investigation is needed to confirm the present research.

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