

## Analysing the Technical Efficiency of the Spanish Football League First Division with a Random Frontier Model

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Postprint / Postprint

Zeitschriftenartikel / journal article

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### Empfohlene Zitierung / Suggested Citation:

Barros, C. P., Garcia-del-Barrio, P., & Leach, S. (2009). Analysing the Technical Efficiency of the Spanish Football League First Division with a Random Frontier Model. *Applied Economics*, 41(25), 3239-3247. <https://doi.org/10.1080/00036840701765379>

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**Analysing the Technical Efficiency of the Spanish Football League First Division with a Random Frontier Model**

Journal:	<i>Applied Economics</i>
Manuscript ID:	APE-06-0604
Journal Selection:	Applied Economics
JEL Code:	L83 - Sports Gambling Recreation Tourism < L8 - Industry Studies: Services < L - Industrial Organization, C69 - Other < C6 - Mathematical Methods and Programming < C - Mathematical and Quantitative Methods
Keywords:	Football, Sports industry, Random frontier models, Policy implication



Analysing the Technical Efficiency of the Spanish Football League First Division with  
a Random Frontier Model

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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.

### **Acknowledgments**

We wish to express our gratitude to Angel Barajas, Miguel Cardenal, Joaquin Serrano, Carlos del Campo and Emilio Garcia-Silvero.

## 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 manufacturing 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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3 The motivation for our research stems from the fact that while efficiency in  
4 sporting terms is observable on the field of play, the financial efficiency of clubs is far  
5 less transparent, being accessible for observation only in the club's financial report.  
6 Thus, the comparison of sporting and financial results is of value when evaluating the  
7 efficiency of a football league club. Moreover, whilst Deloitte & Touche publish an  
8 annual financial report on Spanish football, among other leagues, reports are not  
9 compiled for every European country. Without the publication of a pan-European  
10 standardised report, researchers encounter difficulties in gathering the data sets needed  
11 to compare sporting performance with its financial underpinning.  
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24 The contribution of this paper to sports research is based on two aspects: first, it  
25 adopts an innovative stochastic frontier approach, the random frontier model, which to  
26 the authors' knowledge, has not previously been applied to sports. The random frontier  
27 model assumes that the variables are possibly heterogeneous, overcoming the  
28 hypothesis of homogeneity of the variables applied to earlier frontier models. Secondly,  
29 this is the first time that a stochastic frontier model has been applied to the Spanish  
30 Football League First Division, in relation to which prior analysis had been carried out  
31 with a DEA model (Espitia-Escuer and García-Cebrian, 2004).  
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43 The paper is organised as follows: In Section 2, the contextual setting is  
44 described; Section 3 presents the literature survey; in Section 4, the model is explained;  
45 in Section 5, the data and results are presented; Section 6 discusses the results, and in  
46 Section 7, the concluding remarks are made.  
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## 55 **2. Contextual Setting**

56 The first division (known as the *Primera Liga*) of the Spanish National Football  
57 League is renowned as one of the strongest leagues in the world, since many of the best  
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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<sup>2</sup>. 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.

<sup>2</sup> 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

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3 frontier. Scully (1994) analysed measures of managerial efficiency for professional  
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5 baseball, basketball and American football coaches, with a deterministic and a  
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7 stochastic econometric frontier. A survival analysis was used to measure the coaching  
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9 tenure probability in these sports. Extending the analysis of efficiency in sports,  
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11 Ruggiero, Hadley and Gustafson (1996) analysed the efficiency of baseball teams with  
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13 panel data. Hoeffler and Payne (1997) analysed the stochastic frontier of American  
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15 basketball with cross-section data. Audas, Dobson and Goddard (2000) analysed  
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17 involuntary and voluntary managerial job-termination, with hazard functions for  
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19 English professional football. Hadley, Poitras, Ruggiero and Knowles (2000) analysed  
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21 the performance of the American NFL, using a Poisson regression model. Dawson,  
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23 Dobson and Gerrard (2000) analysed the managerial efficiency of English football  
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25 managers with an econometric stochastic frontier and Carmichael, Thomas and Ward  
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27 (2001) analysed the efficiency of the English Premiership clubs with residuals. Gerrard  
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29 (2001) analysed the production function of coaches working in the English Premier  
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31 League with win-ratios for the period of 1992 to 1998. Kahane (2005) investigated the  
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33 efficiency of the USA Hockey League's discriminatory hiring practices with a  
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35 stochastic frontier model.  
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44 Among the papers which have taken the non-parametric approach, we mention  
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46 Fazel and D' Itri (1996, 1997), who applied the DEA analysis to measure the managerial  
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48 efficiency of college basketball teams to assess the conflicting theses concerning the  
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50 impact of managerial succession on organisational performance, and Porter and Scully  
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52 (1982), who analysed the managerial efficiency of baseball managers with a non-  
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54 parametric approach. Barros (2003) analysed the incentive regulation on sports  
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56 organisational training activities, disentangling technical and allocative efficiency with  
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58 DEA. Haas (2003A) analysed the efficiency of the USA Major Soccer League with  
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3 plain DEA and Barros and Santos (2003) estimated a Malmquist index for Portuguese  
4 sports organisational training activities. In summary, we find no published paper  
5 adopting the approach of this paper.  
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#### 10 11 12 **4. Theoretical Framework**

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15 Our framework is based on two strands of literature: models of industry efficiency and  
16 stochastic frontier models.  
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##### 19 20 **4.1 Models of Industry Efficiency**

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22 Two competing models of industry efficiency exist in the literature. Firstly, the  
23 strategic-group theory (Caves and Porter, 1977), which justifies differences in efficiency  
24 scores as being due to differences in the structural characteristics of units within an  
25 industry, which in turn lead to differences in performance. In the case of Spanish  
26 football clubs, units with similar asset configurations pursue similar strategies with  
27 similar results in terms of performance (Porter, 1979). While there are different strategic  
28 options to be found among the different sectors of an industry, not all options are  
29 available to each club, due to mobility impediments, causing a spread in the efficiency  
30 scores of the industry.  
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47 The second model is the resource-based theory (Barney, 1991; Rumelt, 1991;  
48 Wernerfelt, 1984), which justifies different efficiency scores on the grounds of  
49 heterogeneity in relation to the resources and capabilities on which the clubs base their  
50 strategies. These resources and capabilities may not be perfectly mobile across the  
51 industry, resulting in a competitive advantage for the best-performing clubs.  
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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:

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

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  $\sigma_u^2$ . 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  $\sigma_v^2$  is the variance of the error term  $v$ ,  $\sigma_u^2$  is the variance of the inefficient term  $u$  and  $\lambda$  is defined as  $\lambda = \frac{\sigma_u}{\sigma_v}$ , providing an indication of the relative contribution of  $u$  and  $v$  to  $\varepsilon = u + v$ .

Because estimation procedures of equation (1) yield merely the residual  $\varepsilon$ , 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  $t$ .

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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:

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

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:

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

Where  $\phi$  is the standard normal distribution and  $\Phi$  the respective cumulative distribution function. The parameters  $\lambda$  and  $\sigma^2$  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:

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

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

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

The log likelihood,  $\sum_i \log L_i$ , is then maximised with respect to the parameters  $\beta_0$ ,  $\boldsymbol{\beta}$ ,  $\sigma$ ,  $\lambda$  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:

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

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:

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

where  $\theta$  includes the parameters of the distribution of  $w_i$  and  $w_{ir}$  is the  $r$ th 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:

$$\begin{aligned} \text{LogCost}_{it} = & \beta_0 + \beta_1 \text{Trend} + \beta_2 \text{LogPL}_{it} + \beta_3 \text{LogPK1}_{it} + \beta_4 \text{LogPK2}_{it} \\ & + \beta_5 \text{LogSales}_{it} + \beta_6 \text{LogPoint s}_{it} + \beta_7 \text{LogAtten}_{it} + (V_{it} + U_{it}) \end{aligned} \quad (7)$$

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 ( $\beta_0$ )	1.0380 (5.480)	1.194 (1.442)
Trend ( $\beta_1$ )	0.0269 (5.709)	0.0270 (2.680)
Log PL( $\beta_2$ )	0.6993 (19.610)	0.6809 (5.232)
Log PK1 ( $\beta_3$ )	0.5401 (5.141)	0.5513 (2.248)
Log PK2( $\beta_4$ )	–	0.0490 (0.409)
Log Sales( $\beta_5$ )	0.0540 (2.018)	0.0521 (0.461)
Log Point ( $\beta_6$ )	–	0.2350 (0.793)
Log Atten( $\beta_7$ )	–	0.2881 (1.694)
Mean for Random Parameters		
LogPK2 ( $\beta_2$ )	0.6022 (3.957)	–
LogPoints( $\beta_6$ )	0.1975 (2.219)	–
LogAtten ( $\beta_7$ )	0.3388 (6.256)	–
Scale Parameters for Dists. Of Random Parameter		
LogPK2 ( $\beta_2$ )	1.4281 (10.414)	–
LogPoints( $\beta_6$ )	0.0202 (4.459)	–
LogAtten ( $\beta_7$ )	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	144.338	132.214
Degrees of freedom	3	3
Probability	0.0002	0.0005
Observations	159	159

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



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3 Having estimated two competing Cobb-Douglas models, the homogeneous Cobb-  
4 Douglas frontier model and the heterogeneous Cobb-Douglas frontier model, the  
5 likelihood test enables the selection of the most appropriate functional form, which, in  
6 the present case, is the heterogeneous frontier model. The likelihood test is a statistical  
7 test of goodness-of-fit between two competing models. It compares models with  
8 different numbers of parameters. On comparison, the likelihood test has a chi-square  
9 distribution higher for the heterogeneous frontier than the standard frontier. Therefore, it  
10 is concluded that the heterogeneous frontier model describes better the data set than the  
11 Cobb-Douglas model.  
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25 We also compute the Chi-square statistic that serves as a general specification  
26 test of adding variables to the model. Therefore, it is concluded that the addition of  
27 variables by the heterogeneous frontier model is supported by the test, signifying that  
28 the heterogeneous frontier better describes the data set. Finally, in order to decide if the  
29 frontier model is better than the cost function, the Sigma square and lambda variables of  
30 the cost frontier model are statistically significant, which means that a traditional cost  
31 function is unable to capture adequately all the dimensions of the data set.  
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42 Moreover, the random cost function specified above fits the data well, since both  
43 the R-squared value and the overall F-statistic from the initial ordinary least-squares  
44 estimation used to obtain the starting values for the maximum-likelihood estimation are  
45 higher than the standard cost function, presented for comparative purposes.  
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52 The value of parameter lambda is positive and statistically significant in the  
53 stochastic inefficiency effects. We also verify that the coefficients of the variables have  
54 the expected signs, with the cost increasing with the trend, signifying that there was no  
55 technological improvement to drive costs down in this market during the period studied.  
56 Furthermore, the cost increases with the price of labour, price of capital-premises and  
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3 attendance. These are statistically significant coefficients. However, the price of capital-  
4 investment and sales, despite being positive, are statistically insignificant in the standard  
5 frontier, but become statistically significant in the random frontier models. This  
6 signifies that the random frontier better captures the dynamics in this data set. The  
7 significant random parameters vary along the sample. The identification of the mean  
8 values of random parameters means that the price of capital-finance, points and  
9 attendance are heterogeneous and therefore, a strategy to control costs must take into  
10 account this heterogeneous characteristic of the sample. Hence, a common policy can be  
11 defined for the sample based on the average values of the homogeneous variables, but  
12 no common policy can cater for all of the clusters identified in the heterogeneous  
13 variables. Different policies for the different segments among the Spanish clubs by  
14 heterogeneous variables are required. The model does not identify how many clusters  
15 exist in the sample and only identifies their heterogeneous nature. However, market  
16 knowledge and other techniques can be applied to identify the clusters. The scale  
17 parameters of the heterogeneous variables are statistically significant, meaning that the  
18 heterogeneity of the variables is statistically supported.

## 43 **6. Discussion**

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45 How do we interpret these results? First, we conclude that random frontier models  
46 describe the Spanish football league more accurately than homogenous frontier models.  
47 This is the main result of the present paper. The implication of this result is that a  
48 common (+government?) policy is unable to embrace all of the clubs, since  
49 heterogeneity exists relative to the price of capital-finance, points won and attendance.  
50 Therefore, any policy targeting any of these heterogeneous variables has to be tailored  
51 by clusters. What is the explanation for these findings? This is an intuitive result, since  
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3 football clubs are not homogenous. There are small and large clubs, located in large  
4 cities and small towns, and so on. These visible characteristics translate into the  
5 variations in points gained in the league, wide variations in stadium attendances and  
6 different dimensions of financial debts, resulting in different clusters among the clubs.  
7  
8 In the *Primera Liga*, at least three clusters can be identified: the top group comprises  
9 Real Madrid and Barcelona; The middle group includes the clubs that challenge for  
10 qualification for the lucrative European competitions, or survive in the top flight; and  
11 the last cluster that consists of the weakest clubs which are destined to battle against  
12 relegation. These clusters can be distinguished from each other on the basis of the price  
13 of capital-investment, points and attendance. This finding also signifies that the Spanish  
14 clubs are relatively homogenous in terms of the price of labour, price of capital-  
15 premises and sales. Relative to labour, we observe that competition by resources drives  
16 the market and translates into homogenous dynamics. In addition, relative to capital-  
17 premises, a certain level of investment is found to be a pre-requisite in this market,  
18 translating into homogenous behaviour. Relative to sales, it is unexpected homogenous.  
19 What differs substantially is the price of capital-investment, points and attendance. Why  
20 are sales homogenous, in this context? Probably because there are other factor in action  
21 in this market that forces the sales to be homogenous, despite attendance. This factor  
22 can be the municipal funds allocated to Spanish clubs, which are not taken into account  
23 in the present research, since this information is not displayed in the club accounts.  
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50 Second, the trend is positive which signifies that costs increase along the time.  
51 This is an expected result for football. Football is not driven by technology  
52 improvements; therefore a negative sign is not expected for the cost frontier. However,  
53 this result is problematic since it signifies that costs are always increasing in this  
54 activity, which results in financial distress (Ascagni and Gagnepain, 2006).  
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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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