Measuring efficiency and productivity in professional football teams: Evidence from the English Premier League

Isidoro Guzmán and Stephen Morrow

Faculty of Business Sciences
Department of Financial Economy and Accounting
Politechnic University of Cartagena (Spain)
Paseo Alfonso XIII, nº 50
(30203) Cartagena (Spain)
isidoro.guzman@upct.es

Department of Sports Studies
Faculty of Management
University of Stirling
Stirling (Scotland) FK9 4LA
s.h.morrow@stir.ac.uk

SUMMARY

Professional football clubs are unusual businesses, their performance judged on and off the field of play. This study is concerned with measuring the efficiency of clubs in the English Premier League. Information from clubs' financial statements is used as a measure of corporate performance. To measure changes in efficiency and productivity the Malmquist non-parametric technique has been used. This is derived from the Data Envelopment Analysis (DEA) linear programming approach, with Canonical Correlation Analysis (CCA) being used to ensure the cohesion of the input-output variables. The study concludes that while clubs operate close to efficient levels for the assessed models, there is limited technological advance in their performance in terms of the displacement of the technological frontier.

Keywords: data envelopment analysis; football; economics; efficiency; canonical correlation analysis; Malmquist productivity index.

INTRODUCTION

British football clubs are unusual businesses. Although constituted as limited liability companies and hence ostensibly operating within the same legal and governance framework as companies in other areas of economic activity, they exist in a peculiar emotional and social space, where unusually strong relationships often exist between the company and stakeholders like its supporters and the community; those relationships typically being based on issues like identity and belonging. Unsurprisingly these relationships can impinge on business behaviour and decision-making: for example the objectives of football clubs, in particular the desire for on the field success, are likely to have implications for business decision making (Morrow, 2003). While the debate about the objectives of football clubs in not new (see, for example, Sloane, 1971; Sutherland and Haworth, 1986; Arnold and Benveniste, 1987), the substantial increase in income within football since the 1990s has given it greater prominence among stakeholders. More fundamentally the presence of non-financial objectives also raises the question of how to measure the performance of football clubs.

MEASURING PERFORMANCE

Ratio analysis has been commonly used to assess the financial performance of companies, this analysis being based on company financial statements. Univariate financial analysis involves the examination and discussion of one ratio at a time, with a view to drawing tentative conclusions by comparing the result of that ratio with some yardstick of comparison. However, the use of univariate financial analysis has limitations. For example, it assumes a linear relationship between variables, that the numerator and denominator in the ratio can not take negative values and that there are constant returns (Smith, 1990: 132). More generally its reliance on the financial statements as a source of data means that inevitably the analysis is partial, excluding information that can not be captured in financial terms like managerial competence, staff morale and corporate reputation.

Recognition of the limitations of univariate financial analysis has focused attention on alternative and more inclusive techniques that may be used to assess corporate performance (Abad and Laffarga, 2002). In the 1970s the use of multivariate financial analysis became more prevalent, with techniques like multi discriminant analysis and logit being widely used, particularly in the area of predicting corporate failure (Altman, 1968; Altman *et al*., 1977; Ohlson, 1980; Taffler, 1983). More recently techniques have emerged in operational research that are concerned with measuring efficiency. One such technique is Data Envelopment Analysis (DEA) (Charnes *et al*., 1978), a linear programming method used to evaluate the relative efficiency of a number of producers or decision-making units (DMUs), comparing the levels of inputs and outputs of one DMU with its competitors. DEA has been used to measure efficiency in many areas of economic activity: for example, banking (Doménech, 1992; Sherman and Gold, 1985; Yeh, 1996); the pharmaceutical industry (Smith, 1990); supermarkets (Athanassopoulos and Ballantine, 1995); the computer sector (Thore *et al.,* 1996); gold production (Worthington, 1998); companies quoted on the Madrid Stock Exchange (García and Larran, 1996) and companies with financial difficulties (Fernández-Castro and Smith, 1997). DEA has also been applied in the economics of sport: for example, to measure the relative performance of baseball players (Andersen and Sharp, 1997; Mazur, 1994); to estimate the managerial efficiency of college basketball coaches (Fizel and D'Itri, 1996) and more recently to measure franchise payroll efficiency in the NFL and MLB (Einolf, 2004) and the productive efficiency of football clubs in England (Haas, 2003), Germany (Haas *et al*., 2004) and Spain (Sánchez, 2006).

The attractiveness of DEA is that the derivation of the performance efficiency index is dependent on a mixture of physical data and other types of information. Smith's (1990) development of DEA to include information from the financial statements is of particular interest in this research as it "seeks to determine whether financial statements information can yield any useful insights into efficiency…" (1990: 132). But, while accounting numbers can be variables in DEA, its attractiveness is that other non-financial inputs and outputs may also be included.

Following Smith's approach, this paper extracts information from the financial statements to measure corporate performance. To ensure the cohesion of the input-output variables within the DEA models, the statistical test of Canonical Correlation Analysis (CCA) is used to derive the efficiency scores (Sengupta, 1990; Friedman and Sinuany-Stern, 1998; Tofallis, 1999; Adler and Berechman, 2001). Once a definitive DEA model has been obtained, an additional study is undertaken into variations of efficiency scores using the dynamic efficiency measure, Malmquist productivity index (Malmquist, 1953). Thus additional study develops previous work of Haas and Hass *et al.* on the productive efficiency of football clubs in England (Haas, 2003) and in German (Haas *et al*., 2004).

Section 2 of the paper describes the introduction to the methodologies used for measuring efficiency (DEA and CCA) and productivity (Malmquist Total Factor Productivity (TFP) Index approach). In Section 3 the research design, including the model and the empirical results, is presented, while the conclusions are set out in the final section.

METHODOLOGY

Data Envelopment Analysis (DEA)

The efficiency concept involves relating the means (inputs) with the ends (outputs): a production method is considered technically efficient when any other method uses a larger quantity of an input factor to achieve the same output (Fischer *et al*., 1988: 139). To analyze the efficiency of economic units quantitatively, two approaches are possible: i) the stochastic frontier approach, and ii) DEA. In this paper, the efficiency of certain economic units - professional football clubs - is measured using DEA. This approach was used by Charnes *et al*. (1978) and is a reformulation of Farrell's (1957) efficiency measure to the multiple-output, multiple-input case. DEA allows the use of multiple outputs and inputs, and when solved as a linear programming problem it does not assume any functional form of the reference technology.

From a mathematical perspective, DEA is a technique that allows the extraction of information about a sample of observations in a situation where the production function is not known in advance. The mathematical formulation of DEA calculates a discrete piece-wise frontier determined by a set of referent economic units, called decision making units (DMUs).

Following Charnes *et al*. (1978), to convert *m* inputs into *n* outputs for *p* DMUs, mathematically the DEA model is formulated as follows:

$$\max h_z = \frac{\sum_{r=1}^{n} u_r Y_{rz}}{\sum_{i=1}^{m} v_i X_{iz}} \quad (1)$$

$$\frac{\sum_{r=1}^{n} u_r Y_{rj}}{\sum_{i=1}^{m} v_i X_{ij}} \leq 1 \qquad j = 1, \ldots\ldots, p \quad (2)$$

$$u_r, v_i > 0, \quad r = 1, \ldots n; \quad i = 1, \ldots, m \quad (3)$$

where:

Y_{rz} is amount of the *r*th output produced by the zth DMU
X_{iz} is amount of the *i*th input used by the zth DMU
u_r is the weight given to *r*th output
v_i is the weight given to *i*th input
z is the number of DMU assessed
h_z is DEA score to the zth DMU

The efficiency ratio (h_z) is maximised (1), subject to the above conditions [(2)-(3)], where the first inequality ensures that the efficient ratio can not exceed 1, and the second one indicates that the weights are positive. This fractional linear program can be transformed into the following equivalent linear programming problem by a double orientation: input-oriented models refer to the reductions it would be necessary to make in the inputs of the assessed DMU so that it can be become qualified as efficient. Likewise, output-oriented models can identify the necessary increase in output to achieve the same effect. In addition, it is possible to build non-oriented models, which are able to identify a mix of input reductions and output increases.

Taking an input-oriented model, the previous fractional problem shown in [(1)-(3)] can be transformed into the following equivalent linear programming problem [(4)-(7)]:

$$Min\ h_z \qquad (4)$$

s.t.:

$$\sum_{j=1}^{p} \lambda_j X_{ij} \leq h_z X_{iz} \qquad i = 1, ..., m \qquad (5)$$

$$\sum_{j=1}^{p} \lambda_j Y_{rj} \geq Y_{rz} \qquad r = 1, ..., s \qquad (6)$$

$$h_z \geq 0; \lambda_j \geq 0 \qquad j = 1, ..., p \qquad (7)$$

The above linear programming model includes (λ) as a non-negative intensity vector that determines the combination of observed inputs and outputs taking the weights of the DMUs which form the peer group of the virtual DMU. The model could include (S^i) and (S^o) as slack variables for inputs and outputs respectively. The slack variables mentioned result in the foregoing inequalities becoming equalities within the constraints (5) and (6). From a production point of view, positive values for the slack variables indicate that improvements are necessary in some inputs and outputs, besides the radial reduction expressed by (h_z). When a chosen DMU has a value of (h_z) less than 1, it is not considered as efficient because it could be possible to attain the same output quantity by reducing the consumptions of inputs in the proportion (1-h_z).

The detailed linear program provides the input-oriented constant returns and output-oriented constant returns. Subsequently Banker *et al*. (1984) modified the previous model, adding the limitation ($\sum_{j=1}^{p} \lambda = 1$) to restrict the production possibilities and to study the variable returns (increasing, decreasing or constant). The overall efficiency can be divided between pure technical efficiency and scale efficiency. Therefore, adding the previously mentioned constraint, the returns to scale can be assessed and a measure of pure technical efficiency provided. The scale efficiency is obtained by dividing the overall efficiency by pure efficiency[1].

An important problem exists when selecting the variables for the model. Some authors (for example, Ayela and Gómez, 1993: 147) suggest a general rule to prove different cases until reaching the maximum decomposition of factors: maintaining those that exercise a significant effect on the index of efficiency, while also using the weights to determine the relative importance of each model's variables. In the case of low weights, the variables should be removed. In any case, the number of observations should be higher than the sum of the inputs and outputs (Parkan, 1987; El-Mahgary and Ladhelma, 1995). In fact, one of the objectives of this work is to influence the design of the DEA model using canonical correlation theory, to assure a strong correlation between the selected groups of outputs and inputs. This way the DEA model will have a sufficiently large number of DMUs with regard to the sum of inputs and outputs (Barros and Santos, 2003: 55).

Canonical Correlation Analysis (CCA)

Regression analysis attempts to explain changes in a single output by weighting the various inputs common to all observations. But where there are multiple outputs and inputs what is required is a technique that simultaneously combines the weights of outputs and inputs to obtain the maximum correlation between both groups of variables. This is the basis of the technique adopted in this paper. The CCA objectives can be summarized as: i) To demonstrate if two groups of variables are independent, or, conversely to determine the magnitude of the relationship that exists between the two groups; ii)To explain the nature of the relationships among the groups of dependent and independent variables, measuring the relative importance of each variable to the canonical functions.

[1] Interested readers in the DEA technique can consult Thanassoulis, E. (2001) and Coelli et al. (1998).

The method, developed by Hotelling (1936), uses two sets of variables - inputs and outputs - with both variables being taken from the group of analyzed units. CCA seeks to identify and quantify the associations between two sets of variables, the principal aim being to find the maximal correlation between a chosen linear combination of the first set of variables and a chosen linear combination of the second set of variables. The validity of the relationship between the canonical variables is reflected in the coefficient of canonical correlation (η_{vu}). When this coefficient is elevated to the square, it is called *eingevalue*, and it measures the quantity of shared variance, i.e. the variance of the first variable explained by the second variable for each canonical function[2].

Various tests of significance help to interpret the canonical functions. An overall test can be used to establish whether there is a significant relationship between the two sets of variables. In this research Wilks's criterion was utilized using the Bartlett test to demonstrate significance (Hermoso Gutiérrez, 2000: 474). This statistic is distributed as chi-square with ($m*n$) degrees of freedom, and the criteria to accept the canonical function is a significance level of 0.05 (Hair *et al*., 1998: 450). However, some authors suggest that a single test is insufficient (Hermoso Gutiérrez, 2000: 477; Hair *et al*., 1998: 454). Redundancy analysis can be used in CCA to measure the proportion of explained variance for the set of input-output variables. To date there is no agreement as to the minimum measure of redundancy in terms of accepting the interpretation of the canonical functions, although 0.7 has been selected in this research for its evaluation.

Accepting the significance of the different canonical functions, a problem in examining the canonical variables is establishing the relative importance of each of the original variables in the canonical relationship. Three methods are proposed in this study: i) canonical weights; ii) canonical loadings; and iii) canonical cross-loadings. The first method suggests that the original variables should be interpreted according to the canonical weights, although this can introduce errors because of possible multi-colinearity. A more reliable method based on canonical loading measures the contribution of each original variable with its own canonical variable. But the method that ensures the most reliable interpretation is canonical cross-loading, in which each original variable is related with the opposite canonical variable. At present, although no one method seems to be universally favored, canonical cross-loading is recommended (Hair *et al*., 1998: 454). This said it is clear that the correlations between the canonical variables and original variables should be interpreted with caution.

Malmquist Total Factor Productivity Index (TFP)

Total factor productivity is defined using distance functions[3] to describe a multi-input, multi-output production technology. The non-parametric TFP developed from Caves *et al.* (1982) has been the most commonly used measure of productivity change (see Färe *et al*., 1997)[4].

TPF measures the change between two data points by calculating the ratio of the distances of each data point relative to a common technology. Assuming constant returns to scale (CRS) for an assessed DMU and following Fare *et al*. (1994), it is possible to specify an input-based TPF as[5]:

$$M_i^{t+1}(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{d_i^t(x_{t+1}, y_{t+1})}{d_i^t(x_t, y_t)} \times \frac{d_i^{t+1}(x_{t+1}, y_{t+1})}{d_i^{t+1}(x_t, y_t)} \right]^{1/2} \qquad (8)$$

[2] With m inputs and n outputs, up to a maximum of w canonical functions can be obtained (w = min{m,n}. Each pair of variables is derived on the assumption that the correlation between both is maximized.

[3] An *input distance function* characterizes the production technology by looking at a minimal proportional contraction of the input vector, given an output vector, while an *output distance function* considers a maximal proportional expansion of the output vector, given an input vector (Farrell, 1957).

[4] Other studies measure productivity change using a parametric approach (Berger and Mester, 1999, 2001).

[5] Coelli's computer package has been used for the resolution of TFP (Coelli, 1996). The subscript "i" indicates that these are input-oriented measures.

The previous mathematical formulation in (8) calculates a geometric mean and represents the productivity of the production point (x_{t+1}, y_{t+1}) relative to the production point (x_t, y_t). A value of (M^{t+1}_i) greater than 1 will indicate positive productivity growth from period t to period t+1, while a value smaller than 1 indicates negative productivity growth. Furthermore TPF can be further broken down into the following two components[6]:

$$M_i^{t+1}(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{d_i^{t+1}(x_{t+1}, y_{t+1})}{d_i^t(x_t, y_t)}\right]\left[\frac{d_i^t(x_{t+1}, y_{t+1})}{d_i^{t+1}(x_{t+1}, y_{t+1})} \times \frac{d_i^t(x_t, y_t)}{d_i^{t+1}(x_t, y_t)}\right]^{1/2} \quad (9)$$

In equation (9) the first term is referred to as *catching-up* and compares the relative change in technical efficiency between the two periods with respect to the efficiency frontier of the analyzed unit; the second term is referred to as *technological change* or variation of the production frontier between periods (t, t+1), and thus reflects the technical change of the sector. Both indexes can take a value greater than or less than 1. For *catching-up* a value greater than 1 indicates proximity to the production frontier; a value less than 1 indicates divergence from the production frontier. For *technological change* a value greater than 1 indicates technological progress; a value less than 1 indicates technological deterioration (Thanassoulis, 2001). When a temporary series is analyzed, the results can be sensitive to the selection of the initial year, and an index should be obtained for a couple of adjacent periods by geometric mean (Jorgenson, 1990).

EMPIRICAL MODELS

Variables and data

In the current paper, efficiency is measured using the DEA technique to construct a piece-wise linear production frontier. Thereafter a second study is conducted using the Malmquist productivity index to measure the change in productivity over a six year period (the seasons 1997-98 to 2002-03 inclusive).

The application of DEA in the economics of sport has seen a variety of inputs and outputs used, reflecting the different sports studied. Some authors have considered the output accumulated by the various teams during a season (Dawson *et al*., 2000), while others have used an accumulated output taking each match as a unit of measurement (Carmichael *et al.*, 2000). In this study canonical correlation theory is used to determine the common set of weights to be used in DEA, with efficiency being based on sporting and financial results for a particular season. Data is taken from the Deloitte and Touche Annual Reviews of Football Finance and from the annual reports and accounts of the clubs in the FA Premier League which make up the sample, with supplementary data taken from the Soccerway website (www.soccerway.com).

Given the dual performance perspective of football clubs, namely financial and sporting success, two output variables have been selected: points won in a season and total revenue for the corresponding financial year. The first output variable – points won in the FA Premier League - measures the club's sporting performance over the entire time period of a season, as well as measuring that performance on a regular basis given that each club play 38 league matches per season. Furthermore, points gained in the relevant national league have been used as a proxy for sporting success in other recent papers on professional football (Haas *et al*. 2004; Espita-Escuer and García-Cebrián, 2004; Sánchez, 2006). The second output variable is derived from the company's financial statements and is an indicator of a club's financial success (Smith, 1990). While differences exist in the corporate structure of clubs in the sample - for example, some clubs are independent limited liability companies, while others are part of a group of companies – by using the turnover figures reported in the Deloitte and Touche reviews of football finance, the consistency of the data in the sample is assured as the figures therein have been adjusted as necessary to exclude turnover related to non-football activities. Other than adjustments of this type total turnover has been used as the measure of economic success irrespective of whether it is derived from gate revenues, media broadcasting, merchandising or other incomes, reflecting the fact that the expenses incurred by clubs must be met from total revenues generated rather than from any particular source. Some additional output variables may be included, but it is argued that the outputs selected are sufficient to obtain a measure of the clubs' efficiency (Haas, 2003: 405). Furthermore, the inclusion of additional

[6] For further information on TFP decompositions consult Zofio (2001).

variables can lead to erroneous interpretations in the subsequent analysis of DEA because the number of observations should be greater than three times the sum of total inputs and outputs (El-Mahgary and Ladhelma, 1995; Parkan, 1987).

The inputs selected are various expenses of football clubs derived from the financial statements. In common with previous papers (see, for example, Haas, 2003; Haas et al., 2004), the first input selected is staff costs, including not only the salaries of players, managers and coaching staff, but also all other staff employed in the football business. It is evident that player salaries constitute the major proportion of clubs' total wages and salaries, and hence this input is consistent with Szymanski and Kuypers's evidence demonstrating a relationship between investment in playing staff and on-field football success (Szymanski and Kuypers, 1999). That said, arguably it is appropriate to take the costs of all staff employed by the club given that this research focuses on the productive efficiency of the football business in its entirety. Consistent with the approach adopted for turnover where a club is involved in non-football activities then staff costs related to these activities have been excluded. While the possibility of clubs using performance-related-pay raises the problem of simultaneity, the available evidence suggests that this is not a major problem in practice. For example, in the PKF 2004 survey of football club directors, 83% of FA Premier League respondents claimed that performance-related-pay accounted for less than 10% of the first team players' total salary bill (PKF, 2004). The second input, directors' remuneration, is selected on the grounds that it is a proxy for the professional human capital required to guide the performance of the football club in terms of determining long term objectives and strategies. While clearly the players, manager and coaching staff are fundamental to on-field success, arguably off-field success is likely to be influenced at least in part by the quality of its directors. The figure for directors' remuneration is taken from the financial statements of the club where the club is a single company (e.g. Blackburn Rovers Football and Athletic plc) or from the accounts of the holding company where the football club is part of a group of companies (e.g. West Ham United plc). This approach ensures consistency between directors' remuneration and the turnover and wages and salaries figures used in the paper, but nevertheless has two limitations in respect of groups of companies: first, it is not possible to establish whether all directors' remuneration is in respect of football-related activities, and second, the remuneration may be understated where someone is a director of a football club subsidiary but is not a director of the parent or holding company. Finally, the third input selected was the general or other operating expenses of each club. While not directly related to on-field activity, nevertheless such costs are necessarily incurred by the club in carrying out its operations. Include in this category are items like lease and rental charges, fixed asset depreciation, repairs and renewals, training ground costs and professional fees. Player related costs such as amortisation or gains or losses on disposal of players are not included. These two inputs, directors' remuneration and general expenses, represent resources invested by clubs in pursuit of its financial and sporting objectives and thus their inclusion extend previous studies in this industry.

Inevitably some clubs participate simultaneously in domestic and UEFA club competitions, aiming for success in both arenas. As Haas *et al.* (2004) notes, it is necessary to identify a variable that captures output irrespective of whether a club is participating in UEFA club competitions or not. Turnover comprising income from all sources is the most appropriate variable, reflecting outputs from all the club's activities (Haas *et al*., 2004). On the inputs side, total wages and salaries has been used. The importance of the inputs and outputs selected in this study is demonstrated in recent work on Spanish football clubs which found that these factors were among the most commonly discussed by club presidents in their clubs' annual reports (Barajas Alonso, 2003: 7).

The empirical study was carried out using data for six seasons from 1997-98 to 2002-003 (see Appendix 1). Table 1 sets out the number of teams from the FA Premier League included for each season and how many of those clubs participated in UEFA club competitions in a particular season.

TABLE 1: Number of participant clubs

Season	FA Premier League	UEFA club competitions
1997-98	18	7
1998-99	20	8
1999-00	19	7
2000-01	19	6
2001-02	19	7
2002-03	20	8
Total Pooled Sample	**115**	**43**

Table 2 illustrates descriptive statistics for the preliminary model (two outputs, three inputs). First, for the complete pooled sample of clubs, second, for clubs that have participated in UEFA club competitions in the seasons under review, and third, for clubs that participated solely in domestic competition. In terms of inputs, the mean value of staff costs is 77% greater for clubs participating in UEFA club competitions than for those participating solely in domestic competitions. Similar evidence emerges for clubs' other costs and for directors' remuneration, where the differences are 128% and 100% respectively. With regard to outputs, unsurprisingly, differences in means also emerge between clubs participating in UEFA club competitions and the rest in respect of turnover (106% higher) and points won (38% higher). All variables, other than points won, satisfy the condition of non-normality. Applying a non-parametric Mann-Whitney Test between teams participating in UEFA club and domestic competitions, significant differences were observed at the 1% level for all variables in the pooled sample. A complementary survey was carried out for each individual season, with identical results reported, other than for the directors' remuneration variable, which did not show significant differences in the seasons 2000-01 and 2001-02.

TABLE 2: Preliminary Model - Descriptive statistics

Panel A: All clubs (N=115)				
Variables	**Mean**	**SD**	**Maximum**	**Minimum**
Points won	52.74	14.23	91	19
Turnover (£000s)	45,454.85	29,601.70	174,936	12,520
Staff cost (£000s)	27,220.47	14,422.17	79,517	4,172
Other expenses (£000s)	13,974.10	10,229.32	49,557	1,566
Directors' remuneration (£000s)	530.63	459.28	1830	0
Panel B: Clubs participating in UEFA club competitions (N=43)				
Variables	**Mean**	**SD**	**Maximum**	**Minimum**
Points won	63.63	13.72	91	35
Turnover (£000s)	67,001.93	34,983.74	174,936	19,210
Staff cost (£000s)	37,421.91	16,154.70	79,517	10,200
Other expenses (£000s)	21,535.88	12,221.67	49,557	6,625
Directors' remuneration (£000s)	774.19	444.92	1,748	0
Panel C: Clubs participating solely in domestic competitions (N=72)				
Variables	**Mean**	**SD**	**Maximum**	**Minimum**
Points won	46.24	9.95	71	19
Turnover (£000s)	32,586.46	15,292.78	96,689	12,520
Staff cost (£000s)	21,127.94	8,883.76	45,195	4,172
Other expenses (£000s)	9,458.04	4,933.56	24,088	1,566
Directors' remuneration (£000s)	385.17	405.22	1,830	0

Source: authors' calculation

Note: Staff cost excludes directors' remuneration

An additional problem in using DEA is whether to allow for constant returns to scale or variable returns to scale (Charnes *et al*., 2001: 23-39). In this paper it has been assumed that professional football teams have access to a common technology**.** Therefore each club's DEA score arises out of its productivity, based on the management of its resources. Thus considering the resources applied and the outputs achieved throughout an entire season dilutes the impact of inputs selected at any single point in time, and consequently, constant returns to scale are used (Boscá *et al*., 2003: 5; Sánchez, 2006: 149).

Applying Canonical Correlation Analysis to Data Envelopment Analysis

As discussed previously, CCA seeks to identify and quantify the associations between two sets of variables and is thus an appropriate statistical technique to use when there are various criterion and multiple predictor variables. DEA models are normally based upon variables deemed necessary by the researchers. However, to ensure both the highest degree of correlation in the output and input sets of each model (Sengupta, 1990), and to detect redundant variables thus avoiding an excessive number of inputs and/or outputs which would generate a large number of efficient units (Adler and Golany, 2001), it is beneficial to check whether all variables make a contribution to a model's power. Hence, in this paper CCA is applied to the DEA model design, to ensure both of these objectives.

In order to apply CCA methodology, the first step is to select the variables required to measure the efficiency score in accordance with the expected results, deriving the preliminary DEA model (two outputs: point won and revenues; three inputs: staff cost, other expenses and directors' remuneration). Thereafter CCA is used to derive the degree of correlation between the outputs-inputs sets. Simultaneously, the redundancy index is studied to determine the variance of the criterion variables (outputs) that can be explained by the predictor variables (inputs). Although no guidance is available on an accepted level for this index, an acceptance level of greater than or equal to 0.7 has been adopted.

Assuming the coefficient derived is sufficiently high, the second step is to analyze the contribution of the original variables to different canonical variable couples. Table 3 sets out the results of applying canonical correlation to preliminary model. For each period a high degree of correlation is observed for the first couple of canonical variables, significant at the 1% level, but a low degree of correlation is observed for the second couple and moreover is not significant. Consequently, only the first canonical function is used in deriving the definitive DEA model.

Following the interpretation of the first canonical function, the redundancy index outputs/inputs is calculated. As can be seen from Table 3 this is higher than 0.7 in all seasons other than season 2002-03, although even here it remains close to the accepted level. In other words, in mean values, close to 80% of the outputs variance is explained by the inputs set, a level in excess of that required to validate the first canonical correlation (see Section 2.1).

TABLE 3: Canonical correlation analysis - Preliminary Model (two outputs/three inputs)

Season	Canonical Correlation	Eigenvalue	Wilks Lambda	Significance	Root 1 Redundancy Index O/I
1997-98	0.990	0.980	0.018	a	0.737
1998-99	0.994	0.988	0.012	a	0.768
1999-00	0.992	0.984	0.011	a	0.891
2000-01	0.986	0.972	0.028	a	0.788
2001-02	0.970	0.941	0.045	a	0.896
2002-03	0.924	0.854	0.122	a	0.666

(a). Significant at 1% level
Source: authors' calculation

Taking the first canonical function, Table 4 shows the cross-loading to select the variables required for the definitive DEA model. No agreement exists regarding the value of the cross-loading coefficients required to accept or reject the variables in the model, but a figure greater than 0.7 is proposed to ensure that each variable provides a powerful explanation of the variance of the criterion variables[7].

TABLE 4: Cross-loading - Preliminary Model (two outputs/three inputs)

Season	PW	TU	SC	OE	DR
1997-98	0.703	0.989	0.857	0.948	0.776
1998-99	0.742	0.993	0.838	0.986	0.758
1999-00	0.894	0.991	0.888	0.981	0.733
2000-01	0.777	0.986	0.852	0.981	**0.668**
2001-02	0.864	0.968	0.945	0.922	**0.541**
2002-03	**0.694**	0.923	0.907	0.902	**0.568**

Notes: PW: points won; TU: turnover; SC: Staff cost; OE: Other expenses;
DR: Directors' remuneration.

Therefore, for the analyzed case, the variable directors' remuneration (DR) should be rejected (cross-loading < 0.7 for three seasons) markedly below the proposed level of acceptance. All the remaining variables have a cross-loading higher than 0.7 for all periods, other than the variable "points won" which has a cross-loading of 0.694 in season 2002-03, a figure close to acceptance level.

Moreover, the suppressed variable (DR) does not contribute to explaining a greater percentage of the variance of the outputs group. In fact, the redundancy index in mean values (preliminary model: 79.1%) is largely unaffected by suppressing this variable (definitive model 2: 77.9%), resulting in the same coefficient of canonical correlation (0.976). Consequently, the definitive model has two outputs and two inputs (see Table 5).

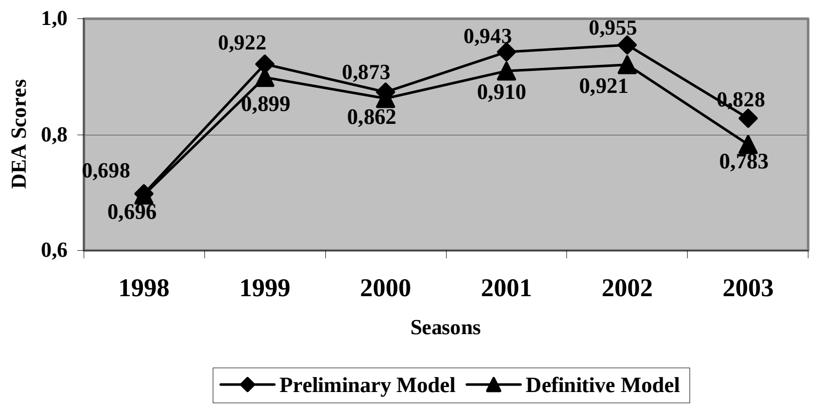
[7] While original variables with a cross-loading smaller than 0.7 have been excluded from the model, some authors, including Hair *et al*. (1998), have argued that variables with values greater than 0.5 can be admitted.

TABLE 5: DEA models applied					
Description		Variables Preliminary Model	Cross-loading(*)	Variables Definitive Model
Inputs				
SC	Staff costs	♦	0.881	♦
OE	Other expenses	♦	0.953	♦
DR	Directors' remuneration	♦	**0.674**	**Rejected**
Outputs				
PW	FA Premier League Points Won	♦	0.779	♦
TU	Turnover	♦	0.975	♦

(*) Mean values for all seasons; ♦ = selected variable to DEA model
Notes: PW: points won; TU: turnover; SC: Staff costs; OE: Other expenses; DR: Directors' remuneration.
Source: authors' calculation

Rather the definitive model highlights important variations in some DEA scores, although the mean values of performance are not excessively different (see Figure 2). Thus, for the 2002—3 season, the CRS-efficiency scores of preliminary model indicate that there are four efficient teams and that the mean efficiency score is 0.828, whereas for the definitive model the mean efficiency score is slightly lower at 0.783, while there are also a smaller number of efficient clubs (2 rather than 4).

FIGURE 1. DEA Scores
Preliminary Model vs Definitive Model 2
(mean values)



Nevertheless, significant differences are evident between the two models when particular clubs are considered; notably Charlton Athletic (-0.1137), Chelsea (-0.2181), Everton (-0.1777) and Middlesbrough (-0.2132). Moreover, when a non-parametric Wilcoxon Test was applied, significant differences were found at the 5% significance level for four seasons (1997-98, 1999-00, 2000-01 and 2002-03), while for two seasons (1998-99 and 2001-02) the differences were significant at the 1% level.

In summary, the mean level of efficiency for the definitive model suggested by CCA is lower than for the preliminary model, with seven clubs reporting a lower score and no club reporting a higher score. These results suggest that in this study the variable, directors' remuneration (DR), can distort the efficiency score if it is included in the DEA model. Given this, it is argued that the DEA model design should adhere to the rules set out previously for the selection of variables, being an appropriate use of CCA for homogenizing models.

As a result the figures that should be adopted for this study correspond to the definitive model[8]. Table 6 sets out more detailed information for season 2002-03, the most recent season in the sample[9].

TABLE 6: DEA Scores to Definitive Model for 2002-03 season (two outputs/two inputs)

Ref.	Team	Rank	DEA Rank	CRS	Peer Group Ref.
1	Arsenal (*)	2	3	0.864	(3) (19)
2	Aston Villa	16	15	0.689	(3) (19)
3	Birmingham City	13	Efficient	1.000	(3)
4	Blackburn Rovers	6	9	0.798	(3)
5	Bolton Wanderers	17	11	0.759	(3) (19)
6	Charlton Athletic	12	4	0.855	(3)
7	Chelsea	4	14	0.694	(19)
8	Everton	7	6	0.822	(3) (19)
9	Fulham	14	17	0.542	(3)
10	Leeds United	15	18	0.470	(3) (19)
11	Liverpool	5	7	0.817	(3) (19)
12	Manchester City	9	12	0.724	(3) (19)
13	Manchester United (*)	1	1	0.961	(3) (19)
14	Middlesbrough	11	10	0.787	(3)
15	Newcastle United	3	2	0.930	(3) (19)
16	Southampton	8	5	0.836	(3) (19)
17	Sunderland	20	16	0.594	(3) (19)
18	Tottenham Hotspur	10	8	0.810	(3) (19)
19	West Bromwich Albion	19	Efficient	1.000	(19)
20	West Ham United	18	13	0.714	(3) (19)
			Mean	**0.845**	

(*) clubs presenting limitation in slacks to the "points won" variable for 38 matches in the season.
Source: authors' calculation

Analyzing the DEA scores overall, there is a mean efficiency level of 0.845, which suggests that clubs should reduce the resources employed (staff cost and other expenses) by 15,5% on average. The column titled "peer group reference" provides the linear combination of clubs on the efficiency frontier closest to each evaluated team. For season 2002-03 it can be seen that technical efficiency was achieved by two clubs (Birmingham City and West Bromwich Albion), while five other clubs report efficiency scores of less than 0.7 (Aston Villa, Chelsea, Fulham, Leeds and Sunderland). Furthermore, a non-parametric Mann-Whitney test reveals that no significant differences exist for the efficiency scores between teams engaged in UEFA club competitions and those which compete only in domestic competitions. This situation is the same for all six seasons sampled.

Also, it is analized the relationship between efficiency scores and league position. Clubs like Birmingham City (13th position) and West Bromwich Albion (19th) are efficient, while Manchester United , Arsenal and Newcastle United (1st, 2nd and 3rd respectively) are not efficient, indicating that while these clubs were successful on the pitch they consumed too much resources for the level of performance achieved in the season.

Performance of FA Premier League Clubs: Malmquist TFP Index

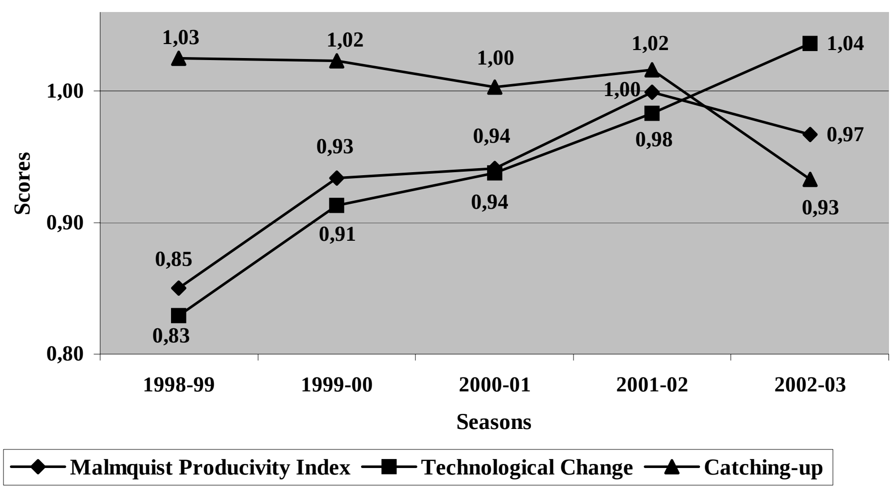
To establish the productivity levels attained by FA Premier League clubs, an additional study using TFP was carried out to improve understanding of empirical implications of productivity measures in professional football. The investigation is based primarily on the non-parametric technique, DEA, to derive efficiency scores for clubs during seasons 1997-98 to 2002-03. The sample was reduced to the 11 clubs that participated in the FA Premier League in all six seasons (see Appendix 1).

[8] As previously stated, differences in the efficiency scores attained by clubs participating in UEFA club competitions and those participating only in domestic competitions were not significant for all seasons (a Mann-Whitney Test reveals significance level (p=0.427) for 2002-2003 season, and similar results were obtained for the other five seasons). Therefore, these findings suggest that turnover, including revenues generated from UEFA club competitions, is not sufficient to change the results in favour of the teams competing in UEFA club competitions.

[9] While all the efficiency measures were calculated for each team in the sample, clearly it is not possible to include this level of detail in the paper. This information is available on request to the authors.

Figure 2 shows TFP movements and their breakdown between technological change and catching-up for the analyzed seasons[10]. It can be seen that TFP has a continuous growth for the first four seasons, with a slight decrease for the 2002-03 season. Hence looking at the overall period a positive productivity change is evident. *Technological change* follows a similar pattern to TFP, the major difference being an increase for the final 2002-2003 season, where a value greater than 1 (1.04) is observed, indicating the existence of a technological advance. With regard to *catching-up* for the period under analysis, the pattern is opposite to that observed for technological change. This catching up variable decreases over the time period as a whole, rising only in season 2001-02, finally reaching a value less than 1 (0.93) in the final 2002-03 season. Hence what this demonstrates is an overall deterioration of the position of clubs relative to the efficiency frontier.

FIGURE 2. Malmquist Productivity Index: Technological change and catching-up



CONCLUSIONS

Football at club level has changed markedly in the last decade or so. Indisputably major football clubs are now complex businesses, intrinsically concerned with financial matters. One of the most important contributory factors in the new business era of football has been television, in particular satellite television, both in terms of much improved deals and also radical alterations to the distribution of that income among clubs. The increasing business orientation of clubs is also evident in other areas: for example, the status of players, where alterations to the transfer system have given players greater freedom of movement and contractual bargaining power, and changes in the ownership structure and governance of clubs. But football clubs remain unusual businesses, judged by what happens on the field as well as by more conventional measure of business performance.

The aim of this study was to analyze the efficiency of clubs in the FA Premier League using non-parametric models to obtain production frontiers. The methodology applied was based jointly on DEA and canonical correlation theory which has a dual objective: first, to ensure the highest degree of correlation in the output and input sets, and second, to detect redundant variables which would generate a large number of efficient units.

Relatively high mean efficiency scores were reported for the sample of all clubs for all six seasons taken together for the revised DEA model (definitive model, efficiency mean value: 0.846), the latter derived after the application of canonical correlation theory. Focusing on definitive model for the most recent 2002-03 season, at the level of individual clubs some interesting results were generated: for example, some clubs which enjoyed success on the field (league position in brackets), notably Arsenal (2nd), Chelsea (4th) and Liverpool (5th), achieved relatively low efficiency scores, while other clubs that enjoyed less on-field success were efficient, notably Birmingham (13th) and West Bromwich Albion (19th). For the

[10] The geometric mean has been applied because Malmquist productivity index is a multiplicative index.

same season, the mean values of all clubs taken together indicated that they were operating at an efficiency level close to 80%. Looking ahead therefore, arguably the best way for inefficient teams to become more efficient is to focus their attention on radially reducing their inputs by approximately 20%.

The study also analyzed variations in performance between seasons 1997-98 and 2002-03 using the TFP. Restricting the study to the eleven clubs that participated in the FA Premier League in all of these seasons, the results indicate that for mean values most clubs report an index value of less than 1, indicating that they do not experience any gain in the level of productivity. When the MPI is deconstructed, two key points emerge: first, technological change offers a positive displacement of the efficiency frontiers along the evaluated periods, and second, catching-up presents a negative trend, resulting in a value of less than 1 in the final season, suggesting that clubs provide poorer performance in terms of movements in the efficient frontiers over the six seasons.

Overall this research shows that DEA can be a suitable tool for measuring the efficiency of professional football clubs. If the technique is applied together with CCA, it is possible to obtain DEA models with acceptable levels of correlation for a given set of data. This study suggests opportunities for future research, notably extending it to other countries and generating further DEA models that simultaneously consider different economic and technical variables that may influence the performance of professional football clubs.

REFERENCES

Abad C, Laffarga J (2002) La utilidad del análisis envolvente de datos con herramienta para el análisis financiero. Comunicación X Encuentro ASEPUC, Santiago de Compostela.
Adler N, Golany B (2001) Evaluation of deregulated airline networks using data envelopment analysis combined with principal component analysis with an application to Western Europe. European Journal of Operational Research, 2: 260-273
Adler N, Berechman J (2001) Measuring airport quality from the airlines' viewpoint: an application of data envelopment analysis. Transport Policy 8: 171-181
Altman EI (1968) Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. Journal of Finance 23,4: 589-609
Altman EI, Haldeman RG, Narayanan P (1977) Zeta analysis: a new model to identify bankruptcy risk of corporations. Journal of Banking and Finance 1,1:29-54
Andersen TR, Sharp GP (1997) A new measure for baseball hitters using DEA. Annals of Operations Research 73:141-155
Arnold A, Benveniste I (1987) Wealth and poverty in the English Football League. Accounting and Business Research 17,67:195-203
Athanassopoulos AD, Ballantine JA (1995) Ratio and frontier analysis for assessing corporate performance: Evidence from the Grocery Industry in the UK. Journal of the Operational Research Society 46:427-440
Ayela R, Gómez JC (1993) Generación de fronteras eficientes en el análisis financiero: Una aplicación empírica. Revista Española de Financiación y Contabilidad XXIII, 74:133-151
Banker RD, Charnes A, Cooper W (1984) Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science 30,9:1078-1092
Barajas Alonso AA (2003) Visión estratégica del negocio del fútbol. La opinión de los presidentes de los clubes de fútbol ingleses que cotizan en Bolsa. Congreso mundial de gestión económica del deporte, Barcelona
Barros CP, Santos A (2003) Productivity in sports organisational training activities: A DEA study. European Sport Management Quarterly 3,1:46-65
Berger AN, Mester LJ (1999) What Explains the Dramatic Changes in Cost and Profit Performance of the US Banking Industry?. Working paper Federal Reserve Bank of Philadelphia No.1, February.
Berger AN. Mester LJ (2001) Explaining the Dramatic Changes in Performance of US Banks: Technological Change, Deregulation and Dynamic Changes in Competition. Working paper Federal Reserve Bank of Philadelphia No.6, April.
Boscá JE, Liern V, Martínez A, Sala R (2003) Análisis de la eficiencia técnica de los equipos de las ligas de fútbol profesional. Congreso mundial de gestión económica del deporte, Barcelona
Carmichael F, Thomas D, Ward R (2000) Team performance: the case of English Premier League. Managerial and Decision Economics 21:31-45
Caves DW, Christensen LR, Diewert W (1982) The economic theory of index numbers and the measurement of input, output and productivity. Econometrica 50:1393-1414
Coelli T, Prasada Rao DS, Battese GE (1998) An introduction to efficiency and productivity analysis. Kluwer Academic Publishers, Boston
Coelli TJ (1996) A guide to DEAP version 2.1: A data envelopment analysis (computer) program. Working paper 8/96, Centre of Efficiency and Productivity Analysis, University of New England, Armidale, Australia
Charnes A, Cooper W, Lewin AY, Seiford L (2001) Data envelopment analysis: theory, methodology and applications. Kluwer, Dordrecht, Netherlands

Charnes A, Cooper W, Rhodes E (1978) Measuring the efficiency of decision making units. European Journal of Operational Research 2:429-444
Dawson P, Dobson S, Gerrard B (2000). Stochastic frontiers and the temporal structure of managerial efficiency in English soccer. Journal of Sports Economics 1,4:341-362
Doménech R. (1992) Medidas no paramétricas de eficiencia en el sector bancario español. Revista Española de Economía 9:171-196
Einolf KW (2004) Is winning everything? A data envelopment analysis of Major League Baseball and the National Football League. Journal of Sports Economics 5,2:127-151
El-Mahgary S, Ladhelma R. (1995) Data envelopment analysis: visualizing the results. European Journal of Operational Research 85:700-710
Espita-Escuer M, García-Cebrián L (2004) Measuring the efficiency of Spanish first division soccer teams. Journal of Sports Economics 5,4:329-346
Fare R, Grosskopf S, Knox Lovell CA (1994) Production Frontiers. Cambridge University Press, Cambridge
Färe R, Grosskopf S. and Roos P. (1997). Malmquist Productivity Indexes: A Survey of Theory and Practice. In Färe, R., Grosskopf, S., Russell, R.R. (Eds.), Index numbers: Essays in honour of Sten Malmquist. Kluwer Academic Publishers, Boston
Farrell MJ (1957) The measurement of productive efficiency. Journal of the Royal Statistical Society. Series A (General) 120:253-289
Fernández-Castro A, Smith P (1997) On the normative use of financial statement data. Revista Europea de Dirección y Economía de la Empresa 6:127-142
Fischer S, Dornbusch R, Schmalensee R (1988) Economics. McGraw-Hill, New York
Fizel JL, D'Itri M (1996) Estimating managerial efficiency: the case of college basketball coaches. Journal of Sport Management 10:435-445
Friedman L, Sinuany-Stern Z (1998) Combining ranking scales and selecting variables in the DEA context: the case of industrial branches. Computer and Operational Research, 25, 9: 781-791
García T, Larran M (1996) La contribución del DEA al análisis financiero: Un estudio empírico. Comunicación VII Encuentro de ASEPUC, Barcelona
Haas DJ (2003) Productivity efficiency of English football teams: A data envelopment analysis approach. Managerial and Decision Economics 24:403-410
Haas DJ, Kocher MG, Sutter M (2004) Measuring efficiency of German football teams by data envelopment analysis. Central European Journal of Operations Research and Economics 12:251-268
Hair JF, Anderson RE, Tatham RL, Black WC (1998) Multivariate Data Analysis. Prentice Hall International, London
Hermoso Gutiérrez JA (2000) Correlaciones canónicas. In: Luque Martínez T (ed.) Técnicas de análisis de datos en investigación de mercados. Editorial Pirámide, Madrid, pp 469-487.
Hotelling H. (1936) Relations between two sets of variables. Biometrika, 28:321-377
Jorgenson DW (1990) Productivity and economic growth. In: Berndt ER, Triplett JE (eds.) Fifty years of productivity measurement. University of Chicago Press, Chicago, pp 19-188
Malmquist S (1953) Index numbers and indifference curves. Trabajos de Estadística 4:209-242
Mazur M (1994) Evaluating the relative efficiency of baseball players. In: Charnes A, Cooper W, Lewin A, Seiford L (eds.) Data envelopment analysis: Theory, methodology and applications. Kluwer, Boston, pp 369-391
Morrow S (2003) The people's game? Football, finance and society. Palgrave, Basingstoke
Ohlson JA (1980) Financial ratios and the probabilistic prediction of bankruptcy. Journal of Accounting Research, 18,1:104-131
Parkan C (1987) Measuring the efficiency of service operations: an application to bank branches. Engineering Cost and Production Economics, 12:237-242
PKF (2004) Financing football – fit for business? The annual survey of football club directors 2004. PKF, London
Sánchez, LC (2006) Son compatibles el "bolsillo" y el "corazón" El caso de las sociedades anónimas deportivas españolas. *Revista de Contabilidad y Tributación,* 283, October: 131-164.
Sengupta JK (1990) Tests of efficiency in data envelopment analysis. Computers and Operations Research 17: 341-356
Sherman HD, Gold F (1985) Bank branch operating efficiency: Evaluation with data envelopment analysis. Journal of Banking and Finance 9:297-315
Sloane P (1971) The economics of professional football: The football club as a utility maximiser. Scottish Journal of Political Economy 18,2:121-146
Smith P (1990) Data envelopment analysis applied to financial statements. Omega: The International Journal of Management Science 18:131-138
Sutherland RJ, Haworth M (1986) The economics of the industry. Managerial Finance 12,1:1-5
Szymanski S, Kuypers T (1999) Winners and losers: The business strategy of football. Viking, London
Taffler RJ (1983) The assessment of company solvency and performance using a statistical model. Accounting and Business Research 15,52:295-308
Thanassoulis E (2001) Introduction to the theory and application of data envelopment analysis. Kluwer, Dordrecht, Netherlands
Thore S, Phillips F, Ruefly TW, Yue P (1996) DEA and the management of the product cycle: The US computer industry. Computers and Operations Research 23: 341-356
Tofallis C (1999) Model building with multiple dependent variables and constraints. The Statistician, 48 (3): 371-378.

Worthington AC (1998) The application of mathematical programming techniques to financial statement analysis: Australian gold production and exploration. Australian Journal of Management 23:97-113
Yeh Q (1996) The application of data envelopment analysis in conjunction with financial ratios for bank performance evaluation. Journal of the Operational Research Society 47:980-988
Zofío JL (2001) Malmquist Productivity Index decompositions: A unifying framework. Working Paper, Universidad Autónoma de Madrid, forthcoming article in *Applied Economics*

APPENDIX 1: FA Premier League – Selected clubs from 1997-98 to 2002-03 seasons

Team	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	UEFA (*)
Arsenal	x	x	x	x	x	x	*
Aston Villa	x	x	x	x	x	x	*
Barnsley	x						
Birmingham City						x	
Blackburn Rovers	n/a	x			x	x	*
Bolton Wanderers	x				x	x	
Bradford City			n/a	n/a			
Charlton Athletic		x		x	x	x	
Chelsea	x	x	x	x	x	x	*
Coventry City	x	x	x	x			
Crystal Palace	n/a						
Derby County	x	x	x	x	x		
Everton	x	x	x	x	x	x	
Fulham					x	x	*
Ipswich Town				x	x		
Leeds United	x	x	x	x	x	x	*
Leicester City	x	x	x	x	n/a		*
Liverpool	x	x	x	x	x	x	
Manchester City				x		x	*
Manchester United	x	x	x	x	x	x	*
Middlesbrough		x	x	x	x	x	
Newcastle United	x	x	x	x	x	x	*
Nottingham Forest		x					
Sheffield Wednesday	x	x	x				
Southampton	x	x	x	x	x	x	
Sunderland			x	x	x	x	
Tottenham Hotspur	x	x	x	x	x	x	*
Watford			x				
West Bromwich Albion						x	
West Ham United	x	x	x	x	x	x	*
Wimbledon	x	x	x				
Total Teams for season	**18**	**20**	**19**	**19**	**19**	**20**	

(*) UEFA club competitions: UEFA Champions' League and UEFA Cup.
n/a: not available
Source: Deloitte and Touche annual reports, financial statements clubs and web site soccerway.com