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Abstract

This paper applies a probabilistic approach to investigate how the top European football clubs' current value and debt levels influence their performance. Specifically, a bootstrapped conditional data envelopment analysis (DEA) is used in order to measure the effect of football clubs' current value and debt levels on their obtained efficiency performances. The results indicate that football clubs' current value levels have a positive influence up to a certain point. But as the current value increases the effect is neutral to football clubs' performance. At the same time, the empirical evidence suggests that there is no influence on football clubs' efficiencies associated with lower and medium football clubs' debt levels while higher debt levels appear to have a direct negative effect.

Keywords: European football clubs; Data Envelopment Analysis; Nonparametric regression; Bootstrapping; Probabilistic approach.

JEL classification: C14**,** C69**,** L83

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I. Introduction

The economic theory behind sporting activity is based on the work of Rottenberg (1956), Neale (1964), Jones (1969) and Sloane (1969, 1971, 1976). However, Scully (1974) was the first to apply a production function in order to provide empirical evidence for the performance of baseball players. The application of frontier production function in order to measure teams' performance has been dated back on the works of Zak *et al.* (1979), Porter and Scully (1982) and Fizel and D'Itri (1996, 1997). Dawson *et al.* (2000) had applied a stochastic frontier approach (SFA), measuring managers' efficiency for a panel of managers in English Football (soccer) Premier league. Haas (2003a, 2003b) applied data envelopment analysis (DEA) measuring team efficiency of the USA Major League Soccer (MLS) and for twenty English Premier League clubs. Barros and Leach (2006a, 2006b, 2007) applying a stochastic Cobb-Douglas production frontier and DEA measured the performance of football clubs in the English F.A. Premier League. More recently Barros and Garcia-del-Barrio (2011) and García-Rubio et al. (2011) used DEA methodology in order to determine the factors influencing Spanish football teams' performance levels.

Our study, similarly to the ones already mentioned, by applying for the first time conditional DEA efficiency estimates (Daraio and Simar, 2005, 2006, 2007a, 2007b) investigates how clubs' value and debt levels influence their performances. In contrast to the main research stream, instead of using data of a specific national football league, our study uses a sample of the top 25 European football clubs and proposes a composite index as output based on several long term football clubs' success factors.

II. Data and Methodology

All the data are extracted from Forbes database (2010) and concern data recorded for the year 2009. In our DEA formulation we use one input and one composite output. The input used is football clubs' revenues (measured in millions $) and one composite output which measures football clubs European and domestic trophies. The composite output contains the sum of the number of European champions' cups (weighted by 5), UEFA cups/ Euroleague cups (weighted by 4), European cup winners' cups (weighted by 3), Intercontinental cups (weighted by 3) and FIFA Club World cups (weighted by 3).

In addition the composite output contains also the sum of the number of domestic championships (weighted by 2) and domestic cups (weighted by 1). Both the number of the weighted domestic champions and domestic cups (includes all domestic cups, i.e. super cups, league cups, national cups, etc) are again weighted by FIFA world ranking score (FIFA, 2010). This extra weight has been added in order to reflect the different difficulty levels of obtaining a domestic cup and/ or championship among the different European leagues[1]. We also assume that club revenues are used from the clubs in order to buy the best (in term of football quality) possible managers and players which can lead to team success (based on world, European and domestic championships and cups).

Recent studies for the English Premier League suggest that revenues are related to clubs' success (Hickman et al., 2008; Carmichael et al., 2010). Moving a step ahead and by applying a conditional efficiency measurement approach we examine in what way European football clubs' current value (CurrVal-Z_1) and debt levels (Debt-Z_2) (measured in millions of $) affect their obtained efficiency levels.

[1] We assume that it is not of the same difficulty to obtain a domestic championship or cup between the English, the Scottish, the Spanish, the German and the Italian football league. All the weights used in order for the composite output to be constructed are subjective and can be subject to criticism.

Table 1 presents the descriptive statistics of the variables used in our study. As can be realized table 1 reports several variations of the variables used indicated by the high standard deviation values. Finally, in our DEA setting we assume an output orientation suggesting by how much football clubs can increase their output while keeping the level of inputs fixed.

Table 1: Descriptive statistics of the variables used

	External Variables		**Input**
	Current Value($mil)	*Debt($mil)*	*Revenue ($mil)*
Mean	597.080	218.238	274.720
Std	443.374	338.197	128.008
Min	194.000	0.002	128.000
Max	1870.000	1284.000	576.000
	Output components		
	Intercontinental Cup	*FIFA Club World Cup*	*Domestic Championships*
Mean	0.56	0.08	13.80
Std	1.00	0.28	12.70
Min	0.00	0.00	2.00
Max	3.00	1.00	51.00
	Output components		
	European Champions Cups	*Uefa Cups/Euroleague Cups*	*European Cup Winners Cup*
Mean	1.600	0.840	0.800
Std	2.432	1.143	0.913
Min	0.000	0.000	0.000
Max	9.000	3.000	4.000
	Output components		
	Domestic Cups	*FiFA country Ranking*	*Composite Output*
Mean	13.48	7.04	27.29
Std	13.04	8.88	33.82
Min	2.00	1.00	1.46
Max	57.00	35.00	142.00

Based on the work by Koopmans (1951) and Debreu (1951) the production set Ψ constraints the production process and is the set of physically attainable points (x, y) :

$$\Psi = \left\{ (x, y) \in \Re_{+}^{N+M} \middle| x \;\; can \;\; produce \;\; y \right\} \qquad (1),$$

where $x \in \Re_{+}^{N}$ is the input vector and $y \in \Re_{+}^{M}$ is the output vector.

Then the output oriented efficiency boundary $\partial Y(x)$ is defined for a given $x \in \Re_+^N$ as:

$$\partial Y(x) = \{y | y \in Y(x), \lambda y \notin Y(x), \forall \lambda > 1\}, \quad (2)$$

and the Debreu-Farrell output measure of efficiency for a production unit can be defined as:

$$\lambda(x,y) = \sup\left\{\lambda | (x, \lambda y) \in \Psi\right\} \quad (3).$$

In equation (3) by construction $\lambda(x,y) \geq 1$ and technical efficiency is achieved when $\lambda(x,y) = 1$. As suggested by several authors (Førsund and Sarafoglou, 2002; Førsund *et al.,* 2009), Hoffman's (1957) discussion regarding Farrell's (1957) paper was the first to indicate that linear programming can be used in order to find the frontier and estimate efficiency scores, but only for the single output case. Later, Boles (1967, 1971) developed the formal linear programming problem with multiple outputs identical to the constant returns to scale (CRS) model in Charnes *et al*. (1978) who named the technique as data envelopment analysis (DEA).

Following Zelenyuk and Zheka (2006, p.149) we apply the assumption of CRS due to the fact that it enables to obtain greater discriminative power, which in turn would result in larger variation of the regressand. In addition, since we examine the 25 European football clubs with the highest values, we are not expecting great differences among their sizes. This formulation can be expressed as:

$$\hat{\Psi}_{CRS} = \left\{(x,y) \in \Re^{N+M} \middle| y \leq \sum_{i=1}^{n} \gamma_i y_i; x \geq \sum_{i=1}^{n} \gamma_i x_i \text{ for } (\gamma_1, ..., \gamma_n) \right. \\ \left. \text{such that } \gamma_i \geq 0, i = 1, ..., n\right\} \quad (4).$$

which then can be computed by solving the following linear program:

$$\hat{\lambda}_{CRS} = \sup\{\lambda \mid \lambda y \le \sum_{i=1}^{n} \gamma_i y_i ; x \ge \sum_{i=1}^{n} \gamma_i x_i \text{ for } (\gamma_1, ..., \gamma_n) \text{ such that } \gamma_i \ge 0, i = 1, ..., n\} \quad (5).$$

II.1 A bootstrap approach for bias correction of the efficiency estimator

Simar and Wilson (1998, 2000, 2008) suggest that DEA estimators were shown to be biased by construction. They introduced an approach based on bootstrap techniques (Efron, 1979) to correct and estimate the bias of the DEA efficiency indicators. The bootstrap bias estimate for the original DEA estimator $\hat{\lambda}_{CRS}(x, y)$ can be calculated as:

$$\hat{BIAS}_B\left(\hat{\lambda}_{CRS}(x, y)\right) = B^{-1}\sum_{b=1}^{B}\hat{\lambda}^*_{CRS,b}(x, y) - \hat{\lambda}_{CRS}(x, y) \quad (6).$$

Furthermore, $\hat{\lambda}^*_{CRS,b}(x, y)$ are the bootstrap values and B is the number of bootstrap replications (2000 replications has been used). Then a biased corrected estimator of $\lambda(x, y)$ can be calculated as:

$$\begin{aligned}\hat{\hat{\lambda}}_{CRS}(x, y) &= \hat{\lambda}_{CRS}(x, y) - \hat{BIAS}_B\left(\hat{\lambda}_{CRS}(x, y)\right) \\ &= 2\hat{\lambda}_{CRS}(x, y) - B^{-1}\sum_{b=1}^{B}\hat{\lambda}^*_{CRS,b}(x, y)\end{aligned} \quad (7).$$

Following the conditional efficiency estimators Daraio and Simar (2005, 2006, 2007a, 2007b) and the theoretical background of their statistical properties (Jeong et al. 2010) the conditional output efficiency measure can be defined as:

$$\lambda(x, y|z) = \sup\left\{\lambda \mid S_{Y|X,Z}(\lambda y|x, z) > 0\right\} \quad (8),$$

where $Z \in \Re^r$ denotes the external variables. Then the conditional survival function introduced in (8) can be estimated as:

$$\hat{S}_{Y|X,Z}\left(y\middle|x,z\right)=\frac{\sum_{i=1}^{n} I\left(Y_i \geq y, X_i \leq x\right) K_h\left(Z_i, z\right)}{\sum_{i=1}^{n} I\left(X_i \leq x\right) K_h\left(Z_i, z\right)} \quad (9).$$

In equation (9) K(.) is the Epanechnikov kernel and h is the bandwidth, which has been calculated following a fully automatic data-driven approach as has been indicated by Bădin et al. (2010) . Since our external variables (Z_1 and Z_2) are correlated (Pearson correlation = 0.65, P-value=0.000) and this will lead us to biased conditional efficiency estimates, we apply the Mahalanobis transformation (Mardia et al., 1979), following Cherchye et al. (2007) in order to de-correlate the variables and thus to apply a sequential kernel estimation as if all external variables were independently distributed. This will enable us to observe separately the effect of the external variables on the obtained efficiency estimates.

Then in order to establish the influence of an external variable on the efficiency scores obtained a scatter of the ratios $Q_Z \frac{\hat{\lambda}_n\left(x,y\middle|z\right)}{\hat{\lambda}_n\left(x,y\right)}$ against Z (in our case as mentioned there are two external factors) and its smoothed non-parametric regression line it would help us to analyse the effect of Z on the European football teams' performance. Following Racine (2008) we use a known local polynomial method due to the fact that does not suffer from edge bias and can enable us to describe better the underlying data generating process (DGP) compared to the local constant estimator (Nadaraya, 1965; Watson, 1964). According to Daraio and Simar (2005) if the regression line is increasing it indicates that Z is unfavourable to the teams' efficiency levels whereas if it is decreasing then it is favourable.

III. Empirical results and conclusions

Following the methodology presented previously, Table 2 presents the results obtained of the efficiency analysis under the CRS assumption. The European football clubs are presented in table 2 in a descending order based on their current values. The second column represents the original efficiency estimates $\left(\hat{\lambda}_{DEA}(x,y)\right)$, whereas the third represents their biased corrected efficiency estimates $\left(\hat{\lambda}_{DEA,BC}(x,y)\right)$. Similarly, the conditional efficiency scores on football clubs' current value levels $\left(\hat{\lambda}_{DEA}(x,y|z_1)\right)$ are presented in the fourth column alongside side with their biased corrected conditional efficiency estimates $\left(\hat{\lambda}_{DEA,BC}(x,y|z_1)\right)$. Finally, the last two columns present the conditional on debt efficiency estimates $\left(\hat{\lambda}_{DEA}(x,y|z_2)\right)$ and their biased corrected conditional efficiency estimates $\left(\hat{\lambda}_{DEA,BC}(x,y|z_2)\right)$.

As can be realized from the descriptive values, football clubs' current value and debt levels appear to decrease their performance levels (in average terms) both for original and biased corrected estimates. In addition high standard deviation values have been reported for all the efficiency estimators indicating high performance variations among the European football clubs. Figure 1 illustrates the nonparametric estimates of the regression functions (using the conditional and unconditional biased corrected CRS efficiency estimates) and their variability bounds of pointwise error bars using asymptotic standard error (Hayfield and Racine, 2008).

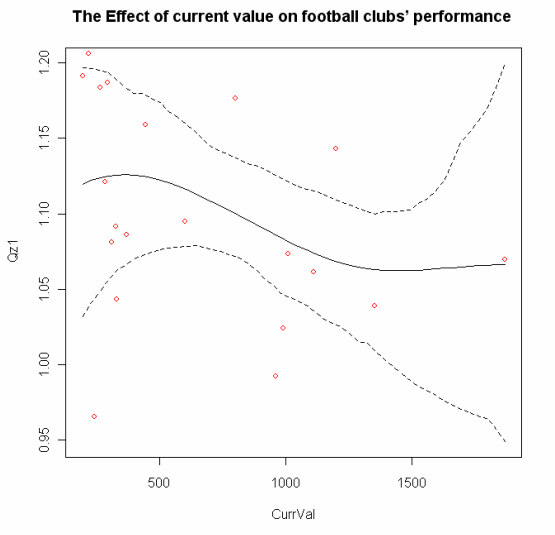
Table 2: Efficiency scores of conditional and unconditional measures

Football Clubs	$\hat{\lambda}_{DEA}(x,y)$	$\hat{\lambda}_{DEA,BC}(x,y)$	$\hat{\lambda}_{DEA}(x,y\|z_1)$	$\hat{\lambda}_{DEA,BC}(x,y\|z_1)$	$\hat{\lambda}_{DEA}(x,y\|z_2)$	$\hat{\lambda}_{DEA,BC}(x,y\|z_2)$
Manchester United FC	1.681	1.773	1.766	1.896	3.051	3.768
Real Madrid FC	1.000	1.209	1.000	1.256	1.000	1.352
Arsenal FC	1.752	1.814	1.974	2.073	3.836	4.367
Bayern Munich FC	1.350	1.449	1.400	1.538	1.198	1.366
Liverpool FC	1.141	1.198	1.203	1.286	1.879	2.231
AC Milan FC	1.051	1.112	1.060	1.138	1.493	1.765
Barcelona FC	1.051	1.186	1.014	1.177	1.274	1.672
Chelsea FC	2.380	2.457	2.759	2.891	1.949	2.110
Juventus FC	1.053	1.096	1.135	1.201	2.588	3.189
Schalke 04 FC	1.511	1.560	1.838	1.925	2.783	3.044
Tottenham Hotspur FC	1.342	1.384	1.532	1.605	2.816	3.126
Olympique Lyonnais FC	1.914	2.040	2.510	2.693	2.770	2.986
AS Roma FC	1.902	1.971	2.366	2.490	2.422	2.618
Internazionale Milan FC	1.097	1.142	1.174	1.241	2.469	2.962
Hamburg SV FC	1.269	1.309	1.301	1.366	2.736	3.016
Borussia Dortmund FC	1.130	1.166	1.215	1.273	2.417	2.669
Manchester City FC	1.281	1.374	1.377	1.485	2.062	2.225
Werder Bremen FC	1.279	1.331	1.486	1.580	2.350	2.546
Newcastle United FC	1.429	1.486	1.561	1.666	2.545	2.756
VfB Stuttgart FC	1.375	1.471	1.615	1.741	2.329	2.513
Aston Villa FC	1.092	1.137	1.000	1.098	1.707	1.845
Olympique Marseille FC	1.461	1.523	1.093	1.180	2.715	2.940
Celtic FC	1.079	1.133	1.274	1.367	1.577	1.703
Everton FC	1.115	1.168	1.325	1.415	1.704	1.841
Glasgow Rangers FC	1.000	1.075	1.175	1.281	1.114	1.201
Mean	1.349	1.423	1.486	1.594	2.191	2.472
Std	0.346	0.350	0.480	0.491	0.693	0.779
Min	1.000	1.075	1.000	1.098	1.000	1.201
Max	2.380	2.457	2.759	2.891	3.836	4.367

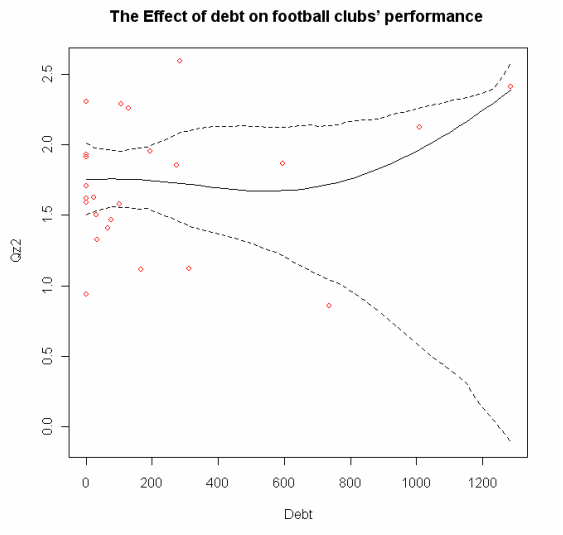
The results indicate that football clubs' current value levels (subfigure 1a) have a positive value up to a certain point. However as the current value increases the effect is neutral to football clubs' performance. In addition it is reported that extremely high football clubs' current values may have even a negative value on football clubs' performance. In addition it appears that lower to medium levels of football clubs' debt levels (subfigure 1b) has a neutral effect on football clubs' performance. However there are strong evidences that higher debt values can affect negatively football clubs' efficiency levels.

Figure 1: Graphical representation of the global effect of current value (CurrVal) and debt (Debt) on football clubs' performance

1a



1b



Finally, in terms of policy implications it appears that when comparing the top European football clubs, their determinants of higher efficiency (in terms of the number of domestic and European club trophies) are not based on their higher revenue and value levels. The conditional DEA approach proved to be a vital tool for showing that other factors like managerial efficiency (Fizel and D'Itri, 1996, 1997; Dawson *et al.*, 2000) and team spirit (Scully, 1974) may be more important when comparing the top European football clubs.

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