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Greek football clubs' efficiency before and after Euro 2004 Victory: a bootstrap approach

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Abstract This paper examines the technical efficiency of Greek football clubs, taking into account the period before the Euro 2004 victory and the period thereafter. The first stage of analysis is based on a bootstrapped data envelopment analysis approach so as to determine Greek clubs' efficiency scores during these two distinct time periods. The second stage of analysis investigates possible factors that may have affected the efficiency scores during the examined periods. Our findings reveal that Greek football clubs exhibit surprisingly lower efficiency scores after Euro victory. In effect and explained in the context of the Resource Based Theory, there appears to be no classification of types of football clubs into various divisions, viz. laggards, followers and champions. Finally, it is also found that clubs' financial health appears to be a crucial factor for their performance in both periods.

Keywords Greek football clubs · Bootstrap DEA · Technical efficiency · Truncated Regression

JEL Classification C24 · C69 · D24 · L83

1 Introduction and motivation

The Greek National Football Team accomplished one of the most remarkable achievements in the history of football in the Euro 2004. As the "outsiders" who had never won a match in a major tournament, Greece managed, against all expectations, to win the Euro 2004 soccer final by soundly defeating the Portuguese National Team twice on their own home turf in Lisbon. This unexpected football outcome motivated

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many Greek football clubs to employ better qualified coaches and players, proposing higher salaries, offer higher transfer costs and negotiate better grants, including TV and merchandising grants. These changes led to an overall investment in the football industry, all of which led to a significant transformation in the soccer environment.

As a result of the above, the Greek Ministry of Culture, the General Secretary of Sports and the Hellenic Football Federation (H.F.F) decided in August 2004 to contribute to this reform through the enactment of the 3479/2004 Law, which basically aimed at boosting Greek football clubs performance. This reform involved a series of measures which focused on the financial improvement and stability of football clubs, the creation of a more competitive champion and the allocation of responsibility to regional administrations, which in turn brought about changes to the administrational and organizational structure of all football authorities. What further contributed to the development and improvement of the Greek champion was the expansion of its commercial and financial database and the further upgrade and modernization of athletic infrastructures.

Efficiency measurement in football is not an easy task given that the identification of football clubs behavioral objectives and means is a rather controversial issue (Borland 2006). Relevant literature on clubs objectives can be distinguished into three different classes. Firstly, Neale (1964) and Quirk and Fort (1992)[1] assume that football clubs behave as common firms aiming at maximizing their profits. However, based on Sloane's 1973 seminal work, many economists have argued that victories are more important than profits (Késenne 1996, 1999, 2006) proposing a model where clubs face a utility maximization problem. Vrooman (2000) recently suggested a mixed situation where profits along with the number of victories are maximized at the same time. This paper follows the approaches of Szymanski and Smith (1997) and Késenne (1999) who argue that bad budgetary balances go against profit maximization and assumes that Greek football clubs, as is the case with European clubs, behave as utility maximizers.

In light of the above, the main research question addressed by the present paper is whether and to what extent *football clubs' productive performance is different before and after Euro 2004 victory.* A further issue which arises concerns the *investigation of exogenous factors* that *are likely to affect the technical efficiency of Greek clubs before and after this victory*. The paper at hand contributes to existing literature in many ways: it firstly employs a DEA bootstrap methodology in measuring Greek football clubs' efficiency so as to obtain efficiency score results with high statistical precision; it secondly investigates whether the unexpected shock of the Euro 2004 victory actually improved clubs' efficiency; thirdly, it attempts to explain technical efficiency from an econometric viewpoint using an exogenous variable set; it finally examines the feasibility of developing a typology of football clubs based on their productive performance before and after Euro 2004 victory. To the best of our knowledge, this is the first study which focuses on the attempt of Greek football clubs to identify and assess the effect of a meaningful event on their efficiency and which analyzes possible football efficiency determinants.

The economics of sports and especially of football clubs has received increasing attention during the last years due to the high profile of the football industry, the

[1] These studies examine American Professional Leagues.

large number of spectators and the financial resources invested in professional football clubs. Despite the financial crisis (Deloitte and Touche, Football Money League 2009) European League Clubs appeared to have a revenue growth of 1 billion Euros during the period 2007–2008, while the football market grew up to 15.7 billion Euros (Deloitte and Touche, Football Money League 2010) during the period 2008–2009. This paper draws from previous research (i.e. Carmichael and Thomas 1995; Szymanski and Kuypers 2000; Dobson and Gerrard 2001) on football efficiency in order to combine financial, resource and sports data to estimate the technical efficiency of Greek clubs and identify potential determinants. Table 1 summarizes the efficiency studies of sporting organizations and particularly football clubs. Most of the works use English, Spanish, Portuguese, Brazilian and Dutch data employing DEA or Stochastic Frontier Analysis. The absence of relevant studies on Greek football clubs before and after the Euro 2004 champion is quite evident.

Football is the most popular spectator sport in Greece surpassing basketball which has admittedly accomplished more achievements at a national and club level. It is worth noting that after the Euro 2004 success, more people attend football matches and an even larger percentage watches them on TV. Based on performance in European competitions, the Greek Super League (GSL)[2] is ranked twelfth among the UEFA ranking of leagues (UEFA Clubs ranking)[3]. As a rather non-significant competitor and taking advantage of its Euro 2004 success, the GSL continuously makes attempts to achieve higher status in the European hierarchy. Note should be made that even though Greek football clubs have financial and administrative independence many operate at considerable financial losses.[4]

This paper is structured as follows. The next section presents the econometric methodology followed, while in the third section we describe the data used and the definition of the examined variables. The fourth section discusses the estimation results and the fifth section concludes.

2 Theoretical underpinnings and modelling issues

Relevant literature refers to two main approaches in measuring efficiency: the parametric-econometric approach which allows for the calculation of errors and imposes a functional form on data; and the non-parametric approach, that allows the use of multiple input and outputs. The most commonly used non-parametric technique is Data Envelopment Analysis-DEA.[5] The most significant drawback of DEA is that it does not explicitly accommodate the effects of data noise and attributes all

[2] It is fair to admit that GSL significantly lags behind leagues from Spain, Italy, France, and Germany in terms of attendance, stadiums, financial health and power.

[3] www.uefa.com.memberassociations/uefarankings

[4] The current situation in Greece favors the phenomenon that teams show fictitious losses, the majority of which are written off by the State. For example, accumulated financial losses of the top 16 teams in 2006 accounted to 204.3 million Euros, while Olympiacos, the dominant club, appears to have losses of 71.2 million Euros.

[5] For a comparative analysis of the Stochastic Frontier Approach, i.e. the main parametric method and DEA see Coelli et al. (2005).

Table 1 Review of the literature on frontier models in football and other sports

Papers	Methodological approach	Inputs	Outputs	Place
Football Clubs				
Barros and Garcia-del-Barrio (2011)	Bootstrap DEA and truncated regression	Operational costs, team payroll and total assets	Attendance receipts and other receipts	Spanish Primera division
Barros et al. (2010)	Bootstrap DEA, truncated regression	Operational costs, total assets and team payroll	Attendance, point and total receipts	Brazilian Premier League
Tiedemann et al. (2010)	Non concave metafrontier	Playing time	Goals, assists, tackle ratio, pass completion ratio	Players participating in German Bundensliga
Espitia-Escuer and García-Cebrián (2010)	Anderson and Peteresen (1993) modified DEA version	Attacking plays, number of players, minutes in possession	Goal attempts, games played	32 European football teams that participate in the Champions League
Picazo-Tadeo and Gonzalez-Gomez (2010)	DEA	Number of players, seasons in the first division, supporters that attend matches	Number of points (control variables: number of games played in European competitions and in the King's cup)	Spanish professional football League
González-Gómez and Picazo-Tadeo (2010)	Directional distance function	Number of players, average number of spectators per match, seasons played in the first division and number of trophies	Points, participation in the League (output 1) and the King's cup (output 2)	Spanish professional football League
Mathieu (2009)	DEA (CCR and BCC models)	Total wage, population	Number of point, turnover	French football clubs (Ligue1)
Barros and Garcia-del-Barrio (2008)	SFA (cost function)	Operational costs	Price of workers, price of capital premises, price of capital investment, sales, number of points and number of attendees	English Premier League

Table 1 continued

Papers	Methodological approach	Inputs	Outputs	Place
Boscá et al. (2009)	DEA, OLS as a second stage	Offensive and defensive inputs	Offensive and defensive outputs	Italian and Spanish football teams
Barros et al. (2008)	Latent class Frontier model	Operational costs	Labor price, capital price, points	English Premier League
Barros and Leach (2007)	SFA (TEEM)	Operational costs	Points, turnover and attendance	English Premier League
Guzman and Morrow (2007)	DEA, MPI and canonical correlation analysis	Staff costs, other costs	Number of point, total revenue	English Premier League
Torgler and Schmidt (2007)	Econometric models	Player performance as independent and a variety of explanatory variables covering player's Salary, Socio demographic characteristics, nationality, situation and teammates information		German Bundensliga
Garcia-Sanchez (2007)	3 Stage DEA approach	Attacking moves, passes to the penalty area and shots at goal, ball recovery and goalkeeper's actions	Points and attendance as an outcome (throughput received and scored goals)	Spanish first division
Barros and Leach (2006b)	SFA	Operational costs	Points and attendance	English Premier League
Barros and Leach (2006a)	DEA (CCR and BCC models)	Players, wages, net assets and stadium facilities	Turnover, points and attendance	English Premier League
Espitia-Escuer and García-Cebrián (2006)	DEA	Number of players, attack moves performed, ball possession, shots at goal	Points	Spanish first division
Guzman (2006)	DEA and MPI	Staff costs and general expenses	Turnover	Spanish first division (14 teams)

Table 1 continued

Papers	Methodological approach	Inputs	Outputs	Place
Ascari and Gagnepain (2007)	DEA (CCR and BCC models)	Ball possession, player and coach wages, red cards and town population	Goal, shots, points and no of victories	Spanish first division
Barros and Santos (2005)	DEA (CCR and BCC models)	Supplies and services expenses, amortization expenses, wage expenses and other costs	Match, sponsorship and membership receipts, television receipts, gains on sold players, tickets, points and financial receipts	Portuguese first division
Espitia-Escuer and García-Cebrian (2004)	DEA	First DEA (training and development) second DEA (attacking and defensive moves)	First DEA (attacking and defensive moves), second DEA success (i.e. points achieved, goals)	Spanish first division
Haas (2003a)	DEA (CCR and BCC models)	Wages, coach salary and hometown population	Points, spectators and revenue	English Premier League (20 teams in 2000/2001)
Dawson et al. (2000)	SFA (Cobb–Douglas)	Player age, goals and career goals, number of previous teams, divisional status, career experience and appearances in the previous	% of wins	English football managers (1992–1998)

Table 1 continued

Papers	Methodological approach	Inputs	Outputs	Place
Basketball teams				
Lee and Berri (2008)	SFA (Cobb–Douglas functional form with CRTS)	Regular season wins	Talent of small guards, talent of power forward and centres	NBA association clubs (2001–2003 period)
Hofler and Payne (1996)	SFA	Rebound (offensive-defensive), steals, assists, blocked shots, % of field goal and % of free throw	Team wins (actual number)	NBA association clubs (2001–2002 period)
Fizel and D'Itri (1997)	2 Stage DEA	Player talent and opponent strength	% of wins	College Teams (147 for the 1961–1980 period)
Zak et al. (1979)	Deterministic frontier model (Cobb–Douglas)	10 different variables	Ratio of final scores	NBA teams
Baseball Teams				
Depkenll (2000)	Fixed effects model	Team winning %	Salary expenditure and intra-team salary	Major League Teams (1985–1998)
Porter and Scully (1982)	LP model	Hitting and Pitching	% of wins	Major League Teams (1961–1980)
National Football League (U.S)				
Hadley et al. (2000)	Deterministic frontier model	24 Different variables	Team wins	NLF teams
Haas (2003b)	DEA (CCR and BCC models)	Player and coach wages and stadium utilization rates	Points, total revenue, number of spectators	U.S. soccer teams

the deviations from the frontier to inefficiencies being particularly sensitive to the dataset used. In addition, the produced efficiency scores are not usually normally distributed and thus cannot be analyzed with standard parameters. Finally, DEA ignores statistical elements in production and may thus be biased. In order to account for such DEA statistical limitations we use the relevant bootstrapping version that enables us to retrieve statistical properties of efficiency estimates, while producing standard errors and confidence intervals (Simar and Wilson 1998, 1999; Simar and Wilson 2000a; Simar and Wilson 2007).

For the purposes of our study we opted for the bootstrapped DEA methodology taking into consideration three additional points: firstly, our main research question requires the specification of two different cohorts, secondly the sample size of our data set is relatively sort and finally there is a "lack of consistency in findings of many studies on football efficiency" (Barros and Garcia-del-Barrio (2011)).

2.1 Data envelopment analysis

A football club $i = 1, 2, \ldots, n$ can be considered as an entity that transforms inputs $x = (x_{1i}, x_{2i}, \ldots, x_{Ni}) \in R_+^N$ into outputs $y = (y_{1i}, y_{2i}, \ldots, y_{Mi}) \in R_+^M$ under a technology set S defined as $S \equiv \{(x, y) : y \text{ are producible by } x\}$. For output-based technical efficiency scores the technology is represented by its production possibility set $P(x) = \{y \in R_+^M : (x, y) \in S\}$, while for measuring efficiency we use the output distance function defined as $D_o(x, y) = \inf\{\delta > 0 : y/\delta \in P(x)\}$.

Technical efficiency scores can be computed using a non parametric linear programming method that estimates "best practice" frontiers relative to producers' measured efficiency scores using the following linear programming formulation.

$$T\widehat{E_o(x, y)} \equiv \widehat{\theta(x, y)} = \max \left\{ \theta \,\middle|\, \theta y \leq \sum_{i=1}^{n} \gamma_i y_i ; \, x \geq \sum_{i=1}^{n} \gamma_i x_i \text{ for } \gamma_i \text{ such that } \sum_{i=1}^{n} \gamma_i = 1; \, \gamma_i \geq 0, i = 1, 2, \ldots, n \right\}$$

The estimate of $P(x)$ is the smallest convex free disposal hull that envelops the observed data and the above equation represents a variable returns to scale specification. A value of $\widehat{\theta}$ equal to unity means that point (x, y) lies on the boundary of P while values less than one imply that the relevant points lie in the interior of P, thus corresponding to inefficient units.

2.2 Bias corrected technical efficiency

As mentioned in the previous section DEA method is typically considered to be deterministic and technical efficiency (TE) scores are computed with respect to the estimated and not the true frontier; thus lacking any statistical properties or accounting for measurement error. Simar and Wilson (1998, 1999, 2000a) have recently shown that it is possible to address the problem (obtaining statistical properties) through a "bootstrap" technique. The main idea behind Simar and Wilson's seminal paper is that the known bootstrap distribution will mimic the original unknown distribution with the assumption that the known DGP is a consistent estimator of the unknown DGP. Later however, Simar and Wilson (1998, 2000b) suggested an improvement in their approach solving the following problem. Because DEA estimates a production boundary and TE scores are bounded between zero and one, the generation of bootstrap samples is not straightforward. They proposed the "smooth" bootstrap on the DEA estimates by drawing with replacement from the original Θ estimates, applying the Silverman's (1986) reflection method.

The steps in this procedure are quite simple to implement and the complete bootstrap algorithm can be summarised in the following steps:

1. Obtain the efficiency scores $\widehat{\theta_1}, \widehat{\theta_2}, \ldots, \widehat{\theta_n}$ for each football club $i = 1, 2, \ldots, n$ by solving the above mentioned linear programming model.
2. Use a smooth bootstrap to generate a random sample size of N $\theta_{\mathrm{B}1}, \theta_{\mathrm{B}2}, \ldots, \theta_{\mathrm{B}n}$ from $\widehat{\theta_1}, \widehat{\theta_2}, \ldots, \widehat{\theta_n}$ where:

$$\theta_i^* = \overline{B} + \frac{\widetilde{\theta_i}^* - \overline{B}}{(1 + h^2/\widehat{\sigma_{\theta^2}})^{1/2}} \text{ and } \widetilde{\theta_i}^* = \begin{Bmatrix} \theta_{\mathrm{B}i} - h\varepsilon_i^*, & \text{if } \theta_{\mathrm{B}i} + h\varepsilon_i^* \geq 1 \\ 2 - \theta_{\mathrm{B}i} + h\varepsilon_i^*, & \text{if } \theta_{\mathrm{B}i} + h\varepsilon_i^* < 1 \end{Bmatrix}$$

   where $\overline{B} = \sum_{i=1}^{n} \theta_{\mathrm{B}i}/n$ and $\widehat{\sigma}_\theta^2 = \sum_{i=1}^{n} (\widehat{\theta_i} - \widehat{\overline{\theta}}_i)^2/n$, h is the smoothing parameter of the kernel density estimate of original efficiency estimates, and $\varepsilon_i^*, i = 1, 2, \ldots, n$ are random draws from the standard normal. Note that h is chosen via maximizing the likelihood cross-validation function and using reflecting method described by Silverman (1986).
3. Compute the bootstrap estimate of technical efficiency for each club $i = 1, 2, \ldots, n$ using the ratio $\widehat{\theta_i}/\theta_i^*$.
4. Resolve the original DEA model using the adjusted outputs to obtain $\widetilde{\theta}_k^*$
5. Repeat step (2)–(4) to obtain a set of estimates i.e. each football club will have B estimates of Θ. In the present analysis 2,000 samples were generated for each club.

Bias corrected estimates of original technical efficiency scores are derived through $\widetilde{\theta_i} = \widehat{\theta_i} - \widehat{bias}_i, \widehat{bias}_i = \frac{1}{B}\widehat{\theta}_{iB}^* - \widehat{\theta_i}$.

2.3 Truncated regression to account for environmental variables

Being consistent with the purpose of this paper we account for the impact of environmental variables on efficiency using the following procedure. We assume that the efficiency scores $\widehat{\theta_i}$ can be regressed on a vector of environmental variables z_i that affect club's efficiency, a vector of estimated parameters β_i and some statistical noise ε_i according to the following equation.

$$\widehat{\theta_i} = \beta_i z_i + \varepsilon_i \tag{1}$$

At this stage we follow Simar and Wilson (2007)[6] procedure to estimate the above equation. According to Simar and Wilson (2007, p. 41) estimating (1) arises from the violation of the regression assumption for the independency between ε_i and z_i creating correlation and dependency problems for the efficiency scores. For this reason we strictly follow their approach estimating Eq. (1) using a truncated regression. The bootstrap algorithm is described below:

1. Use the original data to compute $\widehat{\theta}_i$ by the DEA method for each club $i = 1, 2, \ldots, n$.
2. Use the ML method to obtain the parameter estimates $\widehat{\beta}, \widehat{\sigma}$ from the truncated regression.
3. Now loop over the next four steps B times to obtain a set of bootstrap estimates.
   3.1 For $i = 1, 2, \ldots, M$ draw ε_i^* from $N(0, \widehat{\sigma}_\varepsilon)$ with left truncation $(1 - \widehat{\beta}' z_i)$
   3.2 Then compute the following equation $\theta_i^* = \widehat{\beta}' z_i + \varepsilon_i^*, i = 1, 2, \ldots, M$
   3.3 Set $x_i, y_i^* = y_i \widehat{\theta}_i / \theta_i^*$, $\forall i = 1, 2, \ldots, M$
   3.4 Compute $\widehat{\theta}_i^* = \theta_i(x_i, y_i)$, $\forall i = 1, 2, \ldots, M$ replacing (x_i, y_i) with (x_i^*, y_i^*).
4. Compute the bias-corrected estimator using the bootstrap estimates and the original estimates.
5. Estimate the truncated regression of $\widehat{\widehat{\theta}}_i$ on z_i using the maximum likelihood (ML) method.
6. Repeat the next three steps B_1 times to obtain a set of estimators.
   6.1 For $i = 1, 2, \ldots, M$, ε_i is drawn from $N(0, \widehat{\widehat{\sigma}}_\varepsilon)$ with left truncation $(1 - \widehat{\widehat{\beta}}' z_i)$.
   6.2 For $i = 1, 2, \ldots, M$ compute $\theta_i^{**} = \widehat{\widehat{\beta}}' z_i + \varepsilon_i^{**}, i = 1, 2, \ldots, M$
   6.3 The ML method is used again to estimate the truncated regression of θ_i^{**} on z_i providing $\widehat{\widehat{\beta}}', \widehat{\widehat{\sigma}}_\varepsilon$ estimates.
7. Construct the confidence intervals for the efficiency scores.

3 Data and variables definition

The sample of our study consists of data from 14 football clubs[7] participating in the Greek Super League over the period 2000–2008. In order to examine the effect of the Euro 2004 victory on the performance of Greek football clubs, the 8-year-period has been divided into two 4-year intervals—before, and after the Euro 2004 victory, that is 2000–2004 and 2005–2008 respectively. At the same time we averaged all constructed variables over the 4-year periods to avoid the well-recorded fluctuations of financial data due to business cycles (Tsekouras et al. 2008).

Our dataset is formulated using three different distinct sources. The first comprises all financial data extracted from the ICAP database. The annual directories of ICAP,[8]

[6] Simar and Wilson (2007) in their paper proved that the currently, until then, method of Tobit regression was inappropriate for the estimation of technical efficiency scores. They proposed the use of truncated regression with bootstrap.

[7] Participating for at least two seasons in the examined period.

[8] The annual ICAP directories provide key production, employment and financial information from the published balanced sheets of nearly all Plc and Ltd. firms operating in all sectors of economic activity in Greece.

a private financial and business information service company, part of the AMADEUS[9] database, provide financial information from the published balance sheets of football clubs. The second source of information is the Galanis Sport Data[10] which provides computerized coverage of all football events and contains all statistical scores for the clubs that competed in the Greek Super League over the abovementioned period. Finally, additional data concerning clubs athletic achievements and other variables have been collected from the official website of the Hellenic Football Federation[11] and the clubs' websites.

The identification and selection of inputs and outputs is a particularly crucial issue in any efficiency analysis, and the same applies for the case of Greek football clubs, since it is difficult to distinguish a football club's objectives and means (Borland 2006). In this study we employed two criteria in order to cope with the abovementioned issue. We firstly looked into relevant literature that had previously identified an appropriate input/output mix for representing true technology (Table 1 presents the majority of relevant studies) taking into consideration data availability issues.[12] Secondly, we decided upon several Wilcoxon signed rank tests which we performed for alternative specifications of inputs and outputs. Note that our approach follows Szymanski and Smith's 1997 argument that bad budgetary balances in the majority of clubs cancel out their profit maximization behaviour—this also follows Guzman and Morrow's (2007) approach who take into account financial as well as sporting success for clubs participating in the Spanish League.

For the calculation of the bootstrapped DEA scores we consider as club inputs the total players' transfer expenses and contract renewals (*PLEXREN*) as well as other operational costs (*OPCOSTS*). The input (*PLEXREN*) constitutes the major proportion of clubs' total expenses which is consistent with Szymanski and Kuypers's (2000) theory on the relationship between players and clubs' success (Barros and Garcia-del-Barrio 2011; Barros et al. 2009; Guzman and Morrow 2007). The second variable (*OPCOSTS*) although not directly related to field success, is crucial in terms of running the activities of a club (Barros et al. 2009; Barros and Leach 2007, 2006a; Guzman and Morrow 2007).

On the output side, the points (*POINTS*) that each club gathers and total attendance (*ATTED*) were used to approximate clubs' output productivity. The number of points is a measure of a club's sports achievement as football clubs compete for the champion and access to the Champion and European League or for the relegation (Barros and Garcia-del-Barrio 2011; Picazo-Tadeo and Gonzalez-Gomez 2010; Barros et al. 2008, 2009; Espitia-Escuer and García-Cebrián 2006). Moreover, the (*ATTED*) variable fulfils club's objective of increasing revenues and attracting more fans (Barros

[9] The AMADEUS database contains comprehensive information on over 15 million companies across Europe including financial, corporate structure and other business intelligence.

[10] For more information see http://www.galanissportdata.gr.

[11] Note that 18 football clubs participated in the GSL in the 2000–2001 period and only 16 in the period 2001–2002. Thereafter over the examined period 2002–2008 the GSL involves 16 football clubs.

[12] Even though relevant studies use additional variables such as players or coach salaries (Késenne 2000), this was not feasible in our case due to data limitations.

et al. 2009; Barros and Leach 2007, 2006b; Haas 2003a). The input variables were deflated using the wholesale price index with 1999 as a base year.

The additional variables used to capture possible factors affecting the efficiency scores can be grouped into three categories. The first category includes variables which depict clubs financial strength and consequently their overall business performance (Davidova and Latruffe 2007). As such, we have used the profit margin (*PRMRG*) (Szymanski and Smith 1997) which is defined as the ratio of net profits to the firm's turnover and the financial exposure intensity (*FEXP*) which in turn is captured by total assets to debt ratio. The second group of the inefficiency factors involves variables that reflect a club's attitude towards the underlying knowledge conditions (Nelson and Winter 1982) that shape its dynamic capabilities (Teece and Pisano 1994). In this category, we have included the club's age (*AGE*) as a proxy for the accumulated knowledge which entails learning by doing effects and may thus affect its productive performance. In addition, we used a dummy variable for the club's location (*LOC*) to capture the effects of agglomeration and urbanization externalities. This variable takes the value of 1 if the club is established in the broader Athens region and 0 otherwise (Castellanos-Garcia et al. 2007). Finally, the third group of variables comprise variables that refer to the club's football performance. As such, we have used the ratio of goals that each club achieves over and above the received goals (*GOALRATIO*) (Dawson et al. 2000). It should be noted that we also considered a number of additional variables in the context of the previous three categories (e.g. fixed to total assets, profitability, total assists, kicks inside the penalty, shots and headers); however their inclusion was not found to improve the econometric performance of our model. Basic descriptive statistics of the variables used for the empirical analysis of our study are presented in Table 2.

4 Results and discussion

As discussed in Sect. 1, our study examines Greek football clubs' efficiency before and after the Euro 2004 victory, thus implying the existence of two technology sets. In this section, we present our empirical findings of a two-stage analysis. We firstly derive and compare technical efficiency scores for Greek clubs between the examined periods, and secondly, we investigate a number of factors that are likely to affect clubs' performance in the time periods under study.

4.1 Characteristics of the frontier

The bootstrapped efficiency scores have been calculated with PIM-DEA professional version V2.0 (Thanassoulis and Emrouznejad 2004). Table 3 reports the bootstrapped technical efficiency scores of Greek football clubs during the two distinct periods 2000–2004 and 2005–2008. The first two columns of Table 3 provide the original DEA efficiency scores for the two periods, the third and the fourth column the corresponding DEA bootstrapped efficiency scores, the fifth and the sixth column the bias correction and the last four columns present the lower and upper bound of the DEA bootstrap confidence intervals.

Table 2 Descriptive statistics of the used variables

	Mean		SD		Min		Max	
	2000–2004	2005–2008	2000–2004	2005–2008	2000–2004	2005–2008	2000–2004	2005–2008
Inputs								
*OPCOSTS**	16,118	19,601	16,007	12,391	0,175	0,170	13,878	42,250
PLEXREN	8,959	9,521	13,053	12,314	0,225	0,312	3,995	3,587
Outputs								
POINTS	43	42	14	14	28	23	70	68
ATTED	102720	118332	112607	121780	15375	16530	336180	362940
Second stage variables (truncated regression)								
PRMRG	−26.181	−2.030	95.599	8.626	−358.98	−31.854	5.291	2.734
FEXP	1.653	1.737	0.612	1.362	0.795	0.719	2.682	5.410
LEVER	1.832	0.988	1.812	1.727	0.514	−1.994	3.959	6.193
GOALRATIO	1.249	1.213	0.761	0.718	0.307	0.533	2.891	2.724
AGE	70.107	73.14	23.969	24.31	34.5	36.5	111.5	115
LOC	0.571	0.572	0.414	0.424	0	0	1	1

* Operational costs and total expenses for contracts and renewals are reported in million Euros

Table 3 Bootstrapped Efficiency results

Football clubs	DEA efficiency score		Bootstrap DEA efficiency score**		Bias		Bootstrap DEA LB		Bootstrap DEA UB	
	2000–2004	2005–2008	2000–2004	2005–2008	2000–2004	2005–2008	2000–2004	2005–2008	2000–2004	2005–2008
AEK F.C	1.000	1.000	0.934	0.859	0.066	0.140	0.789	0.782	0.998	0.997
EGALEO F.C	0.787	0.871	0.752	0.849	0.035	0.021	0.685	0.813	0.786	0.869
A.KALAMARIAS	0.864	0.894	0.825	0.848	0.038	0.046	0.739	0.722	0.861	0.892
ARIS F.C	1.000	0.842	0.936	0.800	0.064	0.042	0.806	0.722	0.999	0.838
IRAKLIS F.C	0.892	1.000	0.865	0.935	0.026	0.065	0.822	0.799	0.887	0.998
IONIKOS F.C	0.772	0.610	0.740	0.593	0.032	0.017	0.679	0.555	0.769	0.609
KALITHEA F.C	1.000	0.594	0.932	0.570	0.068	0.023	0.798	0.490	0.998	0.593
OLYMPIAKOS F.C	1.000	1.000	0.675	0.748	0.324	0.252	0.506	0.790	0.790	0.998
OFI F.C	0.808	1.000	0.774	0.906	0.033	0.093	0.709	0.614	0.804	0.998
PANATHINAIKOS	1.000	0.969	0.865	0.871	0.135	0.097	0.717	0.506	0.993	0.966
PANIONIOS G.S.S	1.000	1.000	0.935	0.900	0.065	0.100	0.791	0.566	0.999	0.998
PAOK F.C	1.000	0.891	0.945	0.855	0.054	0.035	0.847	0.774	0.998	0.888
SKODA XANTHI F.C	0.813	1.000	0.793	0.964	0.020	0.036	0.748	0.921	0.814	0.988
CHALKIDONA F.C*	1.000	1.000	0.935	0.879	0.065	0.121	0.797	0.771	0.999	0.999
AVERAGE	0.924	0.905	0.851	0.827	0.078	0.827	0.745	0.597	0.907	0.902
STDEV	0.095	0.140	0.091	0.116	0.063	0.064	0.086	0.132	0.099	0.140

* Atromitos merged with Chalkidona FC and took their place in Greek Super League

** A Mann-Whitney test of hypothesis accepts the null hypothesis that there is no difference in bootstrap TE scores for the two periods

Table 4 Team's ranking and their bootstrapped efficiency scores between the two periods

Football clubs		Ranks in the League (best and worst place)		Firm's technical efficiency behavior after Euro 2004
2000–2004 Period	2005–2008 Period	2000–2004	2005–2008	
AEK F.C (1)*	AEK F.C (7)	2–3	2–3	Decrease
EGALEO F.C (12)	EGALEO F.C (9)	5–10	6–15	Increase
A.KALAMARIAS (9)	A.KALAMARIAS (10)	15	9–16	Increase
ARIS F.C (3)	ARIS F.C (11)	6–13	4–14	Decrease
IRAKLIS F.C (7)	IRAKLIS F.C (2)	5–7	4–13	Increase
IONIKOS F.C (13)	IONIKOS F.C (13)	6–14	10–16	Decrease
KALITHEA F.C (6)	KALITHEA F.C (14)	12–13	9–15	Decrease
OLYMPIAKOS F.C (14)	OLYMPIAKOS F.C (12)	1	1–2	Increase
OFI F.C (11)	OFI F.C (3)	8–12	7–13	Increase
PANATHINAIKOS F.C (8)	PANATHINAIKOS F.C (6)	2–3	1–3	Increase
PANIONIOS G.S.S (4)	PANIONIOS G.S.S (4)	5–9	5–11	Decrease
PAOK F.C (2)	PAOK F.C (8)	4	5–9	Decrease
SKODA XANTHI F.C (10)	SKODA XANTHI F.C (1)	5–10	4–11	Increase
CHALKIDONA F.C (5)	CHALKIDONA F.C (5)	7	8–17	Decrease

* In parenthesis team's ranking according the bootstrapped efficiency scores is refereed

From the first 2 columns it becomes apparent that eight clubs for the period 2000–2004 and seven clubs for the period 2005–2008 are found to lie on the frontier achieving a technical efficiency score equal to one. However, when considering the bootstrapped results none of the previous football clubs appear to be close to the frontier, while the average technical efficiency score is significantly lower. This result is in accordance with Simar and Wilson (1998) who seriously question the traditional DEA in providing accurate efficiency scores.

The most striking result is that the technical efficiency[13] of Greek football clubs after the Euro 2004 victory is lower than before (a reduction of 2.82 % has occurred). This result implies that the "average" distances to the production possibility frontier decrease during the second period although the opposite may be anticipated. However, this is an average trend that does not apply to every case. More specifically, Greek football clubs that compete for the National Champion and the Champion League places[14] are found to increase their technical efficiency, while clubs that compete for places which lead to the UEFA Cup[15] (now Europa League) exhibit lower bootstrapped technical efficiency after the Euro 2004 victory. Finally, a mixed behaviour for remaining clubs is observed (see Table 4). Our results may indicate that after the Euro 2004 vic-

[13] Technical efficiency scores have been calculated by the average of each input and output variable separately for periods 2000–2004 and 2005–2008.

[14] Commonly these clubs are Olympiacos and Panathinaikos.

[15] Such clubs include AEK F.C, PAOK F.C, ARIS F.C,IRAKLIS F.C and PANIONIOS G.S.S

tory, the average Greek football club followed a path of higher expenditures on players, coach and infrastructures relative to the preceding years. It has actually been observed that clubs (mostly the larger) after the Euro 2004 have a tendency to acquire highly paid players, as reflected in their balance sheets where players' salaries represent the largest ratio of expenditure.

But to which extent are the bootstrap DEA results different between the two periods? The existence of such differentials is tested using the non-parametric Mann-Whitney test. Testing the hypothesis that the technical efficiency scores are not different between the cohorts yields a p value of $0.086 < 0.05$ ($Z = -2.946$) leading us to accept the null hypothesis. We thus conclude that there is no significant difference in our efficiency results between the two periods. Furthermore, a Kernel[16] distribution illustrated in Fig. 2 reveals that the efficiency scores after the Euro 2004 victory are lower and more dispersed than those in the previous period.

An interesting feature for this study derives from Fig. 1. In Fig. 1 we tried to identify, if present, a typology concerning the Greek football clubs combining average bootstrapped TE scores before and after the 2004 victory. However, as we can observe from the scatter plot the formation of possible groups is unsubstantial and invalid since a mixed behavior for the majority of Greek clubs is present. The competitors of the Greek champion (Olympiakos F.C and Panathinaikos F.C) appear with relative low scores while clubs that compete for places which lead to the Europa cup or for the relegation come along with relatively high scores. Thus, we should note that the formation of groups using Fig. 1 is, at least from this point of view, non sensible (Fig. 2).[17]

Surprisingly the bootstrapped efficiency scores reported in Table 3 show that the Greek sportive champions are not the most efficient clubs in GSL; a finding that is not confirmed by the standard DEA results. This result does not agree with many relevant studies which find a positive relationship between efficiency scores and sport achievements (Barros and Leach 2006a; Haas 2003a). A possible explanation could be provided on the basis of a general over-investment in big clubs (namely Olympiacos F.C, Panathinaikos F.C, and AEK F.C) that generated a disanalogous turnover with respect to the resources they engaged. In addition, small clubs (i.e ARIS F.C) that compete for 5–8 places, in the middle of the Greek champion appear to use their resources more efficiently than their larger competitors. Moreover Olympiacos F.C, the winner in the last seven out of the eight Greek champion, appears to achieve quite a low technical efficiency and a relatively high score (refer to Fig. 1). This finding may be related to the strategic orientation of Olympiacos F.C according to which this club aims at succeeding not only in the Greek League but also in the Champions League employing more and better players (Espitia-Escuer and García-Cebrián 2010). As a result, Olympiacos F.C would become inefficient when only variables representing

[16] A Gaussian Kernel function was used in all density estimations. Our estimation using alternative functions (i.e uniform, epanechnicov) provided similar results to those obtained by Gaussian. For our estimation, we used the STATA 10 software. The optimal bandwidth provided by STATA minimizes the Mean Integrated Squared Error if a Gaussian Kernel function is used and varies between 0.01 and 0.04.

[17] We owe this to an anonymous referee's comment.

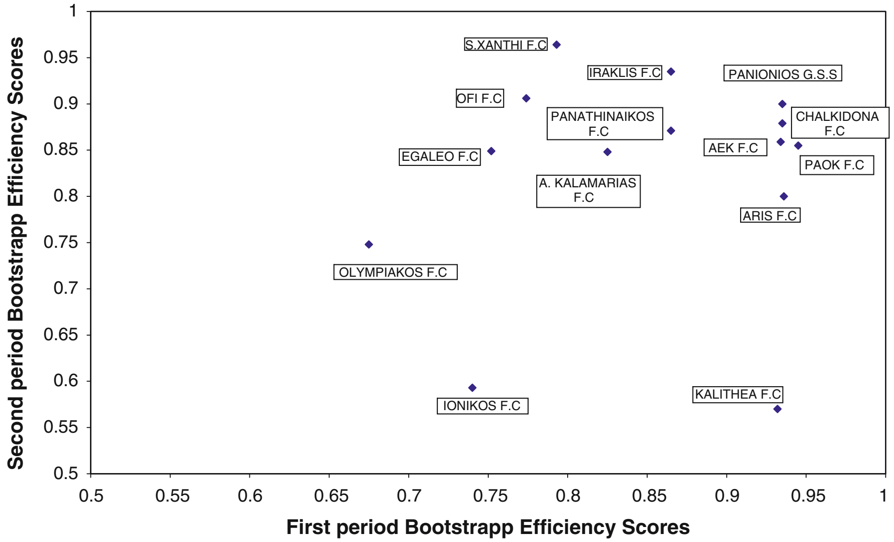

Fig. 1 Scatter plot of club's bootstrap technical efficiency between the two periods

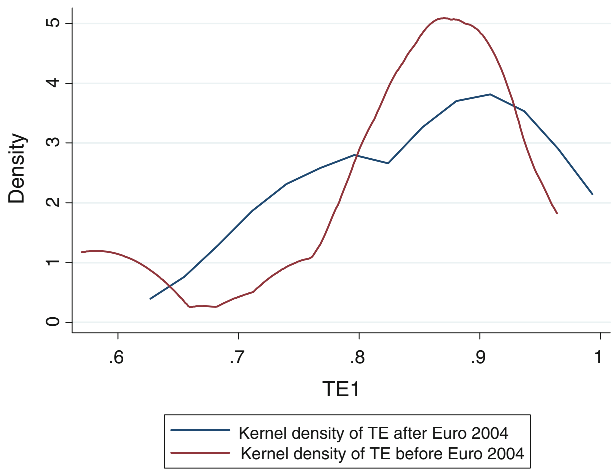

Fig. 2 Kernel Densities of bootstrap TE for football clubs before and after Euro 2004

national outputs are taken into account (Haas 2003a). The same applies to the other large competitor in the Greek champion–Panathinaikos F.C.

Interestingly and contrary to Mathieu's 2009 study on the French Football League results we can assume that a significant pattern for firms that compete in the Greek champion does not exist independently of their strategic orientation. Our findings furthermore imply that clubs which are similar in terms of asset configuration, size, management, budget operations, operational strategies and orientation appear to have different performance variances. In this case, the application of the strategic group theory (Caves and Porter 1977) that explains the performance differences between

Table 5 Truncated second stage regression results

Variable	Coefficient	t-statistic	95 % Confidence interval	
			LB	UB
First period 2000–2004				
Constant	0.754	11.71*	0.628	0.881
FEXP	−0.159	−1.77**	−0.336	0.017
GOALRATIO	0.188	1.91*	−0.004	0.381
LOC	−0.036	−0.63	−0.149	0.004
$Log - L$	18.964			
$Wald\mathrm{X}^2$	7.85			
$N = 14$				
Second Period 2005–2008				
Constant	0.676	4.47**	0.380	0.973
AGE	0.002	1.65**	−0.000	0.006
LOC	−0.111	1−.79**	−0.233	0.010
FEXP	−0.005	−1.71**	−0.107	0.095
$Log - L$	16.377			
$Wald\ \mathrm{X}^2$	7.43			
$N = 14$				

* One and two asterisk indicates significance at the 5 and 10 % levels correspondingly

groups of clubs within the same industry is not valid. We therefore note that State and football authorities need to be both aware and cautious on what type of policies should be designed and implemented for football clubs when aiming for their improvement.

4.2 Examining the efficiency factors

The second stage results of our analysis[18] presented in Table 5 suggest that in general different factors affect the bootstrapped technical efficiency scores in the two cohorts. There is however a variable, namely club's financial exposure ($FEXP$) which exhibits similar behaviour in both periods. This factor negatively affects clubs' technical efficiency indicating that field success and financial performance are interrelated. Based on this result, it can be argued that debts negatively influence a club's technical efficiency justifying the agency theory argument (Davidova and Latruffe 2007). This result emphasizes the importance of football clubs financial health and sustainability in the long run and is applicable in many cases apart from the Greek league (Barros and Garcia-del-Barrio 2008; Barros and Leach 2006b).

For the first period from 2000 to 2004, our results reveal that the variable of goals ratio (*GOALRATIO*) positively affect clubs' technical efficiency implying that the

[18] We are aware of two studies examining factors that may influence teams' efficiency using a two stage analysis; one on the Spanish football clubs (Barros and Garcia-del-Barrio 2011) and another on the Brazilian football league (Barros et al. 2010)

number of goals obtained influences their sporting behaviour (Dawson et al. 2000; Garcia-Sanchez 2007). This specific finding seems to confirm Barros et al. (2010) and Sala-Garrido et al. (2009) studies concerning the Brazilian and Spanish leagues, showing a positive relationship between clubs' efficiency and pitch results. On the other hand, it is quite surprising to observe that, location (LOC) has no statistical effect on clubs' technical efficiency as noted by Barros et al. (2010) regarding the Brazilian football league.

Concerning the second period under examination, the attitude of football clubs towards knowledge accumulation and agglomeration economies seems to affect bootstrapped technical efficiency in a rather interesting way. According to the "Resource-Based View" (Penrose 1956) clubs' age is found to positively affect clubs' efficiency. This finding indicates that older football clubs gain experience in productivity from learning by doing effects and hence become more efficient than their younger counterparts. On the other hand, the negative sign of (LOC) variable implies an efficiency loss due to the economies of agglomeration. The latter suggests that clubs located in the broader Athens area are not more efficient than others located in other regions, although the GSL structure and the ranking of the participating clubs reflect the city effects.

These results are actually in line with the Resource Based Theory (Penrose 1956; Barney 1991; Rumelt 1991) according to which organizational structure and strategic management practices are the main sources of heterogeneity (Penrose 1956) in different football clubs performance. The intra-firm resources can be tangible (financial and physical factors of production) or intangible (age, networks that operate as channels) reflecting the firm's core competences (Prahalad and Hamel 1990). Moreover, our findings seem to agree with studies from the Spanish (Barros et al. 2010) and English (Espitia-Escuer and García-Cebrián 2006) premier leagues recognizing heterogeneity as an underlying cause of clubs' performance differences or arguing on the efficient use of clubs' resources in the Champions league as a means to achieve good results (Espitia-Escuer and García-Cebrián 2010). The specific result of this study highlights and generalizes the fact that common policies are not always the correct strategy in improving football clubs efficiency. In contrast, individual policies taking into account clubs specific characteristics may be prescribed to account for heterogeneity.

5 Conclusions

To the best of our knowledge, this study is a first attempt to examine in a systematic way the performance of Greek clubs in football champion. Based on the Greek football supporters' point of view it was probably expected that the victory of the Greek National club in the Euro 2004 would improve clubs' performance. Increased expenditure for transfers, signing contracts with better footballers and coaches, larger shares/revenues from TV rights and the employment of managers to improve clubs' operational ability were expected to create new prospects for the Greek champion and the participation of Greek clubs in the Champions and Europa league. Moreover, the establishment of the Super League and governmental promises for new stadiums and infrastructure generated great expectations for the creation of more competitive Greek clubs in Europe. On the other hand, the opposers of this rationale seriously questioned the above argument supporting the idea of inefficient resource allocation due to the unexpected shock of the Euro victory.

Based on the 2000–2008 season, we compute bootstrapped technical efficiency scores of clubs in the GSL, over two different periods taking into account the period before and the period after the Euro 2004 victory. In a second stage of analysis, we use a truncated regression to identify possible factors that affect clubs' efficiency in the above-mentioned periods.

The main policy implication of the preceding pages is that football clubs did not improve their technical efficiency after the Euro 2004 victory, suggesting a different model of development based on investments in physical assets of sport production. Furthermore, examining the significant variation in clubs' efficiency scores along with their ranking in the league does not support the idea of clubs having similar business models or similar strategic characteristics in the Greek champion. Overall, football authorities should be very skeptical in taking into account an athletic success in order to schedule and improve the standards of clubs, referees, players and sport clubs administration. Thus, public policies aiming at improving performance of football clubs ought to take into account characteristics such as the number of clubs that participate in the specific country National League, the size of football clubs compared to European competitors, their financial situation, their level of operation, structure and strategic orientation.

Second stage regression results reveal that financial exposure intensity was the main determinant of clubs' technical efficiency which negatively affected clubs performance in both examined periods. Thus, their asset to debt ratio was not expected to serve to the full extent the aim of clubs performance in terms of point and spectators gathering. The specific finding highlights the fact that, at least in the Greek case, economic objectives are of most importance. The development of policies to overcome identified inefficiencies should aim at improving clubs' financial stability by providing subsidies to improve their infrastructures (for example, creating new stadiums), accelerating the restructuring of the football league for a more competitive champion and finally, adopting a legal framework aimed at preventing financial deficits of Greek clubs including the embroilment of tax debts.

With respect to other efficiency correlates, considerable differences are found between the examined periods. While in the first period clubs' technical efficiency appears to be affected in a positive way by the number of goals ratio, clubs' performance in the second period seems to be affected by accumulated knowledge, indicating that clubs located in the Athens area are not able to use their resources more efficiently than their counterparts who are located in other Greek regions.

To sum up the empirical evidence provided in the present study, it is evident that the technical efficiency of Greek clubs appears to be specific to the resources of each club in terms of financial, individual and sport characteristics. Public policy initiatives should thus focus on the development of benchmarks in order to improve their financial stability and operational management.

The main limitations of this work concern the range of the examined years and the variables used in the first and second stage of analysis. Moreover, the present study points to interesting directions for further research including the application of this analysis to other countries which compare to Greece in size, and the consideration of potential technology heterogeneity based on country-specific characteristics.

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