INTERDEPARTMENTAL PROGRAMME OF POSTGRADUATE STUDIES (I.P.P.S.) IN ECONOMICS (MASTER IN ECONOMICS)

Thesis Title: *"ANALYZING THE OPERATING EFFICIENCY OF GREEK FOOTBALL CLUBS"*

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Abstract

Several recent papers on Football Clubs performance evaluation tend to focus on their athletic performance and in particular, on examining separately their offensive and defensive operation because this way provide a more detailed picture about their on-field performance. Along these lines, the present study analyses the athletic/on-field performance of Football Clubs in Greek league, using data from ten consecutive seasons (1998/99 to 2007/08), by applying a two-stage DEA. In the first stage, the offensive and defensive operations are evaluated and then (in the second stage), the corresponding efficiency scores are introduced as inputs to account for the final ranking of each team in every season. For the analysis of offensive operation, goals scored are used as an output and the number of shots and headers, crosses and assists as inputs. For the analysis of defensive operation, the inverse of goals conceded is used as an output and the number of saves, clearances and steals as inputs. In the second stage, the accumulated points at the end of season are used as an output, whiles the efficiency scores of its offensive and defensive operation (obtained from the first stage) are used as inputs.

The results indicate that in the Greek league there seems to be more room for improving defensive rather than offensive efficiency, as the mean efficiency of the former was estimated at almost 60% and of the latter at almost 84%. In addition, Football Clubs seem to be more homogeneous in terms of their offensive rather than their defensive operation. As a result, it seems that defensive errors modulate the final result in most of the football matches and thus, for a team to get a better ranking requires improvement of defensive efficiency. On the other hand, it was found that the relative offensive and defensive efficiency accounts on average for almost 80% of season's accumulated points by each team. Moreover, there seem to be no changes over time in the upper tale of the performance effectiveness scores distribution, implying the group of highly qualified teams remained unchanged over the period under consideration.

Keywords: Efficiency; Effectiveness; DEA

CHAPTER ONE

INTRODUCTION

1.1 Sports economics in retrospect

Since the beginning of the 1950s, research on the economics of professional team sports has received a continuously increasing attention. Mainly, this has been due to the great popularity of the industry, its permanently growing financial magnitude, the strong emotional bonds of many economists with this field and its unprecedented structure, in which the uncertainty about the outcome and the competitiveness among the participants are usual phenomena. As a result, sporting contests and tournaments offer economists an opportunity to study over a wide range of subjects ranging from consumer's theory to labour economics and industrial organization.

Rottenberg (1956) first developed the idea of a sporting production function for major-league baseball, where individual player's performance were used as inputs and team performance was considered as output. Scully (1974) provided the first empirical results for this model followed by Zech (1981). Other applications include, for example, Scott et al. (1985) for basketball, Atkinson et al. (1988) for football, Schofield (1988) for cricket, Carmichael and Thomas (1995) for rugby and Carmichael et al. (2000) for soccer (European football).

According to the authors of the latter paper, sporting production function studies have been almost entirely US based concentrating largely on baseball. Mainly due to a shortage of statistics, there have been few studies of other sports with that of association football being a considerable omission given the sport's international appeal and coverage. [1]

[1] This section is partly based on the papers of Dawson et al. (2000a) and Carmichael et al. (2000).

1.2 Problem setting

European football is a competitive sport with two teams of eleven (11) players. In order to win, a Football Club should score more goals than its opponent during the ninety (90) minutes of a match. The Greek national football league that is considered in the present study requires each of the participating clubs to play against all others twice (once in its home field and once away in the opponent's home ground) during a single football season. According to the point system assigned by the league regulations, victories are rewarded with three, draws receive one and defeats receive no points. The more times a team wins, the more points it obtains and the championship winner is the club that at the end of the season has accumulated the most points. Except from being a champion, there are additional incentives for a team to obtain more points, as better ranking is rewarded with the chance to play in next season's European competitions. On the other hand, the worse placed clubs are relegated and obligated to play in an inferior national league in the next season.

The multifaceted nature of a football game has traditionally been difficult to quantify in Greece until the advent of the Galanis spots data company in 1998. The data used in this study was obtained from the company's website *www.galanissportsdata.com* and is based on match by match statistics for the period 1998-2008.

Except from providing information for each match as well as aggregated over the season for each player and team, Galanis sports data company works also (with the use of specialized constructed indices) on the teams' and players' ranking according to their offensive and defensive operation as well as their general athletic/on-field performance.

Among other indicators presented in the aforementioned website, the index "Goals Scored/Total Shots & Headers" provides a partial measure of a team's efficient offensive play. Similarly and within the scope of the present study, two additional indices have been constructed in order to provide partial measures of a team's efficient defensive play (Goals Conceded/Total Opponent's Shots & Headers) and effective athletic/on-field performance (Goals Scored/Goals Conceded). [2]

[2] Due to brevity, the alternative measures rankings are presented in tables 1-6 of the appendix.

From table 1.2.1, it becomes obvious that the average (of the ten-year period) value of the correlation between teams' official final ranking and the alternative measure's ranking of their athletic/on-field performance is really significant (90%). This can be easily justified by the fact that it is very common for a football team, which scores more goals and at the same time concedes fewer than others, to obtain also the most points.

Additionally, it can be observed that: firstly, it is the level of efficient offensive function that results in victories and points and secondly, almost three out of ten teams score a lot and concede few goals at the same time. The former statement is supported by the fact of the higher average values of the correlation between points and the alternative measure of efficient offensive operation as well as the correlation between the alternative measures of both the efficient offensive operation and the effective athletic/on-field performance of teams (69% and 71%, respectively) in relation to the corresponding numbers concerning the efficient defensive operation (60% and 59%, respectively).

Furthermore, it should be noticed that teams conceding the minimum number of goals are ranked among the first positions of the alternative measure of efficient defensive operation ranking. Accordingly, the negative value of the correlations between final teams' ranking and alternative measure of efficient defensive operation, alternative measures of efficient defensive and offensive operation, as well as alternative measures of efficient defensive operation and effective athletic/on-field performance can be easily justified.

Unfortunately, these alternative measures often turn out to be misleading because they aim at the quantitative dimension of a production process without including the necessary operating cost (here, in terms of the effort made). In other words, these indices tend to reward only the better ranked teams that perform effectively (score lots of goals and concede only a few). As a consequence, discrimination in favor of the wealthier teams (which sometimes spend a fortune in order to obtain better results) actually exists.

Table 1.2.1: Correlations between alternative measures and final teams' rankings [3]

	Average
Points & GC/TOS [4]	-0.60
Points & GS/TS [5]	0.69
Points & GS/GC [6]	0.90
GC/TOS & GS/TS	-0.34
GC/TOS & GS/GC	-0.59
GS/TS & GS/GC	0.71

Source: www.galanissportsdata.com, own calculations.

Furthermore, the inadequacy of these indicators lies in the fact that they concentrate one-sidedly to just a single resource, which is "Total Shots & Headers" as well as "Total Opponent's Shots & Headers", in order to describe the operating efficiency of the offense and defence, respectively. Nevertheless, these two operations comprising a club's main production process include several inputs in order the output (victory) to be obtained.

From the point of view of managing any organization, the establishment of the relationship between the inputs used in production and their relative contributions to output is of primal importance (Carmichael et al., 2000). Football Clubs, that can be analysed like any other Decision Making Unit (DMU), having at their disposal a certain level of abilities and skills try to score goals by offensive actions and at the same time to prevent opponents from scoring by defensive moves (Garcia-Sanchez, 2007).

Therefore, estimating the efficiency of a team's offensive operation means to analyze the relationship between its players' attacking moves and the goals scored (i.e., the relative contribution of inputs such as the number of shots and headers, crosses and assists to the aforementioned output), while estimating the efficiency of a team's defence means to analyze the relationship between its players' defensive actions and the inverse of goals conceded (i.e., the relative contribution of inputs such as the number of saves, clearances and steals to the aforementioned output).

[3] For further details, see table 20 of the appendix.

[4] Goals Conceded/Total Opponent's Shots & Headers.

[5] Goals Scored/Total Shots & Headers.

[6] Goals Scored/Goals Conceded.

The objective of the present study is to estimate the operating efficiency of the offense and defence as well as the athletic/on-field performance effectiveness, which is the transformation of on-field effort into accumulated points, of the teams participating in the first division of Greek professional league during the period 1998 to 2008. For this purpose a two-stage DEA (Data Envelopment Analysis) approach is applied.

In the first stage, the offensive and defensive operations are evaluated and then (in the second stage) the corresponding efficiency scores are introduced as inputs to account for the final ranking of each team in every season. So, the technical efficiency of Football Clubs in different operations (defensive and offensive) is related to the sport performance of them, i.e., the number of points obtained along a season (Bosca et al., 2009). Several recent papers on Football Clubs performance evaluation (e.g., Garcia-Sanchez, 2007; Bosca et al., 2009) tend to focus on their athletic performance and in particular, on examining separately their offensive and defensive operation because this way provide a more detailed picture about their on-field performance.

The final results of the present work should reward the technically efficient Greek football teams, determine the problems facing the inefficient clubs and propose specific norms in order these inefficiencies to be tackled. Additionally, a rather crucial question should be answered: which qualities (offensive or defensive) of a Football Club are the more influential in winning the Greek league considering that Carmichael and Thomas in their research paper (2005) indicated that the success of the Greek national football team (which was announced EURO 2004 tournament winner) was supported entirely by its defensive operation.

1.3 Thesis Structure

This study is divided into six (6) chapters. The second chapter presents the methodological aspects of the technical efficiency discussing the various types of analysis (such as the methods of frontier, optimization and specifically, DEA approach). The third chapter presents the literature survey where further explanations (also with the use of tables) are made.

The fourth chapter summarizes the data used in this work and some points are made according to the descriptive statistics presented. The fifth chapter presents the empirical findings and analyses the first division of Greek football league during ten consecutive seasons (1998/99 to 2007/08), while in the sixth chapter a series of final comments, conclusions and suggestions about further researching efforts is presented.

CHAPTER TWO

METHODOLOGY

2.1 Introduction

The static analysis of the Greek Football Clubs' operating efficiency measurement includes both the estimation of teams' (TE) technical efficiency level as well as the identification of its sources. The analysis is characterized as static due to the fact that it refers to a specific period of time. The technical efficiency term is connected directly to the use of inputs by a Decision Making Unit (DMU) during a period of production and estimates any possible waste of resources for a given technology.

The extravagance of resources (especially of money) is particularly evident in the Football Clubs' case, where the cost minimization choice is not always the first priority of a team's director. Accordingly, the efficiency notion is usually discussed by the football fans, especially when they are convinced that their team should have performed better (accumulate more points) according to the budget spent.

Nevertheless, it should be considered that the monetary indicators of football (that are the salaries of the team's members, the football team's revenues etc.) are difficult to obtain and there are serious doubts with respect to the reliability of these data (Garcia-Sanchez, 2007). Accordingly, researchers turned to the use of sport data, which is compiled during each football season and supplied by apposing companies, in order to estimate Football Clubs' efficient performance. As a result, an insight into the constitution, the general quality and the competitiveness of every football league, as well as into the participating clubs has been attainable for everyone interested.

Considering that the economic targets achievement is not always the first priority of a Football Club's manager, the technical efficiency estimation can be deservedly characterized as adequate only via the analysis of the technological relations that describe a team's operation. Additionally, the fact that there are no market prices for a team's products, which are goals scored and the inverse of goals conceded, enhances the choice of the analysis' specific form.

The structure of the present chapter is the following: in the next section, are presented both the basics and definitions of the technical efficiency methodological aspects. Then, during the third section, the two contemporary approaches of the efficiency measurement are described. In the fourth section, the output-oriented DEA model used in this study is presented, while several returns to scale tests are presented during the last section.

2.2 Basics and definitions

The idea of estimating the efficiency level of a production process is easily conceivable. From a sample of Decision Making Units (DMU), which can be companies performing in the same sector or parts of the same firm, and making use of specialized optimization methods a production frontier is developed that according to Coelli et al. (2005): "reflects the current state of technology in the industry", "defines the relationship between the input and the output" and "represents the maximum output attainable from each input level". Productive entities under study can either operate <u>on</u> or <u>beneath</u> the production frontier, which can be represented by the line 0F in figure 1.

The technically efficient Decision Making Units (DMU) comprise a benchmark for the inefficient ones, while the distance from the production frontier is considered as inefficiency. The efficiency scores are normalised to be equal to one for the efficient (according to the sample) units but less than one for the inefficient ones. There are two ways of improving the operating efficiency level of an inefficient unit, for example, a team performing in point A could either increase output to the point B (output-oriented efficiency → TE^O = DA/DB) or alternatively, could use less input producing the same quantity of output, that is performing in point C <u>on</u> the frontier (input-oriented efficiency → TE^I = EC/EA).

When inputs are assumed to be under the control of the DMU (the aim of which is to maximize its output), the output-oriented model should be chosen. Assuming that Football Clubs' aim is to maximize sporting results (score the maximum and concede the minimum number of possible goals), an output-oriented technically efficient DEA model has to be estimated for the purposes of the present work.

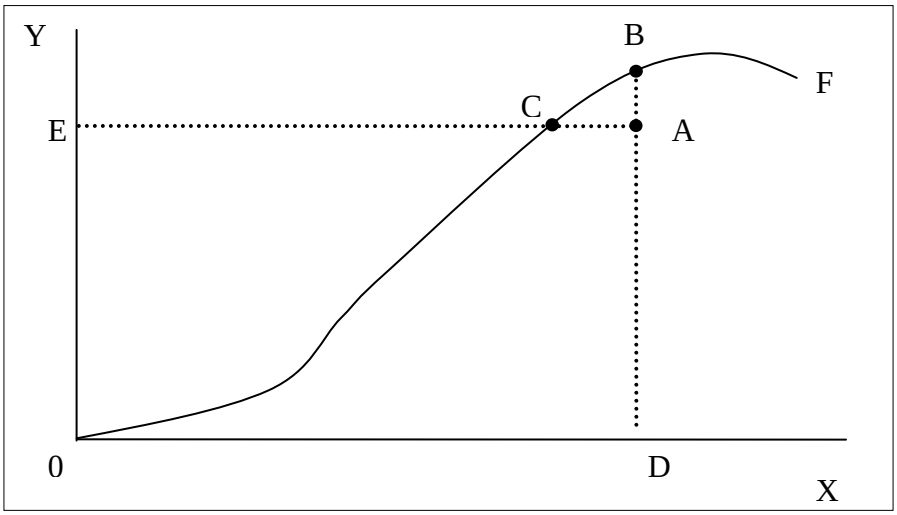

Figure 1: Production Frontier and Technical Efficiency

According to Fare et al. (1994), the overall technical efficiency (which, by using the figure 2, can be defined as: TE_{CRS} = DA/DG) consists of two components:

Firstly, the *pure technical efficiency* that refers to a DMU's ability to generate the maximum attainable quantity of outputs given the restricted inputs quantity and the current technology of production. With reference to figure 2, the pure technical efficiency is defined as: TE_{VRS} = DA/DB.

Secondly, the *scale efficiency* that refers to a DMU's ability to operate exploiting scale economies given the current technology of production. When a DMU is scale efficient, it reaches the point of maximum possible productivity (point H in figure 2). At this point that represents the optimal scale of production, the average product Y/X is maximized. To illustrate this, a ray through the origin that is tangent to the production frontier and its slope is Y/X is utilized. With reference to figure 2, the scale efficiency can be easily defined as: SE = DB/DG.

It should be indicated that scale efficiency displays the percentage of output increment that a technically efficient production unit can attain adapting its scale of production, in order to maximize its average product Y/X given the current technology. With reference to figure 2, it becomes obvious the fact that scale efficiency is connected to constant returns to scale (CRS), while both increasing and decreasing returns to scale are connected to scale inefficiency. Thus, according to Coelli et al. (2005), it can be concluded that: "a firm may be technically efficient but may still be able to improve its productivity by exploiting scale economies".

Moreover, a scale efficient DMU is characterized by a scale elasticity value equal to one:

$$E = \Sigma^{N}_{i=1} \varepsilon_i = \Sigma^{N}_{i=1} \partial \ln Y / \partial \ln X_i = \Sigma^{N}_{i=1} (\partial Y / \partial X_i) * (X_i / Y) = \Sigma^{N}_{i=1} MP_i * (1/AP_i) = 1$$

The (E) scale elasticity term, which comprises the sum of all input elasticities (ε_i = 1, 2,…, N), describes the change of the (Y) output's quantity when the quantity of all inputs (X_i = 1, 2,…, N) changes proportionally and to the same direction. When the above presented equation holds, every input is characterized by a marginal product value that coincides with its average product value and constant returns to scale are assumed. In that case, a 1% increase (decrease) of all inputs quantities leads to a proportional increase (decrease) of the output's quantity. On the other hand and when E > 1 (< 1) or $MP_i > AP_i$ ($MP_i < AP_i$), increasing (decreasing) returns to scale are assumed. In that case, a 1% increase (decrease) of all inputs quantities leads to a more (less) than 1% increase (decrease) of the output's quantity.

When increasing returns to scale (IRS) are assumed, a technically efficient DMU operates <u>on</u> the section 0H of the production frontier (presented in figure 2) and should increase its scale of production, in order to be scale efficient. Nevertheless, the opposite is true (that is, a technically efficient DMU operates <u>on</u> the section HF of the production frontier and should decrease its scale of production, in order to be scale efficient) when decreasing returns to scale (DRS) are assumed.

From the above,

$$TE_{CRS} = DA/DG = TE_{VRS} * SE = DA/DB * DB/DG.$$

That is, the overall technical efficiency is equal to the pure technical efficiency under CRS, due to the fact that SE = 1. It should also be noted that the combination of the pure technical and scale efficiency corresponds to the PE (productive efficiency).

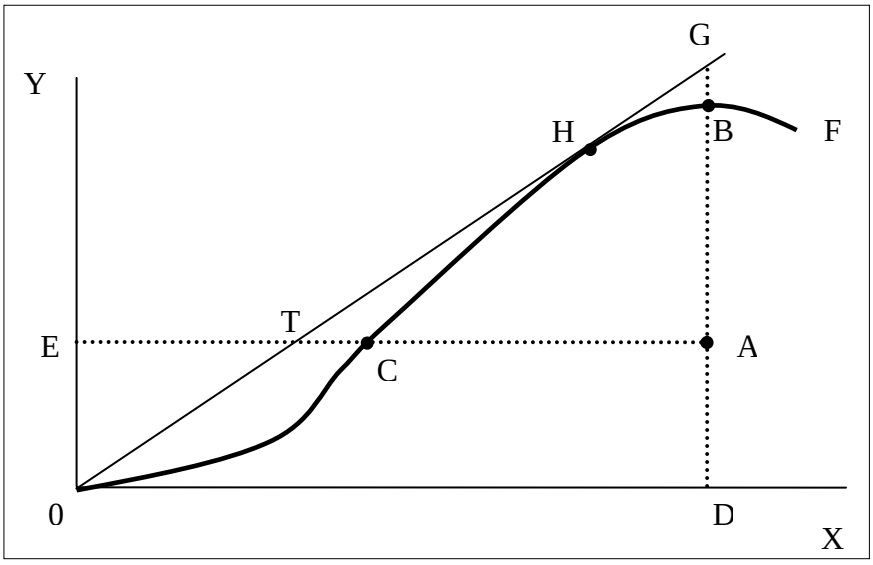

Figure 2: Productivity, Technical Efficiency and Scale Economies

2.3 Efficiency measurement approaches

Despite the fact that the aforementioned efficiency definitions require the technology of production to be defined and known from the beginning of analysis, this (unfortunately) is not that really happens. Therefore and by conducting applied research, the production frontier can be specified with the use of the collected sample data. Under these circumstances, the technically efficient production frontier is always relative to the sample under analysis.

According to the applied method of production frontier estimation, there are two contemporary approaches to the efficiency measurement:

- The econometric or parametric SFA (stochastic frontier analysis) approach and
- The deterministic/non-parametric DEA approach.

The former is mainly based on econometric techniques and measures the difference between the benchmark and the inefficient entities by the residuals, while the latter is based on linear programming techniques. Some of the advantages of SFA over DEA are: firstly, the fact that it accounts for noise and secondly, the fact that it can be used in order conventional tests of hypotheses to be conducted. [7]

[7] The main issue when a stochastic frontier model is used that assumes residuals to have two components (noise and inefficiency) is the decomposition of the error terms (Barros and Leach, 2006b).

On the other hand, some disadvantages are: firstly, the specification requirements of both a distributional form for the inefficiency term as well as a functional form for the production function and secondly, the inability to accommodate multiple outputs (Coelli et al., 2005). A direct comparison of deterministic and stochastic frontier analysis was provided for the first time (within the sports economics literature) in the Ruggiero et al. (1996) paper for baseball, in which both procedures as well as OLS regression analysis were applied.

2.4 Presentation of the DEA (Data Envelopment Analysis) approach

The deterministic non-parametric frontier DEA method is applied for the purposes of the present research. Football Clubs produce identical outputs, use the same units of input abilities, compete under identical rules, employ the same production function and share the same technology (tactics, formation, physical preparations etc.) that is very homogeneous and fundamentally known by all professionals.

The following equation for each DMU is solved:

$$Max\ \theta_1\ subject\ to:\ \{\theta_1 u \leq zUx \geq zXz\} \rightarrow R_+^K$$

Where:

- θ_1 is the total technical efficiency index from the output-oriented perspective,
- *u* the vector representing the values of the *m* products produced by the DMU,
- U the k.m matrix representing the values of the *m* products for the *k* DMUs
- *x* the values of the *n* productive factors used by the DMU whose efficiency is being measured,
- *z* a vector of intensity parameters which determine the combination of factors and products observed and
- X the k.n matrix of the values of the *n* productive factors used by the *k* DMUs.

When $\theta_1 = 1$, the DMU lies on the production frontier and it is impossible to obtain a radial increase of its production vector while maintaining the same quantity of resources used. Furthermore and once the θ_1 value has been calculated, the potential output (given an efficient use of the actual inputs) represented in the vector $\theta_1 u$ of each sample firm can be determined. [8]

2.5 Tests of returns to scale

In order to be proved that Greek Football Clubs operate at an optimal scale, four different constructed statistics which test the null hypothesis of constant relative to the alternative of variable returns to scale are used within the scope of the present study:

- Test statistic T_{EX} is evaluated relative to the critical value of the F-distribution with (2N, 2N) degrees of freedom.
- Test statistic T_{HN} is evaluated relative to the critical value of the F-distribution with (N, N) degrees of freedom.
- Test statistic T_{EX}^* is evaluated relative to the critical value of the half-F distribution with (2N, 2N) degrees of freedom.
- Test statistic T_{HN}^* is also evaluated relative to the critical value of the half-F distribution but with (N, N) degrees of freedom.

It should be noticed that: $T_{EX} = \Sigma^N_{j=1}(\hat{\Theta}^C_j - 1) / \Sigma^N_{j=1}(\hat{\Theta}^B_j - 1)$

$$T_{HN} = \Sigma^N_{j=1}(\hat{\Theta}^C_j - 1)^2 / \Sigma^N_{j=1}(\hat{\Theta}^B_j - 1)^2$$

$$T_{EX}^* = \Sigma^N_{j=1} \ln(\hat{\Theta}^C_j) / \Sigma^N_{j=1} \ln(\hat{\Theta}^B_j)$$

$$T_{HN}^* = \Sigma^N_{j=1} [\ln(\hat{\Theta}^C_j)]^2 / \Sigma^N_{j=1} [\ln(\hat{\Theta}^B_j)]^2$$

$$\hat{\Theta}^C_j \geq \hat{\Theta}^B_j \text{ for all observations j.}$$ [9]

[8] This section is partly based on the papers of Espitia-Escuer and Garcia-Cebrian (2006) and Bosca et al. (2009).
[9] $\hat{\Theta}^C$ corresponds to the DEA inefficiency estimator of the so-called CCR model (Charnes, Cooper and Rhodes, 1978), $\hat{\Theta}^B$ corresponds to the DEA inefficiency estimator of the so-called BCC (Banker, Charnes and Cooper, 1984), while N represents the number of Football Clubs.
Source: Banker (1996) and Banker et al. (2004).

CHAPTER THREE

LITERATURE REVIEW

3.1 Introduction

In general, there are four different football related approaches on which the operating efficiency estimation can be applied:

- The first regards each football match as a unit of reference, where efficiency measures whether a team's effort on field is transforming into victory using shots at goal, corners, ball possession, etc. as inputs and the final result of every single match as an output (Carmichael et al., 2000, 2001).

- The second calculates the football manager's efficiency mostly with the use of financial data (Gerrard, 2001; Dawson et al., 2000a, 2000b; Dawson and Dobson, 2002).

- The third determines the level of individual players' efficient operation, for example the performance of goalkeepers (Alp, 2006).

- The fourth approach focuses on estimating a club's general efficiency in every season (Haas, 2003a, 2003b; Haas et al., 2004).

The following studies are discussed within the scope of the present work: twelve (12) articles applying both DEA and SFA methodology that make use of sport <u>and</u> financial data to analyse a team's general efficiency in every football season, three (3) papers applying the DEA approach and using <u>only</u> sport/match level data, two (2) researches that estimate the Football Clubs' operating efficiency of the offense and defence separately, two (2) studies applying a multiple stage analysis, one (1) article that studies the UEFA Champions League tournament, one (1) paper that presents the most efficient goalkeepers and one (1) research that analyzes the football manager's efficiency. [10]

[10] The characteristics of the papers reviewed are listed in tables 7-13 of the appendix.

These papers can be further discriminated according to:

- The efficiency measurement approach adopted (DEA or SFA),
- The input-output orientation system specified,
- The nature (cross sectional or panel) of the data used and
- The variables comprising the inputs and outputs.

The structure of the present chapter is the following: in the next section, the papers making use of financial and sport data are presented. Then, during the third section, the papers making use of only sport/match level data are introduced. Finally, some articles that estimate the Football Clubs' operating efficiency of the offense and defence separately are thoroughly discussed in the last section.

3.2 Use of financial and sport data

As mentioned above, there are twelve (12) articles in this category applying both DEA and SFA methodology. Two (2) of them make use of only financial data in order to analyse a football club's efficiency level (Guzman, 2006; Guzman and Morrow, 2007). From table 3.2.1 it can be seen that: first, there are seven (7) articles using the DEA approach, while the SFA approach is applied in five (5) of them. Second, there are two (2) articles applying the output-oriented model, while the remaining five (5) utilize the input-oriented model. Third, there are six (6) researches using cross sectional, as many as those using panel data.

From table 3.2.2, it should be noticed that the inputs mostly used in the aforementioned studies are: firstly, the teams' total Salaries and Wage bills, secondly, their Net assets and Stadium facilities and thirdly, some other teams' costs or general expenses (e.g., Investments). Additionally, there are several more variables used as inputs, such as the teams' total Supplies and Services expenditure, the Number of their players and their Director's remuneration. On the other hand, the variables used as outputs are the clubs' Points and Qualifications as well as its Revenues (e.g., from tickets, TV rights sold, sales of products, players etc.) obtained across a football season.

Table 3.2.1: Classification of previous literature

Method of estimation		Orientation		Data	
DEA	SFA	Output	Input	Cross sectional	Panel
Barros and Santos, 2005	Barros and Leach, 2006b	Barros and Santos, 2005	Haas, 2003a	Haas, 2003a	Barros and Santos, 2005
Barros and Leach, 2006a	Barros and Leach, 2007	Barros and Leach, 2006a	Haas, 2003b	Haas, 2003b	Barros and Leach, 2006a
Haas, 2003a	Barros and Garcia-del-Barrio, 2008		Haas et al., 2004	Haas et al., 2004	Barros and Leach, 2006b
Haas, 2003b	Barros et al.(forthcoming)		Guzman, 2006	Kern and Süssmuth, 2005	Barros and Leach, 2007
Haas et al., 2004	Kern and Süssmuth, 2005		Guzman and Morrow, 2007	Guzman, 2006	Barros and Garcia-del-Barrio, 2008
Guzman, 2006				Guzman and Morrow, 2007	Barros et al. (forthcoming)
Guzman and Morrow, 2007					

Table 3.2.2: Types of inputs and outputs

Paper	Salaries & Wage bills	Net assets & Stadium facilities	Other costs: Investments etc.	Points & Qualifications	Revenues from tickets, sales, TV etc.
Barros & Santos, 2005	**X**	Supplies & Services expenditure	**X**	**X**	**X**
Barros & Leach, 2006a	**X**	**X**	Number of players	**X**	**X**
Barros & Leach, 2006b	**X**	**X**		**X**	**X**
Barros & Leach, 2007	**X**	**X**		**X**	**X**
Barros & Garcia-del-Barrio, 2008	**X**	**X**	**X**	**X**	**X**
Barros et al., forthcoming	**X**	**X**	**X**	**X**	**X**
Haas, 2003a	**X**			**X**	**X**
Haas, 2003b	**X**			**X**	**X**
Haas et al., 2004	**X**			**X**	**X**
Kern & Süssmuth, 2005	**X**			**X**	**X**
Guzman, 2006	**X**		**X**		**X**
Guzman & Morrow, 2007	**X**	Director's remuneration	General expenses	**X**	**X**

3.3 Use of sport/match level data

There are six (6) papers in this category. As mentioned before, in two (2) of them (Carmichael et al., 2001; Garcia-Sanchez, 2007) a multiple stage analysis is adopted, while the case study of one (1) article (Papahristodoulou, 2006) is the 2005/06 football period's UEFA Champions League tournament. It should be mentioned that all papers in this category make use of cross sectional data.

Table 3.3.1: Classification of previous literature

Method of estimation		Orientation	
DEA	SFA	Output	Input
Espitia-Escuer and Garcia-Cebrian, 2004 Espitia-Escuer and Garcia-Cebrian, 2005 Espitia-Escuer and Garcia-Cebrian, 2006 Garcia-Sanchez, 2007 Papahristodoulou, 2006	Carmichael et al., 2001	Espitia-Escuer and Garcia-Cebrian, 2006 Garcia-Sanchez, 2007 Papahristodoulou, 2006	Espitia-Escuer and Garcia-Cebrian, 2004 Espitia-Escuer and Garcia-Cebrian, 2005

From table 3.3.1 it can be seen that: first, there are five (5) studies using the DEA approach, while the SFA approach is applied by only one. Second, there are three (3) articles applying the output-oriented model, while the remaining two (2) utilize the input-oriented model.

Table 3.3.2a: Types of inputs and outputs

Paper	Number of players	Attacking moves	Ball possession	Shots	Headers	Points	Goal difference
Espitia-Escuer and Garcia-Cebrian, 2004	**X**	**X**	**X**	**X**	**X**	**X**	
Espitia-Escuer and Garcia-Cebrian, 2005	**X**	**X**	**X**	**X**	**X**		**X**
Espitia-Escuer and Garcia-Cebrian, 2006	**X**	**X**	**X**	**X**		**X**	

Table 3.3.2b: Types of inputs and outputs

Inputs	Carmichael et al., 2001 [11]	Garcia-Sanchez, 2007 [12]
Saves	**X**	**X**
Cards	**X**	
Shots	**X**	**X**
Ball touches	**X**	
Goals (for & against)	**X**	
Ball recovery		**X**
Attacking moves	**X**	**X**
Ball possession	**X**	**X***
Passes & Crosses	**X**	**X**
Outputs	**Carmichael et al., 2001**	**Garcia-Sanchez, 2007**
Points	**X**	**X**
Attendance		**X**
Goals (for & against)	**X**	**X**
Shots	**X**	

* For both the observed team and its opponent.

From tables 3.3.2a and 3.3.2b, it becomes evident that the mostly used input variables are: the Attacking moves, the Ball possession and the Shots of every team. On the other hand, the mostly used output variables are each team's Points and Goals (for and against, or the difference of them).

3.4 Separation of offensive and defensive operation

There are three (3) papers included in this category that make use of cross sectional data. Two (2) studies use the output-oriented DEA model, while the SFA approach is applied by one. The mostly used input variables are each team's Shots (on and off goal) and Ball possession, while the only output variable used is the Goals (scored, conceded, as well as the difference of them) of every team (see table 3.4.1).

The study case of the Bosca et al. (2009) paper is the Spanish Primera Division and the Italian Campionato for seasons 2000/01 and 2002/03. The technical efficiency of every team in different operations (defensive and offensive) and in different situations (home and away) is estimated and related to the sport performance of theirs (i.e., the number of accumulated points along a season). Moreover, the correlations between points earned and DEA scores of offensive and defensive efficiency are examined. Furthermore, six OLS and SUR regressions are carried out using points earned across a season (in total, in home and away) standardized for the number of games played as a dependent variable and DEA scores of offensive and defensive efficiency (obtained in total, in home and away) as an independent variable.

[11] A multiple stage equation system is applied for the purposes of this paper.
[12] A three-stage-DEA model is applied for the purposes of this paper.

Carmichael and Thomas (2005) examined the performance of all sixteen national teams participated in the Euro 2004 tournament. Firstly, a ratio analysis with the use of average values is carried out. Then, an aggregated production function model utilizing a match play data set is estimated, in order predicted tournament rankings to be generated and the relative efficiency of every team (based on an analysis of residual patterns) to be examined. The selected variables are expressed as averages and/or ratios, while they are aggregated over all matches regardless of the tournament stage reached by every national squad. The technical efficiency of every team is measured by the difference between actual goal difference and the predicted by regression estimates one.

Garcia-Sanchez (2007) studied the twenty (20) Football Clubs participated in the Spanish Primera Division over the course of the 2004/05 season. A three-stage-DEA model approach that separates every team's economic behavior into three components (operating offensive and defensive efficiency, athletic or operating effectiveness, as well as social effectiveness) is applied. Additionally, Malmquist productivity indices are estimated, in order the changes in the factors' total productivity as well as the sport behavior evolution of the fifteen (15) teams uninterruptedly participated in the specific football league (during the considered period) to be observed.

Table 3.4.1: Types of inputs and outputs

Inputs	Bosca et al., 2009	Carmichael and Thomas, 2005
Shots (on & off goal)	**X***	**X**
Ball possession	**X***	**X***
Passes & Crosses	**X***	
Attacking moves	**X***	
Tackles & Cards		**X**
Saves		**X**
Corners		**X**
Outputs		
Goal difference		**X**
Goals scored	**X**	
Goals conceded (inverse)	**X**	

* For both the observed team and its opponent.

CHAPTER FOUR

DATA DESCRIPTION

4.1 Introduction

The analysis of the Football Clubs' operating efficiency of the offense and defence, as well as athletic/on-field performance effectiveness evaluation (with the use of a two-stage DEA model) requires the gathering of sample data, in order the variables comprising the inputs and outputs to be constructed.

The data used in this study was obtained from the Galanis sports data company's website *www.galanissportsdata.com* and is based on match by match statistics for the period 1998-2008. In the first stage, the offensive and defensive operations are evaluated and then (in the second stage), the corresponding efficiency scores are introduced as inputs to account for the final ranking of each team in every season.

The structure of this chapter is the following: in the next section, the first and second stage of the DEA model are presented. In the final section, the descriptive statistics of the outputs-inputs variables are introduced and a series of statements concerning the general structure of the Greek football league is made.

4.2 First and second stage of the DEA model

First stage:

Estimation of the offensive efficiency frontier assumes that teams are maximizing the number of goals scored over the course of a season. During a single season, teams also try to minimize the number of goals conceded by opponents. Accordingly, the output measure to calculate the frontier of defensive efficiency will be the inverse of the goals conceded. From the above, it is apparent that the estimation of the efficient production frontier of the offense is independent of that of the defence.

With respect to inputs choice in offensive operation, active actions that lead to goal opportunities are *total shots and headers* (inside and outside penalty area, on and off goal), *total crosses* (including these that failed to reach a teammate) and *total assists* (including these that did not turn into goal). These inputs cover the effort and the abilities a team has employed, in order to dominate on the field and box up the opponent in its penalty area.

Defensively, activities that prevent opposing team from scoring are *saves* (originating from goalkeeper and other players' moves), *clearances* (originating from goalkeeper and other players' moves) and *steals* (apart from preventing, this action aims also at launching a new attack). In this case, the idea is similar to the previous concept but in the other way meaning that are rewarded these teams, which concede fewer goals and are subject to less pressure from the rivals. These six input variables showing a team's level of offense and defence were selected among others, due to availability and for the sake of comparability across all seasons under examination. Furthermore, inputs that are subject to luck or referee's decisions (such as the number of fouls, offsides etc.) are discarded from the study.

Second stage:

The DEA scores of the clubs' efficient offensive and defensive operation (obtained in the previous stage) are introduced here as inputs to produce the output, which is the points' accumulation of every team during a single season. This separation between offensive and defensive operation enables in defining which tactics characterize most every team's function. Furthermore, the key for each team (in order to obtain a better ranking) becomes evident and some useful hints about the importance of every play style (offensive or defensive) are made to football managers.

4.3 Descriptive statistics presentation

The descriptive statistics for offensive and defensive variables describing the Greek national league in the considered seasons (1998/99-2007/08) are presented in Table 4.3.1. As the number of participating clubs differs year by year (18 teams during the first two seasons, 14 teams during the season 2001/02 and 16 teams during all other seasons), the average and the standard deviation of variables are not helpful in making comparisons across the whole period under study. Accordingly, the table shows the previously mentioned descriptive statistics normalized for the number of games played.

Taking into consideration the figures of table 4.3.1 regarding the output measures, several points can be made: first, the fact of the equal Goals scored and Goals conceded average values can be explained by the observation that when a team scores, another team concedes a goal at the same time. In addition, it becomes apparent that spectators used to witness the ball into the back of every team's net above one and up to 1.5 times per game. Second, the average value of the per game points obtained by every team varies from 1.35 (season 2004/05) to 1.41 (season 1998/99). Thus, it should be mentioned that the victory/loss occasion (that gives totally 3 points) takes place more frequently in relation to the draw event (that gives totally 2 points).

Table 4.3.1: Descriptive statistics of outputs-inputs variables [13]

	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
Offensive output and inputs (per game)										
Goals scored	1.36	1.45	1.49	1.44	1.29	1.31	1.16	1.16	1.16	1.16
(Standard deviation)	(0.52)	(0.56)	(0.52)	(0.63)	(0.60)	(0.45)	(0.36)	(0.39)	(0.43)	(0.39)
Total shots & headers	14.63	13.55	13.58	13.14	12.51	12.65	11.73	11.62	11.82	11.44
(Standard deviation)	(3.05)	(2.87)	(2.50)	(2.45)	(2.15)	(2.35)	(2.28)	(2.38)	(2.09)	(2.06)
Total crosses	27.42	23.75	23.36	25.73	25.27	26.86	25.81	22.11	20.38	19.24
(Standard deviation)	(6.26)	(4.73)	(5.27)	(4.31)	(4.75)	(4.43)	(4.41)	(4.26)	(3.34)	(2.79)
Total assists	1.38	1.19	1.12	1.30	1.29	1.38	1.50	1.44	1.55	1.36
(Standard deviation)	(0.67)	(0.47)	(0.63)	(0.60)	(0.67)	(0.64)	(0.45)	(0.44)	(0.45)	(0.38)
Defensive output and inputs (per game)										
Goals conceded	1.36	1.45	1.49	1.44	1.29	1.31	1.16	1.16	1.16	1.16
(Standard deviation)	(0.44)	(0.40)	(0.43)	(0.35)	(0.45)	(0.46)	(0.36)	(0.29)	(0.33)	(0.40)
Saves	6.37	5.88	5.76	5.59	5.37	5.73	5.55	5.40	4.83	4.74
(Standard deviation)	(1.52)	(1.05)	(0.91)	(1.41)	(1.09)	(1.26)	(1.00)	(0.95)	(0.87)	(0.78)
Clearances	20.48	17.50	17.10	18.54	17.64	17.61	17.58	15.53	15.63	15.22
(Standard deviation)	(3.82)	(3.46)	(3.02)	(3.47)	(2.78)	(2.63)	(2.77)	(2.60)	(2.23)	(2.28)
Steals	14.08	12.79	14.21	18.87	15.88	14.55	15.55	10.96	11.09	17.30
(Standard deviation)	(1.63)	(1.64)	(2.69)	(3.55)	(3.46)	(2.96)	(2.64)	(1.37)	(1.62)	(1.73)
Points	1.41	1.40	1.39	1.37	1.38	1.38	1.35	1.38	1.36	1.38
(Standard deviation)	(0.57)	(0.57)	(0.53)	(0.56)	(0.62)	(0.61)	(0.48)	(0.53)	(0.47)	(0.49)

Source: www.galanissportsdata.com, own calculations.

[13] Due to brevity, information about maximum and minimum values is not presented but is available on request.

From the dispersion values, it can be noticed that (in seven out of ten championships) teams differ among them more in their ability to score than to prevent opponent from scoring. Apart from seasons 2003/04, 2004/05 and 2007/08 in which the standard deviation of per game goals scored by every team is equal to that of goals conceded, for the rest of periods under consideration the dispersion of goals scored is persistently greater than the corresponding number of goals conceded. Thus, the better classified clubs used to score much more and to concede a bit fewer goals in relation to the weaker teams.

From the offensive perspective, it can be seen that the number of both per game total shots & headers and total crosses made by every team has been decreased over time. Despite that every team participated in the 1998/99 football season attempted almost 15 total shots & headers and almost 27.5 total crosses per game, the corresponding numbers of the 2007/08 season was reduced to almost 11.5 and 19, respectively. On the contrary, the number of per game total assists made by every team was remained almost unchanged over time as varied from 1.12 (season 2000/01) to 1.55 (season 2006/07).

From the defensive perspective, it can be seen that the number of per game saves made by every club was almost between 5 and 6, the number of per game clearances made by every club was reduced from almost 20.5 (season 1998/99) to approximately 15 (season 2007/08), while the number of per game steals made by every club varied from almost 11 (season 2005/06) to approximately 19 (season 2001/02).

Three additional points relating to the dispersion of all input variables used can be made: first, the league of the season 1998/99 presents the slightest competition among teams (namely, the high dispersion values indicate that the better ranked teams dominated clearly on the field, while the worse ranked clubs incurred greater pressure when defending their goalposts) in relation to the rest seasons. Second, the differences (relative to their defensive abilities) among the participating in the championship of the season 2005/06 teams are minimal comparing to the rest years. Third, the offensive differentiations among the clubs which took part in the league of the season 2007/08 are trivial, while the same championship can be deservedly characterized as the most homogeneous and competitive across all seasons under examination due to the low dispersion values observed.

Despite of the (more or less) equal respective average values, the high dispersion of the outputs relative to the corresponding numbers of the Spanish and Italian football league indicates the unequal and non-competitive level of the Greek football league (see table 4.3.2). It should be mentioned that the figures of both tables (4.3.1 & 4.3.2) were extracted with the use of the same method and thus, they are comparable.

From table 4.3.3, it can be seen that the better ranked Greek and Italian football teams dominated over their opponents more intensively than the respective Spanish Football Clubs. This can be justified by the higher correlation values of the Greek and Italian football leagues, in relation to those concerning the Spanish Primera Division.

Table 4.3.2: Offensive and defensive outputs in the Spanish and Italian league

	Spanish league			Italian league		
	2000-01	2001-02	2002-03	2000-01	2001-02	2002-03
Goals scored	1.44	1.26	1.34	1.39	1.32	1.29
(Standard deviation)	(0.32)	(0.28)	(0.37)	(0.31)	(0.30)	(0.36)
Goals conceded	1.44	1.26	1.34	1.39	1.32	1.29
(Standard deviation)	(0.26)	(0.25)	(0. 25)	(0.33)	(0.34)	(0.29)

Source: Bosca et al. (2009).

Table 4.3.3: Correlations between output indicators [14]

	Spanish league	Italian league	Greek league	
	2001-02	2001-02	2001-02	Average
Points & Goals Scored	0.78	0.91	0.94	0.91
Points & Goals Conceded	-0.73	-0.90	-0.74	-0.86
Goals Scored & Goals Conceded	-0.33	-0.76	-0.55	-0.64

Source: Bosca et al. (2009), own calculations.

[14] For further details, see table 20 of the appendix.

CHAPTER FIVE

EMPIRICAL RESULTS

5.1 Introduction

The empirical results concerning the (TE) technical efficiency level of the Football Clubs participated in the first division of Greek football league during the period 1998-2008 are presented in this chapter. Specifically, the production frontiers for every single football season are estimated in order to be shed light on the mean efficiency level of the teams' both offensive and defensive operation as well as on the average value of their athletic/on-field performance effectiveness. Furthermore and in order to be proved that all Greek Football Clubs under study are scale efficient, the values of four different constructed statistics, which test the null hypothesis of constant relative to the alternative of variable returns to scale, and their critical values are presented.

The final results of the present work reward the technically efficient Greek football teams, determine the problems facing the inefficient clubs and propose specific norms in order these inefficiencies to be tackled. Additionally, a rather crucial question is answered: which aspects (offensive or defensive) of a Football Club are the more influential in winning the Greek league considering that Carmichael and Thomas (2005) indicated that the success of the Greek national football team (which was announced EURO 2004 tournament winner) was supported entirely by its defensive operation.

The structure of the present chapter is the following: in the next section, the reasons of the CRS hypothesis acceptance, along with a series of this event's possible explanations are presented. Then, during the third section, the results of the teams' offensive efficiency are introduced and discussed, while the same procedure regarding the defensive efficiency is followed in the 5.3 section. In the final section, the results of the teams' athletic/on-field performance effectiveness are analyzed, while several concluding remarks concerning the features of Greek football league are also made.

5.2 Hypothesis testing

As it can be seen from the figures of table 5.2.1, the critical values (relative to which test statistics were evaluated at a significance level of 5%) are always greater than the estimated values of no scale inefficiency tests independent of which constructed test statistic is used, the number of participating teams/degrees of freedom and the season under consideration. Accordingly, the null hypothesis of constant returns to scale is not rejected and therefore, both teams' offensive and defensive operation and their athletic/on-field performance are characterized by constant returns to scale.

Table 5.2.1: Test statistics and respective critical values

	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
Defence										
T_{EX} [15]	0.794	0.686	0.462	0.713	0.774	0.724	0.680	0.725	0.648	0.811
T_{HN} [16]	0.755	0.633	0.409	0.715	0.714	0.631	0.636	0.628	0.635	0.785
T_{EX}^{*} [17]	0.775	0.660	0.441	0.713	0.750	0.675	0.657	0.691	0.644	0.789
T_{HN}^{*} [18]	0.720	0.598	0.382	0.718	0.682	0.558	0.588	0.575	0.625	0.728
Offense										
T_{EX}	0.683	0.832	0.694	0.918	0.529	0.545	0.578	0.503	0.418	0.252
T_{HN}	0.667	0.868	0.678	0.902	0.392	0.566	0.547	0.398	0.302	0.125
T_{EX}^{*}	0.682	0.838	0.689	0.915	0.498	0.548	0.572	0.487	0.392	0.236
T_{HN}^{*}	0.683	0.869	0.650	0.900	0.344	0.586	0.526	0.368	0.251	0.108
Athletic/on-field performance										
T_{EX}	0.581	0.708	0.574	0.605	0.631	0.703	0.646	0.422	0.624	0.414
T_{HN}	0.415	0.701	0.524	0.576	0.517	0.634	0.676	0.304	0.412	0.266
T_{EX}^{*}	0.518	0.703	0.559	0.597	0.580	0.683	0.656	0.393	0.558	0.389
T_{HN}^{*}	0.268	0.676	0.483	0.572	0.407	0.605	0.702	0.252	0.282	0.225
Critical values										
F-d (2N, 2N) [19]	1.7	1.7	1.8	1.9	1.8	1.8	1.8	1.8	1.8	1.8
F-d (N, N)	2.2	2.2	2.3	2.5	2.3	2.3	2.3	2.3	2.3	2.3
Half F-d (2N, 2N)	1.7	1.7	1.8	1.9	1.8	1.8	1.8	1.8	1.8	1.8
Half F-d (N, N)	2.2	2.2	2.3	2.5	2.3	2.3	2.3	2.3	2.3	2.3

Source: Coelli's computer program (DEAP version 2.1-1996b), own calculations.

[15] *Source:* Banker (1996).
[16] The same as in footnote 15.
[17] *Source:* Banker et al. (2004).
[18] The same as in footnote 17.
[19] F-distribution with (2N, 2N) degrees of freedom/ level of significance $\alpha = 0.05$.

5.3 Operating efficiency of the offense

The results obtained when measuring the technical efficiency of the offensive operation (i.e., the relationship between the players' attacking moves and the goals scored) are presented in table 5.3.1. [20]

Table 5.3.1: Frequency distribution of the offensive operation's efficiency level

	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
0.3 – 0.399	1	0	0	0	0	0	0	0	0	0
0.4 – 0.499	0	0	1	0	1	0	0	0	1	0
0.5 – 0.599	1	2	0	1	1	0	1	0	0	0
0.6 – 0.699	4	2	1	3	3	0	1	2	1	0
0.7 – 0.799	5	4	3	1	4	2	3	1	3	5
0.8 – 0.899	3	2	5	3	2	9	6	4	3	4
0.9 – 1	4	8	6	6	5	5	5	9	8	7
Mean	0.765	0.830	0.841	0.839	0.791	0.888	0.829	0.893	0.851	0.868
Min	0.359	0.561	0.481	0.527	0.492	0.711	0.576	0.640	0.454	0.700
Standard deviation	0.167	0.144	0.149	0.165	0.162	0.085	0.117	0.118	0.153	0.109

Source: Coelli's computer program (DEAP version 2.1-1996b), own calculations.

Table 5.3.2: Full efficiency benchmarks of the offensive operation [21]

1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
OSFP [22] (1)	OSFP (1)	OSFP (1)	OSFP (1)	AEK (3)	PAO [23] (1)	SKODA XANTHI (4)	OSFP (1)	OSFP (1)	OSFP (1)
IONIKOS (5)	PANILIAKOS (13)	PANAHAIKI (11)	AEK (2)	PAOK (4)	OSFP (2)	KALLITHEA (9)	PAO (3)	PAOK (6)	AEK (2)
APOLLON ATHENS (14)		PAS GIANNENA (13)	OFI (8)	OFI (8)	PANIONIOS (6)		IRAKLIS (4)	OFI (7)	PAOK (9)
					AKRATITOS (14)		PAOK (6)		LEVADIAKOS (11)
							APOLLON KALAMARIAS (9)		
16.7%	11.1%	18.75%	21.4%	18.75%	25%	12.5%	31.25%	18.75%	25%

Source: Coelli's computer program (version 2.1-1996b) has been used for the resolution of the DEA model.

[20] Due to brevity, the rankings of offensive efficient operation are presented in tables 16 & 17 of appendix.

[21] The number in the brackets represents team's final league ranking.

[22] Olympiacos S.F.P.

[23] Panathinaikos A.O.

With reference to table 5.3.1, several points can be made:

- The average technical inefficiency (i.e., the potential increase in the goals scored without differentiating the quantity of inputs used) varies from 10.7% (season 2005/06) to 23.5% (season 1998/99).
- Season 2003/04 presents the lowest standard deviation value (0.085), the highest minimum efficiency score (0.711) and a relatively high average (0.888) comparing to the rest years. Thus, it can be said that teams operated closer to the offensive efficiency frontier during that football period and in relation to the rest.
- Season 1998/99 presents the highest dispersion (0.167) and the lowest both mean (0.765) and minimum efficiency score (0.359) comparing to the rest years. Thus, it can be said that teams operated wide of the offensive efficiency frontier during that football period and in relation to the rest.
- The top efficiency stage (0.9-1) includes the majority of teams (namely, 63), while only one (1) club is included in the 0.3-0.399 efficiency stage.

With reference to table 5.3.2, several points can be made:

- The stronger teams (rankings 1-4) such as OSFP, AEK, PAO, PAOK (2002/03), Iraklis and Skoda Xanthi that usually score a lot of goals comprise the 50% of the offensive operation's full efficiency benchmarks.
- Both the middle and worse ranked teams (rankings 5-14) such as PAOK (2005-08), OFI, Apollon Athens, Ionikos, Paniliakos, Panahaiki, Pas Giannena, Panionios, Akratitos, Kallithea, Apollon Kalamarias and Levadiakos are also technically efficient comprising the 50% of the full efficiency benchmarks, due to the fact that score a lot according to their effort.
- Apart from seasons 2002/03 and 2004/05 the champion always presents a technically efficient offensive operation.
- The season that proportionally includes the most full efficiency clubs is the 2005/06 football season (31.25%), while the opposite is true when it comes to the 1999/2000 football season (11.1%).

Table 5.3.3: The most inefficient offensively clubs [24]

1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
VERIA (17)	-	SKODA XANTHI (8)	-	PANAHAIKI (15)	-	-	-	IONIKOS (16)	-
5.6%	-	6.25%	-	6.25%	-	-	-	6.25%	-

Source: Coelli's computer program (version 2.1-1996b) has been used for the resolution of the DEA model.

From table 5.3.3, three additional points can be made: first, only middle and worse ranked teams (rankings 8-17) are characterized as the most inefficient offensively clubs. Second, it can be observed that four (4) different teams participated in four (4) different football seasons (specifically, the 6.25% of the participated teams in the 2000/01, 2002/03 and 2006/07 football season as well as the 5.6% of the participated in the 1998/99 season teams) were characterized as the most inefficient according to their offensive operation.

5.4 Operating efficiency of the defence

The results obtained when measuring the technical efficiency of the defensive operation (i.e., the relationship between the players' defensive actions and the inverse of goals conceded) are presented in table 5.4.1. [25]

Table 5.4.1: Frequency distribution of the defensive operation's efficiency level

	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
0.2 – 0.299	1	1	0	0	1	1	0	0	0	2
0.3 – 0.399	2	5	1	0	0	6	4	0	0	4
0.4 – 0.499	8	8	6	0	6	3	2	3	2	4
0.5 – 0.599	1	2	5	1	4	3	4	7	1	1
0.6 – 0.699	2	0	1	4	1	0	2	2	4	0
0.7 – 0.799	3	0	1	3	1	1	1	0	4	3
0.8 – 0.899	0	1	0	2	1	0	1	1	2	0
0.9 – 1	1	1	2	4	2	2	2	3	3	2
Mean	0.538	0.475	0.566	0.786	0.588	0.519	0.581	0.635	0.730	0.527
Min	0.272	0.272	0.394	0.560	0.298	0.286	0.305	0.457	0.403	0.267
Standard deviation	0.185	0.178	0.179	0.147	0.208	0.227	0.226	0.187	0.187	0.233

Source: Coelli's computer program (DEAP version 2.1-1996b), own calculations.

[24] The number in the brackets represents team's final league ranking.
[25] Due to brevity, the rankings of defensive efficient operation are presented in tables 14 & 15 of appendix.

With reference to table 5.4.1, several points can be made:

- The average technical inefficiency (i.e., the potential decrease in the goals conceded without altering the quantity of inputs used) varies from 21.4% (season 2001/02) to 52.5% (season 1999/2000).
- Season 2001/02 presents the lowest standard deviation value (0.147) and the highest both minimum efficiency score (0.560) and average (0.786) comparing to the rest years. Thus, it can be said that teams operated closer to the defensive efficiency frontier during that football period and in relation to the rest.
- Season 1999/2000 presents the lowest average value (0.475) and a relatively low value of both minimum efficiency score (0.272) and standard deviation (0.178) comparing to the rest years. Thus, it can be said that teams operated wide of the defensive efficiency frontier during that football period and in relation to the rest.
- The 0.4-0.499 efficiency stage includes the majority of teams (namely, 42), while only six (6) clubs are included in the 0.2-0.299 efficiency stage.

With reference to table 5.4.2, several points can be made:

- The better ranked teams (rankings 1-3) such as OSFP, PAO and AEK with constant presence in the league across all the examined period comprise the 88.2% of the defensive operation's full efficiency benchmarks. A possible explanation for this result may be the fact that these squads usually possess the ball more time in relation to the rest teams and do not permit their rivals to dominate on the field.
- Apart from seasons 2000/01, 2001/02 and 2007/08, the championship winner always presents a technically efficient defensive operation.
- The season that proportionally includes the most full efficiency clubs is the 2006/07 football season (18.75%), while the opposite is true when it comes to the 1998/99 and 1999/2000 football seasons (5.6%).

From table 5.4.3, three additional points can be made: first, only middle and worse ranked teams (rankings 5-18) are characterized as the most inefficient defensively clubs. Second, the season that proportionally includes the highest number of the most inefficient defensively clubs is the 2003/04 football season (43.75%), while the opposite is true when it comes to the 2001/02, 2005/06 and 2006/07 football periods.

On general and according to the comparison between offensive and defensive teams' efficiency, it can be said that the Football Clubs participated in the first division of Greek league during the 1998-2008 period operated in a more efficient way when attacking than when defending. Thus, in all football seasons, it is the level of efficient defensive function that creates more differentiations among Greek Football Clubs and results in victories, as well as points. An exception is the 2001/02 season, in which the minimum efficiency score of the defence (0.560) is greater than that of the offense (0.527) and (despite that the mean values are more or less the same) the dispersion of the defence (0.147) is smaller than the corresponding number of the offense (0.165).

Therefore, the results indicate that in the Greek league there is in general more room for improving defensive rather than offensive efficiency. This may be explained as follows: first, the mean efficiency of the defensive efficiency was estimated at almost 60%, while of the offensive efficiency at almost 84% and second, the 61% of all teams are included in the four (4) bottom defensive efficiency stages (0.2-0.599), while the 83.3% of all teams are included in the top three (3) offensive efficiency stages (0.7-1).

In addition, Football Clubs seem to be more homogeneous in terms of the offensive rather than the defensive operation. As a result, it seems that defensive errors modulate the final result in most of the football matches and thus, to obtain a better ranking requires improvement of defensive efficiency. It is quite surprising the fact that Greek Football Clubs operated in a more efficient way when attacking than when defending considering that the defensive and not the attacking aspects of the Greek national football team were more influential in winning the EURO 2004 tournament (Carmichael and Thomas, Research Paper 2005).

With reference to table 5.4.4, several points can be made:

- The average (of the ten-year period) correlation between points earned and DEA scores of defensive operation (78%) is greater than the corresponding number concerning the operation of the offense (45%) indicating that it is the level of efficient defensive function that results in victories and points.

- There is significant difference between the correlation of points and DEA scores of offensive efficiency (45%) and the corresponding number of the efficient offensive function's alternative measure and the aforementioned DEA scores (71%) in relation to the respective numbers concerning the defensive operation (78% and 73%, respectively). As already mentioned, the negative value of the latter correlation is justified by the fact that teams conceding the minimum number of goals are ranked among the first positions of the efficient defensive function's alternative measure ranking.
- Only three out of ten teams (on average and across the years) present the same operating efficiency level both in offense and defence.

Table 5.4.2: Full efficiency benchmarks of the defensive operation [26]

1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
OSFP [27] (1)	OSFP (1)	PAO [28] (2)	PAO (3)	OSFP (1)	PAO (1)	OSFP (1)	OSFP (1)	OSFP (1)	PAO (3)
			PANIONIOS (7)	PAO (2)	OSFP (2)	PAO (2)	AEK (2)	AEK (2)	
								SKODA XANTHI (11)	
5.6%	5.6%	6.25%	14.3%	12.5%	12.5%	12.5%	12.5%	18.75%	6.25%

Source: Coelli's computer program (version 2.1-1996b) has been used for the resolution of the DEA model.

Table 5.4.3: The most inefficient defensively clubs [29]

1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
ETHNIKOS PIRAEUS (18)	KAVALA (15)	KALAMATA (15)	-	PANAHAIKI (15)	PANILIAKOS (15)	ERGOTELIS (15)	-	-	APOLLON KALAMARIAS (16)
APOLLON ATHENS (14)	PROODEFTIKI (16)				OFI (11)	OFI (13)			OFI (12)
PANIONIOS (15)	PANIONIOS (8)				AKRATITOS (14)	PAOK (5)			LEVADIAKOS (11)
	TRIKALA (18)				SKODA XANTHI (10)	APOLLON KALAMARIAS (12)			ERGOTELIS (13)
	APOLLON ATHENS (17)				ARIS (13)				VERIA (15)
	IRAKLIS (6)				PROODEFTIKI (16)				SKODA XANTHI (8)
					IRAKLIS (8)				
16.7%	33.3%	6.25%	-	6.25%	43.75%	25%	-	-	37.5%

Source: Coelli's computer program (version 2.1-1996b) has been used for the resolution of the DEA model.

[26] The number in the brackets represents team's final league ranking.
[27] Olympiacos S.F.P.
[28] Panathinaikos A.O.
[29] The number in the brackets represents team's final league ranking.

Table 5.4.4: Correlations between alternative measures of effectiveness-points-DEA scores [30]

	Average
Points & defensive efficiency [31]	0.78
Defensive efficiency & GC/TOS [32]	-0.73
Points & offensive efficiency [33]	0.45
Offensive efficiency & GS/TS [34]	0.71
Defensive & offensive efficiency	0.30

Source: www.galanissportsdata.com, Coelli's computer program, own calculations.

5.5 Athletic/On-field effectiveness

The results obtained when estimating the on-field effectiveness of Greek Football Clubs, i.e., the relationship between each team's DEA scores of efficient offensive and defensive operation and its accumulated points, are presented in table 5.5.1. [35]

Table 5.5.1: Frequency distribution of the on-field effectiveness level

	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
0.2 – 0.299	1	0	0	0	1	0	0	0	1	0
0.3 – 0.399	0	0	0	0	0	0	1	0	0	0
0.4 – 0.499	0	2	1	3	1	2	0	1	0	0
0.5 – 0.599	1	3	2	2	4	4	1	1	0	0
0.6 – 0.699	5	0	2	0	0	2	2	1	5	2
0.7 – 0.799	5	5	3	4	3	3	5	3	3	3
0.8 – 0.899	2	3	2	0	1	2	3	4	3	4
0.9 – 1	4	5	6	5	6	3	4	6	4	7
Mean	0.747	0.773	0.797	0.742	0.743	0.717	0.784	0.820	0.758	0.866
Min	0.236	0.400	0.458	0.442	0.279	0.429	0.366	0.483	0.299	0.600
Standard deviation	0.185	0.192	0.182	0.219	0.231	0.187	0.177	0.173	0.177	0.134

Source: Coelli's computer program (DEAP version 2.1 – 1996b), own calculations.

[30] For further details, see table 20 of the appendix.

[31] DEA scores of operating efficiency of the defence.

[32] Goals Conceded/Total Opponent's Shots & Headers.

[33] DEA scores of operating efficiency of the offense.

[34] Goals Scored/Total Shots & Headers.

[35] Due to brevity, the rankings of the on-field effectiveness are presented in tables 18 & 19 of appendix.

Table 5.5.2: Benchmarks of the athletic/on-field performance effectiveness [36]

1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
PAO [37]	OSFP [38]	OSFP	OSFP	PAO	PAO	PAO	AEK	OSFP	OSFP
(3)	(1)	(1)	(1)	(2)	(1)	(2)	(2)	(1)	(1)
OFI	PAO	AEK	AEK	AEK	PAOK	PAOK	PAO	OFI	PAO
(8)	(2)	(3)	(2)	(3)	(3)	(5)	(3)	(7)	(3)
	AEK	PAOK	PAOK	PAOK			PAOK		PANIONIOS
	(3)	(4)	(4)	(4)			(6)		(5)
	OFI	SKODA XANTHI		IRAKLIS					OFI
	(4)	(8)		(7)					(12)
11.1%	22.2%	25%	21.4%	25%	12.5%	12.5%	18.75%	12.5%	25%

Source: Coelli's computer program (version 2.1-1996b) has been used for the resolution of the DEA model.

With reference to table 5.5.1, several points can be made:

- The average on-field ineffectiveness (i.e., the potential increase in the accumulated by each team points during a season, given the fact that the obtained from the first stage DEA scores remain the same) varies from 13.4% (season 2007/08) to 28.3% (season 2003/04) across seasons under examination.
- Season 2007/08 presents the highest average (0.866) and minimum efficiency score (0.600), as well as the lowest standard deviation value (0.134) comparing to the rest years. Thus, it can be said that teams operated closer to the performance effectiveness frontier during that football period and in relation to the rest.
- Season 2003/04 presents the lowest average value (0.717) and a relatively high dispersion (0.187) comparing to the rest years. Thus, it can be said that teams operated wide of the performance effectiveness frontier during that football period and in relation to the rest.
- The top effectiveness stage (0.9-1) includes the majority of teams (namely, 50), while only one (1) club is included in the 0.3-0.399 effectiveness stage.
- According to the mean values, it can be seen that the relative offensive and defensive efficiency account on average for almost 80% of season's accumulated by each team points.

[36] The number in the brackets represents team's final league ranking.

[37] Panathinaikos A.O.

[38] Olympiacos S.F.P.

With reference to table 5.5.2, several points can be made:

- Football Clubs which exhibit points' accumulation effectiveness are more or less the same squads that either declared as champions (in six out of ten seasons), or have struggled to participate in European football competitions.
- Specifically, the better and middle ranked teams (rankings 1-8) such as PAO, PAOK, OSFP, AEK, OFI, as well as Skoda Xanthi, Iraklis and Panionios with constant presence in the league across all the examined period comprise the benchmarks of the athletic/on-field performance effectiveness.
- Olympiacos S.F.P. that was the championship winner of the seasons 1998/99, 2002/03, 2004/05 and 2005/06 should have accumulated more points according to its operating efficiency of both the offense and defence.
- Accumulated experience and getting used to play under great pressure are significant factors in earning points in Greece considering that there is a standard group of teams in the Greek football league, which earn the maximum number of possible points given an a priori estimated level of offensive and defensive efficiency.
- The football seasons that proportionally include the most benchmarks of the athletic/on-field performance effectiveness are the 2000/01, 2002/03 and 2007/08 (25%), while the opposite is true when it comes to the 1998/99 football season (11.1%).

Table 5.5.3: Inefficient but effective teams [39]

1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
PAO [40] (3) OFI (8)	PAO (2) AEK (3) OFI (4)	AEK (3) PAOK (4) SKODA XANTHI (8)	PAOK (4)	IRAKLIS (7)	PAOK (3)	PAOK (5)	-	-	PANIONIOS (5) OFI (12)
11.1%	16.7%	18.75%	7.1%	6.25%	6.25%	6.25%	-	-	12.5%

Source: Coelli's computer program (version 2.1-1996b) has been used for the resolution of the DEA model.

[39] The number in the brackets represents team's final league ranking.

[40] Panathinaikos A.O.

Table 5.5.4: Spectacular but ineffective teams [41]

1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
IONIKOS (5)	-	-	OFI (8)	OFI (8)	OSFP [42] (2) PANIONIOS (6)	SKODA XANTHI (4)	IRAKLIS (4)	PAOK (6)	AEK (2)
5.6%	-	-	7.1%	6.25%	12.5%	6.25%	6.25%	6.25%	6.25%

Source: Coelli's computer program (version 2.1-1996b) has been used for the resolution of the DEA model.

From table 5.5.3, it can be seen that it is thanks to the organizational design by the club's coach and/or technical director, or to individual moves made by really talented players the fact that (mainly, the better and middle ranked) teams (rankings 2-8), which do not operate efficiently in offense and/or defence, accumulate points effectively. Moreover and despite that OFI ranked 12th in the championship of the 2007/08 football season, this team accumulated the maximum points according to its on-field effort. Furthermore, the 2000/01 football season proportionally includes the most inefficient but effective teams (18.75%), while the opposite is true when it comes to the 2005/06 and 2006/07 seasons.

From table 5.5.4, it can be pointed out that several better and middle ranked teams (rankings 2-8) such as OFI, Ionikos, OSFP, Panionios, Skoda Xanthi, Iraklis, PAOK and AEK that exhibit offensive efficiency (without being effective in point's accumulation) played spectacularly on-field offering goals and pleasure to football funs at the price of a better ranking. Moreover, it can be mentioned that the season that proportionally includes the most spectacular but ineffective teams is the 2003/04 football season (12.5%), while the opposite is true when it comes to the 1999/2000 and 2000/01 football seasons.

[41] The number in the brackets represents team's final league ranking.

[42] Olympiacos S.F.P.

Table 5.5.5: Correlations between alternative measures of effectiveness-points-DEA scores [43]

	Average
Points & on-field effectiveness [44]	0.82
On-field effectiveness & GS/GC [45]	0.67
On-field effectiveness & defensive efficiency [46]	0.47
On-field effectiveness & offensive efficiency [47]	0.31

Source: www.galanissportsdata.com, Coelli's computer program, own calculations.

Table 5.5.6: The most ineffective clubs [48]

1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
ETHNIKOS PIRAEUS 18)	TRIKALA (18) APOLLON ATHENS (17)	ATHINAIKOS (16)	IONIKOS (12) AKRATITOS (11) PANAHAIKI (13)	PANAHAIKI (15) PAS GIANNENA (16)	PROODEFTIKI (16) KALLITHEA (12)	KERKIRA (16)	AKRATITOS (16)	IONIKOS (16)	-
5.6%	11.1%	6.25%	21.4%	12.5%	12.5%	6.25%	6.25%	6.25%	-

Source: Coelli's computer program (version 2.1-1996b) has been used for the resolution of the DEA model.

With reference to table 5.5.5, several points can be made:

- The correlation between DEA scores of the on-field performance effectiveness and the official final league rankings (82%) is significant and greater than the corresponding number concerning DEA scores and the alternative measure's rankings of the on-field performance effectiveness (67%).
- The correlation between DEA scores of both the on-field performance effectiveness and the defensive efficiency (47%) is greater than the corresponding number concerning the DEA scores of both the on-field performance effectiveness and the offensive efficiency (31%) indicating that it is the level of defensive efficiency that results in victories and points.

Finally and according to table 5.5.6, two additional points can be made: first, only worse ranked teams (rankings 11-18) are characterized as the most ineffective in points accumulation clubs and second, the season that proportionally includes the highest number of the most ineffective clubs is the 2001/02 football season (21.4%), while the opposite is true when it comes to the 2007/08 football period.

[43] For further details, see table 20 of the appendix.
[44] DEA scores of on-field performance effectiveness.
[45] Goals Scored/Goals Conceded.
[46] DEA scores of operating efficiency of the defence.
[47] DEA scores of operating efficiency of the offense.
[48] The number in the brackets represents team's final league ranking.

CHAPTER SIX

CONCLUSIONS

In the methodology used in the present study, it is assumed that each Football Club participating in the Greek league operates as a decision making unit (DMU) that uses inputs in order to transform them into an output of a specific form. Mathematical methods of optimization (i.e., DEA models) enabled the estimation of the efficient production's frontier (which reflects the maximum attainable quantity of final product given available productive factors), while the level of each team's inefficiency was measured by its distance from that frontier. A two-stage DEA approach using match-level data from ten consecutive seasons (1998/99 to 2007/08) was chosen as the most appropriate method for estimating the operating efficiency of both the offense and defence as well as the athletic/on-field performance effectiveness of Greek Football Clubs.

In the first stage, the offensive and defensive operations were evaluated and then the corresponding efficiency scores were introduced as inputs to account for the final ranking of each team in every season. This separation between offensive and defensive operation enabled to define which tactics characterize most every team's function. Furthermore, the key for each team (in order to obtain a better ranking) became evident and some useful hints about the importance of every play style (offensive or defensive) were made to football managers.

The results indicated that there is in general more room for improving defensive rather than offensive efficiency, as the mean efficiency of the former was estimated at almost 60% and of the latter at almost 84%. In addition, Football Clubs seem to be more homogeneous in terms of the offensive rather than the defensive operation. On the other hand, it was found that the relative offensive and defensive efficiency account on average for almost 80% of season's accumulated by each team points. Moreover, there seem to be no changes over time in the upper tale of the performance effectiveness scores distribution, implying the group of highly qualified teams remained unchanged over the period under consideration.

Some additional points can be made about both the offensive and defensive efficiency as well as the on-field effectiveness of Greek Football Clubs across seasons under examination:

- Except from the stronger and better ranked teams (which usually score a lot of goals), the weaker and worse ranked teams found also to be offensively efficient due to the fact that scored a lot according to their effort.
- Only the better ranked teams with constant presence in the league across all the examined period were characterized as defensively efficient. A possible explanation may be the fact that these squads usually possess the ball more time in relation to the rest teams and do not permit their rivals to dominate on field.
- The level of efficient defensive function that creates more differentiations among Greek Football Clubs results in victories as well as points.
- Defensive errors modulate the final result in most of the football matches and thus, to obtain a better ranking requires improvement of defensive efficiency.

It is quite surprising that Greek Football Clubs operated in a more efficient way when attacking than when defending considering that the defensive and not the attacking aspects of the Greek national football team were more influential in winning the EURO 2004 tournament (Carmichael and Thomas, Research Paper 2005).

Moreover, it can be stated that:

- Football Clubs that exhibited points' accumulation effectiveness are squads that either declared as champions (in six out of ten seasons), or have struggled to participate in European football competitions. Accordingly, it is generally accepted the idea that accumulated experience and getting used to play under great pressure are significant factors in earning points in Greece.
- It is thanks to the organizational design by the club's coach and/or technical director, or to individual moves made by really talented players the fact that teams (which did not operate efficiently in offense and defence) presented on-field effectiveness.

- The better classified clubs used to score much more and to concede a bit fewer goals in relation to the weaker teams. Accordingly, the Greek football league can deservedly be characterized as non-competitive given also the relatively high correlations between output measures. [49]

Finally, it should be mentioned that further researching effort has to be made within the scope of Greek football league due to dearth in the relative literature and in order to be illuminated the impact of exogenously determined factors (e.g., the referee's decisions, the breadth of each team's fan base etc.). A second-stage regression analysis might probably be adequate in order to be thoroughly analyzed the causes of teams' defensive and offensive efficiency differentials.

Along these lines, there is also the opportunity of a productivity analysis using the Malmquist index in order to be confirmed whether it is a progressive technical change or an advance in efficiency (i.e., better use of the inputs), the cause behind a possibly observed increase in a club's efficiency across two or more time periods. Special focus has also to be given by future studies on the use of financial data, which can be gathered from the balance-sheets of Football Clubs. So, (along with the athletic performance) some light might be shed on the costs (e.g., of rostering) and revenues (e.g., from sold tickets, sponsorships, sales of products or even players etc.) of every team.

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[49] See table 20 of the appendix.

References

Alp I. Performance evaluation of goalkeepers of the world cup. *Gazi University journal of science*, 2006, 19(2), 119-125.

Andersen, P. and N.C. Petersen. A procedure for ranking efficient units in data envelopment analysis. *Management science*, 1993, 39(10), 1261-1264.

Atkinson, S.E., Stanley, L.R. and J. Tschirart. Revenue sharing as an incentive in an agency problem: an example from the national football league. *Rand journal of economics*, 1988, 19, 27-43.

Banker, R.D., Charnes, A. and W.W. Cooper. Models for the estimation of technical and scale inefficiencies in Data Envelopment Analysis. *Management Science*, 1984, Sept., 1078-1092.

Banker, R.D. Hypothesis Tests Using Data Envelopment Analysis. *The Journal of Productivity Analysis*, 1996, 7, 139-159.

Banker, R.D., Janakiraman, S. and R. Natarajan. Analysis of trends in technical and allocative efficiency: an application to Texas public school districts. *European Journal of Operational Research*, 2004, 154, 477-491.

Barros, C.P. and A. Santos. Les relations entre performance sportive et la performance financiere: application au cas du football Portugais, in: Balle, G. and Desbordes, M., eds., Marketing et football: une perspective internationale. *Presses Universitaires du sport, (Voiron, France)*, 2005, 347-374.

Barros, C.P. and S. Leach. Performance evaluation of the English premier football league with data envelopment analysis. *Applied economics*, 2006a, 38, 1449-1458.

Barros, C.P. and S. Leach. Analyzing the performance of the English F.A. premier league with an econometric frontier model. *Journal of sports economics*, 2006b, 7(4), 391-407.

Barros, C.P. and S. Leach. Technical efficiency in the English Football Association premier league with a stochastic cost frontier. *Applied economics letters*, 2007, 14, 731-741.

Barros, C.P. and P. Garcia-del-Barrio. Efficiency measurement of the English football premier league with a random frontier model. *Economic modelling*, 2008, 25(5), 994-1002.

Barros, C.P., Garcia-del-Barrio, P. and S. Leach. Analysing the technical efficiency of the Spanish football league first division with a random frontier model. *Applied economics*, forthcoming.

Bosca, J.E., Liern, V., Martinez, A. and R. Sala. Increasing offensive or defensive efficiency? An analysis of Italian and Spanish football. *Omega*, 2009, 37, 63-78.

Carmichael, F. and D. Thomas. Production and efficiency in team sports: an investigation of rugby league football. *Applied economics*, 1995, 27, 859-869.

Carmichael, F., Thomas, D. and R. Ward. Team performance: the case of English premiership football. *Managerial and decision economics*, 2000, 21(1), 31-45.

Carmichael, F., Thomas, D. and R. Ward. Production and efficiency in association football. *Journal of sports economics*, 2001, 2(3), 228-243.

Carmichael, F. and D. Thomas. Does the best team win? An analysis of team performances at Euro 2004. *Football Governance Research Centre*, Research Paper 2005, No. 2, Birkbeck, University of London.

Charnes, A., Cooper, W.W. and E. Rhodes. Measuring the efficiency of Decision Making Units. *European Journal of Operational Research*, 1978, 429-444.

Coelli, T.J., Rao, D.S.P., O'Donnell, C.J. and G.E. Battese. An Introduction to Efficiency and Productivity Analysis. *Springer Editions*, 2nd ed., 2005.

Dawson, P., Dobson, S. and B. Gerrard. Estimating coaching efficiency in professional team sports: evidence from English association football. *Scottish journal of political economy*, 2000a, 47(4), 399-421.

Dawson, P., Dobson, S. and B. Gerrard. Stochastic frontiers and the temporal structure of managerial efficiency in English soccer. *Journal of sports economics*, 2000b, 1(4), 341-362.

Dawson, P. and S. Dobson. Managerial efficiency and human capital: an application to English association football. *Managerial and decision economics*, 2002, 23, 471-486.

Espitia-Escuer, M. and L.I. Garcia-Cebrian. Measuring the efficiency of Spanish first-division soccer teams. *Journal of sports economics*, 2004, 5(4), 329-346.

Espitia-Escuer, M. and L.I. Garcia-Cebrian. Evaluating organizational design through efficiency values: an application to the Spanish first division soccer teams. *Documento de trabajo 2005-04*, Facultad de ciencias economicas y empresariales, Universidad de Zaragoza.

Espitia-Escuer, M. and L.I. Garcia-Cebrian. Performance in sports teams. Results and potential in the professional soccer league in Spain. *Management decision*, 2006, 44(8), 1020-1030.

Fare, R., Grosskopf, S., and C.A.K. Lovell. Production frontiers. *Cambridge, UK: Cambridge University Press*, 1994.

Garcia-Sanchez I.M. Efficiency and effectiveness of Spanish football teams: a three-stage-DEA approach. *Central European Journal of Operations Research*, 2007, 15, 21-45.

Gerrard B. Football, fans and finance: understanding the business of professional football. *Mainstream publishing*, 2001, Edinburgh.

Guzman I. Measuring efficiency and sustainable growth in Spanish football teams. *European sport management quarterly*, 2006, 6(3), 267-287.

Guzman, I. and S. Morrow. Measuring efficiency and productivity in professional football teams: evidence from the English Premier League. *Central European Journal of Operations Research*, 2007, 15, 309-328.

Haas D.J. Productive efficiency of English football teams-a data envelopment analysis approach. *Managerial and decision economics*, 2003a, 24, 403-410.

Haas D.J. Technical efficiency in the major league soccer. *Journal of sports economics*, 2003b, 4(3), 203-215.

Haas, D.J., Kocher, M.G. and M. Sutter. Measuring efficiency of German football teams by data envelopment analysis. *Central European Journal of Operations Research*, 2004, 12, 251-268.

Kern, M. and B. Süssmuth. Managerial efficiency in German top league soccer: an econometric analysis of club performances on and off the pitch. *German economic review*, 2005, 6(4), 485-506.

Papahristodoulou C. Team performance in UEFA champions league 2005-06. *Munich personal Research Papers in Economics archive*, 2006, No. 138(06).

Rottenberg S. The baseball player's labor-market. *Journal of political economy*, 1956, 64, 242-258.

Ruggiero, J., Hadley, L. and E. Gustafson. Technical efficiency in major league baseball. In J. Fizel, E. Gustafson and L. Hadley eds. Baseball economics: current research, *Praeger Publishers*, 1996, 191-200.

Schofield J.A. Production functions in the sports industry: an empirical analysis of professional cricket. *Applied economics*, 1988, 20, 177-193.

Scott, F.A., Long, J.E. and K. Somppi. Salary vs. marginal revenue product under monopsony and competition: the case of professional basketball. *Atlantic economic journal*, 1985, 13, 50-59.

Scully G.W. Pay and performance in major league baseball. *American economic review*, 1974, 64, 915-930.

Zech C.E. An empirical estimation of a production function: the case of major league baseball. *American economist*, 1981, 25, 19-23.

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Appendix

Table 1: Alternative rankings of effective defensive operation [50]

1998-99	GC/TOS [51]	1999-2000	GC/TOS	2000-01	GC/TOS	2001-02	GC/TOS	2002-03	GC/TOS
PROODEFTIKI (12)	0.0637	OSFP (1)	0.0592	PAO (2)	0.06173	SKODA XANTHI (5)	0.0783	PANIONIOS (5)	0.06944
SKODA XANTHI (7)	0.0692	PAO (2)	0.0870	OSFP (1)	0.06607	AKRATITOS (11)	0.0861	PAO (2)	0.07308
OSFP [52] (1)	0.0724	PANAHAIKI (14)	0.0911	SKODA XANTHI (8)	0.08665	AEK (2)	0.0906	OSFP (1)	0.07473
IONIKOS (5)	0.0727	OFI (4)	0.0924	PANIONIOS (9)	0.09459	ETHNIKOS ASTIR (14)	0.0978	AEK (3)	0.08382
PAOK (4)	0.0816	ETHNIKOS ASTIR (12)	0.0958	AEK (3)	0.09659	PAO (3)	0.1000	PROODEFTIKI (11)	0.08559
AEK (2)	0.0844	AEK (3)	0.0970	IONIKOS (6)	0.10110	PANIONIOS (7)	0.1019	SKODA XANTHI (9)	0.09041
IRAKLIS (9)	0.0854	PROODEFTIKI (16)	0.0973	ETHNIKOS ASTIR (10)	0.10400	IRAKLIS (6)	0.1023	IRAKLIS (7)	0.09814
PANELEFSINIAKOS (16)	0.0872	PANILIAKOS (13)	0.0986	ARIS (7)	0.10406	OFI (8)	0.1111	KALLITHEA (13)	0.10022
OFI (8)	0.0938	SKODA XANTHI (11)	0.1005	OFI (12)	0.11111	OSFP (1)	0.1154	IONIKOS (14)	0.10294
ETHNIKOS ASTIR (11)	0.0945	APOLLON ATHENS (17)	0.1014	IRAKLIS (5)	0.11594	ARIS (9)	0.1156	ARIS (6)	0.10559
ARIS (6)	0.0962	ARIS (7)	0.1048	PANILIAKOS (14)	0.11765	IONIKOS (12)	0.1224	PAS GIANNENA (16)	0.11370
PAO [53] (3)	0.0997	IONIKOS (10)	0.1116	PANAHAIKI (11)	0.12556	EGALEO (10)	0.1296	OFI (8)	0.11371
PANILIAKOS (13)	0.0998	IRAKLIS (6)	0.1196	PAS GIANNENA (13)	0.12559	PANAHAIKI (13)	0.1322	PAOK (4)	0.11480
ETHNIKOS PIRAEUS (18)	0.1033	PAOK (5)	0.1215	ATHINAIKOS (16)	0.13830	PAOK (4)	0.1630	AKRATITOS (12)	0.11832
KAVALA (10)	0.1042	KAVALA (15)	0.1272	KALAMATA (15)	0.14699			EGALEO (10)	0.12188
PANIONIOS (15)	0.1088	PANIONIOS (8)	0.1278	PAOK (4)	0.14769			PANAHAIKI (15)	0.14730
APOLLON ATHENS (14)	0.1176	KALAMATA (9)	0.1284						
VERIA (17)	0.1253	TRIKALA (18)	0.1360						

Source: www.galanissportsdata.com, own calculations.

[50] The number in the brackets represents team's final league ranking.

[51] Goals Conceded/Total Opponent's Shots.

[52] Olympiacos S.F.P.

[53] Panathinaikos A.O.

Table 2: Alternative rankings of effective defensive operation (Continue) [54]

2003-04	GC/TOS [55]	2004-2005	GC/TOS	2005-06	GC/TOS	2006-07	GC/TOS	2007-08 [56]	GC/TOS
PAO [57] (1)	0.063	PAO (2)	0.0619	AEK (2)	0.0709	SKODA XANTHI (11)	0.0585	AEK (2)	0.0550
PANIONIOS (6)	0.069	AEK (3)	0.0696	SKODA XANTHI (5)	0.0801	OSFP (1)	0.0769	ARIS (4)	0.0612
PAOK (3)	0.076	EGALEO (6)	0.0765	PAO (3)	0.0868	ARIS (4)	0.0781	OSFP (1)	0.0712
EGALEO (5)	0.077	PANIONIOS (11)	0.0802	IRAKLIS (4)	0.0909	PAOK (6)	0.0810	PAO (3)	0.0769
OSFP [58] (2)	0.080	IRAKLIS (7)	0.0928	PAOK (6)	0.0923	ERGOTELIS (9)	0.0814	ASTERAS TRIPOLIS (7)	0.0814
CHALCEDON (7)	0.090	IONIKOS (10)	0.0944	ATROMITOS ATHENS (7)	0.0981	KERKIRA (14)	0.0878	IRAKLIS (10)	0.0883
IRAKLIS (8)	0.101	SKODA XANTHI (4)	0.0951	AKRATITOS (16)	0.0985	PAO (3)	0.0892	LARISSA (6)	0.0943
IONIKOS (9)	0.103	CHALCEDON [59] (8)	0.0967	LARISSA (8)	0.1011	PANIONIOS (5)	0.0939	ERGOTELIS (13)	0.1032
PROODEFTIKI (16)	0.107	OSFP (1)	0.1017	APOLLON KALAMARIAS (9)	0.1032	APOLLON KALAMARIAS (12)	0.0963	PAOK (9)	0.1036
AEK (4)	0.108	KALLITHEA (9)	0.1021	OSFP (1)	0.1036	AEK (2)	0.0989	SKODA XANTHI (8)	0.1121
KALLITHEA (12)	0.109	OFI (13)	0.1063	EGALEO (10)	0.1046	IRAKLIS (13)	0.1024	OFI (12)	0.1137
SKODA XANTHI (10)	0.111	PAOK (5)	0.1080	IONIKOS (12)	0.1049	OFI (7)	0.1054	ATROMITOS ATHENS (14)	0.1143
PANILIAKOS (15)	0.118	KERKIRA (16)	0.1126	LEVADIAKOS (14)	0.1084	LARISSA (10)	0.1173	PANIONIOS (5)	0.1210
OFI (11)	0.121	ARIS (14)	0.1149	OFI (13)	0.1085	ATROMITOS ATHENS (8)	0.1192	VERIA (15)	0.1279
ARIS (13)	0.131	APOLLON KALAMARIAS (12)	0.1260	PANIONIOS (11)	0.1166	EGALEO (15)	0.1223	LEVADIAKOS (11)	0.1304
AKRATITOS (14)	0.160	ERGOTELIS (15)	0.1295	KALLITHEA (15)	0.1204	IONIKOS (16)	0.1501	APOLLON KALAMARIAS (16)	0.1475

Source: www.galanissportsdata.com, own calculations.

[54] The number in the brackets represents team's final league ranking.

[55] Goals Conceded/Total Opponent's Shots.

[56] The 90-minute result of the football game APOLLON KALAMARIAS vs. OSFP (1-0) and not the, exogenously determined, official is incorporated in the study.

[57] Panathinaikos A.O.

[58] Olympiacos S.F.P.

[59] The football club CHALCEDON participated in the following league as ATROMITOS ATHENS.

Table 3: Alternative rankings of effective offensive operation [60]

1998-99	GS/TS [61]	1999-2000	GS/TS	2000-01	GS/TS	2001-02	GS/TS	2002-03	GS/TS
OSFP [62] (1)	0.1376	OSFP (1)	0.150	OSFP (1)	0.1600	AEK (2)	0.16497	AEK (3)	0.1741
AEK (2)	0.1195	PAO (2)	0.138	PAOK (4)	0.1325	OSFP (1)	0.14807	OSFP (1)	0.1634
IONIKOS (5)	0.1183	AEK (3)	0.135	AEK (3)	0.1253	PAOK (4)	0.14323	PAOK (4)	0.1446
APOLLON ATHENS (14)	0.1080	OFI (4)	0.122	PANIONIOS (9)	0.1250	PAO (3)	0.13119	IRAKLIS (7)	0.1092
PANIONIOS (15)	0.1066	TRIKALA (18)	0.118	PAS GIANNENA (13)	0.1159	AKRATITOS (11)	0.12500	SKODA XANTHI (9)	0.1000
KAVALA (10)	0.1050	PANIONIOS (8)	0.117	ATHINAIKOS (16)	0.1156	SKODA XANTHI (5)	0.12057	OFI (8)	0.0995
IRAKLIS (9)	0.0968	PANILIAKOS (13)	0.112	PAO (2)	0.1099	PANIONIOS (7)	0.10165	PANIONIOS (5)	0.0992
ARIS (6)	0.0957	IRAKLIS (6)	0.109	IRAKLIS (5)	0.1095	IRAKLIS (6)	0.08964	PAO (2)	0.0969
ETHNIKOS ASTIR (11)	0.0924	KALAMATA (9)	0.107	IONIKOS (6)	0.1060	OFI (8)	0.08533	ARIS (6)	0.0954
OFI (8)	0.0914	PAOK (5)	0.106	PANAHAIKI (11)	0.1024	PANAHAIKI (13)	0.08360	AKRATITOS (12)	0.0946
PAO [63] (3)	0.0909	ARIS (7)	0.102	ETHNIKOS ASTIR (10)	0.0988	ARIS (9)	0.07740	PROODEFTIKI (11)	0.0893
SKODA XANTHI (7)	0.0854	PANAHAIKI (14)	0.093	OFI (12)	0.0987	EGALEO (10)	0.07736	KALLITHEA (13)	0.0799
PAOK (4)	0.0835	PROODEFTIKI (16)	0.087	KALAMATA (15)	0.0954	IONIKOS (12)	0.07473	PAS GIANNENA (16)	0.0760
PANILIAKOS (13)	0.0822	IONIKOS (10)	0.086	ARIS (7)	0.0894	ETHNIKOS ASTIR (14)	0.07280	IONIKOS (14)	0.0692
PROODEFTIKI (12)	0.0798	APOLLON ATHENS (17)	0.085	PANILIAKOS (14)	0.0732			EGALEO (10)	0.0656
PANELEFSINIAKOS (16)	0.0587	SKODA XANTHI (11)	0.077	SKODA XANTHI (8)	0.0721			PANAHAIKI (15)	0.0385
ETHNIKOS PIRAEUS (18)	0.0499	KAVALA (15)	0.073						
VERIA (17)	0.0417	ETHNIKOS ASTIR (12)	0.069						

Source: www.galanissportsdata.com, own calculations.

[60] The number in the brackets represents team's final league ranking.

[61] Goals Scored/Total Shots.

[62] Olympiacos S.F.P.

[63] Panathinaikos A.O.

Table 4: Alternative rankings of effective offensive operation (Continue) [64]

2003-04	GS/TS [65]	2004-2005	GS/TS	2005-06	GS/TS	2006-07	GS/TS	2007-08 [66]	GS/TS
OSFP [67] (2)	0.14675	KALLITHEA (9)	0.1318	PAOK (6)	0.1397	OFI (7)	0.1340	AEK (2)	0.153
AEK (4)	0.13073	AEK (3)	0.1230	PAO (3)	0.1244	OSFP (1)	0.1289	OSFP (1)	0.125
PAO [68] (1)	0.12375	PAOK (5)	0.1215	OSFP (1)	0.1152	AEK (2)	0.1224	OFI (12)	0.113
PANIONIOS (6)	0.11527	SKODA XANTHI (4)	0.1208	AEK (2)	0.1148	ATROMITOS ATHENS (8)	0.1198	PANIONIOS (5)	0.110
CHALCEDON (7)	0.10959	CHALCEDON [69] (8)	0.1115	ATROMITOS ATHENS (7)	0.1139	PAO (3)	0.1106	SKODA XANTHI (8)	0.108
PAOK (3)	0.10780	OSFP (1)	0.1055	KALLITHEA (15)	0.1057	KERKIRA (14)	0.0994	IRAKLIS (10)	0.104
AKRATITOS (14)	0.10653	OFI (13)	0.1053	IRAKLIS (4)	0.1054	PAOK (6)	0.0976	LEVADIAKOS (11)	0.100
IONIKOS (9)	0.10645	PAO (2)	0.1014	IONIKOS (12)	0.1037	ARIS (4)	0.0938	ASTERAS TRIPOLIS (7)	0.099
KALLITHEA (12)	0.10109	APOLLON KALAMARIAS (12)	0.0954	APOLLON KALAMARIAS (9)	0.1006	LARISSA (10)	0.0935	ARIS (4)	0.098
PROODEFTIKI (16)	0.10039	IRAKLIS (7)	0.0909	PANIONIOS (11)	0.0938	APOLLON KALAMARIAS (12)	0.0854	LARISSA (6)	0.096
IRAKLIS (8)	0.09153	EGALEO (6)	0.0906	SKODA XANTHI (5)	0.0886	PANIONIOS (5)	0.0842	PAOK (9)	0.095
PANILIAKOS (15)	0.08211	ARIS (14)	0.0804	LEVADIAKOS (14)	0.0830	ERGOTELIS (9)	0.0815	PAO (3)	0.091
SKODA XANTHI (10)	0.08163	PANIONIOS (11)	0.0776	LARISSA (8)	0.0803	IRAKLIS (13)	0.0803	APOLLON KALAMARIAS (16)	0.081
EGALEO (5)	0.07957	IONIKOS (10)	0.0769	EGALEO (10)	0.0772	EGALEO (15)	0.0796	ERGOTELIS (13)	0.080
OFI (11)	0.07918	KERKIRA (16)	0.0742	AKRATITOS (16)	0.0757	SKODA XANTHI (11)	0.0748	VERIA (15)	0.078
ARIS (13)	0.06761	ERGOTELIS (15)	0.0633	OFI (13)	0.0632	IONIKOS (16)	0.0475	ATROMITOS ATHENS (14)	0.075

Source: www.galanissportsdata.com, own calculations.

[64] The number in the brackets represents team's final league ranking.

[65] Goals Scored/Total Shots.

[66] The 90-minute result of the football game APOLLON KALAMARIAS vs. OSFP (1-0) and not the, exogenously determined, official is incorporated in the study.

[67] Olympiacos S.F.P.

[68] Panathinaikos A.O.

[69] The football club CHALCEDON participated in the following league as ATROMITOS ATHENS.

Table 5: Alternative rankings of effective athletic/on-field performance [70]

1998-99	GS/GC [71]	1999-2000	GS/GC	2000-01	GS/GC	2001-02	GS/GC	2002-03	GS/GC
OSFP [72] (1)	3.727	OSFP (1)	4.778	OSFP (1)	3.818	AEK (2)	2.321	OSFP (1)	3.571
AEK (2)	2.630	PAO (2)	3.833	PAO (2)	3.050	OSFP (1)	2.300	PAO (2)	2.632
PAO [73] (3)	1.833	AEK (3)	1.769	AEK (3)	1.794	PAO (3)	2.120	AEK (3)	2.552
IONIKOS (5)	1.778	PAOK (5)	1.455	PAOK (4)	1.375	SKODA XANTHI (5)	1.308	PAOK (4)	1.553
PAOK (4)	1.677	OFI (4)	1.364	IRAKLIS (5)	1.125	PAOK (4)	1.222	PANIONIOS (5)	1.400
SKODA XANTHI (7)	1.333	ARIS (7)	1.087	IONIKOS (6)	1.000	PANIONIOS (7)	1.121	IRAKLIS (7)	1.189
ARIS (6)	1.233	IRAKLIS (6)	1.000	PANIONIOS (9)	0.929	IRAKLIS (6)	0.914	OFI (8)	1.147
IRAKLIS (9)	1.200	PANILIAKOS (13)	0.917	ARIS (7)	0.902	OFI (8)	0.914	ARIS (6)	1.088
OFI (8)	1.136	SKODA XANTHI (11)	0.837	OFI (12)	0.796	ARIS (9)	0.735	SKODA XANTHI (9)	0.939
PROODEFTIKI (12)	0.757	IONIKOS (10)	0.800	PAS GIANNENA (13)	0.755	AKRATITOS (11)	0.707	PROODEFTIKI (11)	0.658
KAVALA (10)	0.742	PANIONIOS (8)	0.794	PANAHAIKI (11)	0.696	EGALEO (10)	0.587	EGALEO (10)	0.636
PANIONIOS (15)	0.724	PANAHAIKI (14)	0.787	ETHNIKOS ASTIR (10)	0.654	PANAHAIKI (13)	0.473	KALLITHEA (13)	0.630
ETHNIKOS ASTIR (11)	0.690	KALAMATA (9)	0.719	SKODA XANTHI (8)	0.649	IONIKOS (12)	0.447	PAS GIANNENA (16)	0.568
PANILIAKOS (13)	0.685	ETHNIKOS ASTIR (12)	0.660	KALAMATA (15)	0.591	ETHNIKOS ASTIR (14)	0.432	AKRATITOS (12)	0.532
APOLLON ATHENS (14)	0.677	APOLLON ATHENS (17)	0.508	ATHINAIKOS (16)	0.569			IONIKOS (14)	0.524
PANELEFSINIAKOS (16)	0.510	KAVALA (15)	0.500	PANILIAKOS (14)	0.565			PANAHAIKI (15)	0.155
VERIA (17)	0.364	PROODEFTIKI (16)	0.491						
ETHNIKOS PIRAEUS (18)	0.210	TRIKALA (18)	0.473						

Source: www.galanissportsdata.com, own calculations.

[70] The number in the brackets represents team's final league ranking.

[71] Goals Scored/Goals Conceded.

[72] Olympiacos S.F.P.

[73] Panathinaikos A.O.

Table 6: Alternative rankings of effective athletic/on-field performance (Continue) [74]

2003-04	GS/GC [75]	2004-2005	GS/GC	2005-06	GS/GC	2006-07	GS/GC	2007-08 [76]	GS/GC
OSFP [77] (2)	3.684	OSFP (1)	3.000	OSFP (1)	2.739	OSFP (1)	2.696	AEK (2)	3.824
PAO [78] (1)	3.444	PAO (2)	2.833	PAO (3)	2.391	AEK (2)	2.222	PAO (3)	2.444
AEK (4)	1.781	AEK (3)	2.091	AEK (2)	2.100	PAO (3)	1.679	OSFP (1)	2.292
PAOK (3)	1.741	SKODA XANTHI (4)	1.483	PAOK (6)	1.419	ARIS (4)	1.231	ARIS (4)	1.650
EGALEO (5)	1.423	EGALEO (6)	1.192	IRAKLIS (4)	1.258	PAOK (6)	1.103	LARISSA (6)	1.167
PANIONIOS (6)	1.379	IRAKLIS (7)	1.161	SKODA XANTHI (5)	1.240	SKODA XANTHI (11)	1.091	ASTERAS TRIPOLIS (7)	1.167
CHALCEDON (7)	1.026	PAOK (5)	1.103	ATROMITOS ATHENS (7)	0.973	PANIONIOS (5)	1.065	PANIONIOS (5)	0.929
IRAKLIS (8)	1.026	CHALCEDON [79] (8)	0.895	APOLLON KALAMARIAS (9)	0.889	KERKIRA (14)	0.944	SKODA XANTHI (8)	0.846
KALLITHEA (12)	0.881	KALLITHEA (9)	0.886	IONIKOS (12)	0.878	ERGOTELIS (9)	0.938	PAOK (9)	0.829
IONIKOS (9)	0.767	OFI (13)	0.818	LARISSA (8)	0.838	OFI (7)	0.911	IRAKLIS (10)	0.824
SKODA XANTHI (10)	0.667	PANIONIOS (11)	0.781	PANIONIOS (11)	0.733	ATROMITOS ATHENS (8)	0.909	OFI (12)	0.796
OFI (11)	0.614	ARIS (14)	0.730	LEVADIAKOS (14)	0.667	LARISSA (10)	0.789	ERGOTELIS (13)	0.667
ARIS (13)	0.522	IONIKOS (10)	0.688	OFI (13)	0.622	APOLLON KALAMARIAS (12)	0.750	ATROMITOS ATHENS (14)	0.639
PANILIAKOS (15)	0.500	APOLLON KALAMARIAS (12)	0.633	KALLITHEA (15)	0.571	IRAKLIS (13)	0.647	LEVADIAKOS (11)	0.608
PROODEFTIKI (16)	0.464	KERKIRA (16)	0.429	EGALEO (10)	0.561	EGALEO (15)	0.600	APOLLON KALAMARIAS (16)	0.519
AKRATITOS (14)	0.449	ERGOTELIS (15)	0.380	AKRATITOS (16)	0.404	IONIKOS (16)	0.237	VERIA (15)	0.477

Source: www.galanissportsdata.com, own calculations.

[74] The number in the brackets represents team's final league ranking.

[75] Goals Scored/Goals Conceded.

[76] The 90-minute result of the football game APOLLON KALAMARIAS vs. OSFP (1-0) and not the, exogenously determined, official is incorporated in the study.

[77] Olympiacos S.F.P.

[78] Panathinaikos A.O.

[79] The football club CHALCEDON participated in the following league as ATROMITOS ATHENS.

Table 7: Analysis of a team's general efficiency in every season with the use of financial & sport data

Paper	Country	Methodology	Orientation	Data	Inputs			Outputs	
					Salaries & Wage bills	Net assets & Stadium facilities	Other costs e.g., Investments	Points & Qualifications	Revenues from tickets, sales, TV etc.
Barros & Santos, 2005	Portugal	DEA	Output oriented	Balanced panel data	**X**	Supplies & Services expenditure	**X**	**X**	**X**
Barros & Leach, 2006a	U.K.	DEA	Output oriented	Balanced panel data	**X**	**X**	Number of players	**X**	**X**
Barros & Leach, 2006b	U.K.	SFA	-	Balanced panel data	**X**	**X**		**X**	**X**
Barros & Leach, 2007	U.K.	SFA	-	Balanced panel data	**X**	**X**		**X**	**X**
Barros & Garcia-del-Barrio, 2008	U.K.	SFA	-	Balanced panel data	**X**	**X**	**X**	**X**	**X**
Barros et al., forthcoming	Spain	SFA	-	Unbalanced panel data	**X**	**X**	**X**	**X**	**X**
Haas, 2003a	U.K.	DEA	Input oriented	Cross sectional data	**X**			**X**	**X**
Haas, 2003b	USA	DEA	Input oriented	Cross sectional data	**X**			**X**	**X**
Haas et al., 2004	Germany	DEA	Input oriented	Cross sectional data	**X**			**X**	**X**
Kern & Süssmuth, 2005	Germany	SFA	-	Cross sectional/pool data	**X**			**X**	**X**
Guzman, 2006	Spain	DEA	Input oriented	Financial cross sectional data	**X**		**X**		**X**
Guzman & Morrow, 2007	U.K.	DEA	Input oriented	Financial cross sectional data	**X**	Director's remuneration	General expenses	**X**	**X**

Table 8: Analysis of a team's general efficiency in every season with the use of sport/match level data

Paper	Country	Methodology	Orientation	Data	Inputs				Outputs		
					Number of players	Attacking moves	Ball possession	Shots	Headers	Points	Goal difference
Espitia-Escuer & Garcia-Cebrian, 2004	Spain	DEA	Input oriented	Cross sectional/pool data	**X**	**X**	**X**	**X**	**X**	**X**	
Espitia-Escuer & Garcia-Cebrian, 2005	Spain	DEA	Input oriented	Cross sectional data	**X**	**X**	**X**	**X**	**X**		**X**
Espitia-Escuer & Garcia-Cebrian, 2006	Spain	DEA	Output oriented	Cross sectional data	**X**	**X**	**X**	**X**		**X**	

Table 9: Separation of offensive/defensive operation

Paper	Country	Methodology	Orientation	Data	Inputs				Outputs		
					Shots on & off goal	Ball possession	Passes & Crosses	Attacking moves	Goal difference	Goals scored	Goals conceded (inverse)
Bosca et al., 2009	Spain	DEA	Output oriented	Cross sectional data	**X ***	**X ***	**X ***	**X ***		**X**	**X**
Carmichael & Thomas, 2005	EURO 2004	SFA	-	« »	**X**	**X ***			**X**		
					Tackles & Cards	Saves	Corners				
« »	Spain	DEA	« »	« »							
« »	EURO 2004	SFA	-	« »	**X**	**X**	**X**				

* For both the observed team and its opponent.

Table 10: Analysis of a team's general efficiency in multiple stages with the use of sport/match level data

Paper	Country	Methodology	Orientation	Data	Inputs					Outputs	
					Saves	Cards	Shots	Ball touches	Goals (for/against)	Points	Attendance
Carmichael et al., 2001	U.K.	SFA [80]	-	Cross sectional data	**X**	**X**	**X**	**X**	**X**	**X**	
Garcia-Sanchez, 2007	Spain	DEA [81]	Output oriented	« »	**X**		**X**			**X**	**X**
					Ball recovery	Attacking moves	Ball possession	Passes & Crosses		Goals (for/against)	Shots
Carmichael et al., 2001	U.K.	SFA	-	« »		**X**	**X**	**X**		**X**	**X**
Garcia-Sanchez, 2007	Spain	DEA	Output oriented	« »	**X**	**X**	**X ***	**X**		**X**	

* For both the observed team and its opponent.

[80] Application of a multiple stage equation system.

[81] Application of a three-stage-DEA model.

Table 11: Analysis of a team's general efficiency during a European football competition with the use of sport/match level data

Paper: Papahristodoulou, 2006

Unit: All thirty two (32) participated football teams in the UEFA Champions League (CL) tournament of the period 2005-06

Methodology: DEA

Orientation: Output oriented

Data: Cross sectional

Inputs:
- UEFA ranking
- Ball possession
- Shots on goal
- Corners
- Home attendance

} *"High quality"*

- Yellow cards
- Fouls committed
- Shots wide
- Offsides
- Goals conceded

} *"Low quality"*

Outputs:
- Points won
- Goals scored

Comments: The DEA model was applied in thirty different outputs-inputs (five dataset) specifications.

Table 12: Analysis of the efficient play level of individual sportsmen

Paper: Alp, 2006

Unit: All thirty six (36) goalkeepers participated in the 2002 FIFA World Cup

Methodology: DEA

Orientation: Output oriented

Data: Cross sectional sport data

Inputs: The input value of all goalkeepers is one (1)

Outputs: - The inverse of the goals conceded per match
- Penalty kicks saved per match
- Free kicks saved per match
- Corner kicks saved per match
- Fast break saved per match
- Individual saves per match

Comments: The Andersen/Petersen super efficiency separation technique (1993) was applied, in order the best units to be additionally arranged.

Table 13: Analysis of the football manager's efficiency

Paper: Dawson et al., 2000b
Unit: Managers in English soccer's Premier League for the period 1992 to 1998
Methodology: SFA with the use of fix and random effects models
Data: Sport unbalanced panel data
Inputs: - Player age - Career league experiences - Career goals - Number of previous clubs - League appearances in the previous season - Goals scored in previous season - The player's divisional status in the previous season - A binary variable with the value of unity for current international players and zero for noncurrent internationals
Outputs: Ratio of the total number of wins to the total number of games played

Table 14: Operating efficiency of the defence [82]

1998-99		1999-2000		2000-01		2001-02		2002-03	
OSFP [83] (1)	1	OSFP (1)	1	PAO (2)	1	PAO (3)	1	OSFP (1)	1
AEK (2)	0.793	PAO (2)	0.837	OSFP (1)	0.935	PANIONIOS (7)	1	PAO (2)	1
SKODA XANTHI (7)	0.784	PANAHAIKI (14)	0.572	SKODA XANTHI (8)	0.723	OSFP (1)	0.954	PANIONIOS (5)	0.872
PAOK (4)	0.711	PANILIAKOS (13)	0.525	AEK (3)	0.621	AEK (2)	0.92	PROODEFTIKI (11)	0.702
PAO [84] (3)	0.663	SKODA XANTHI (11)	0.489	IRAKLIS (5)	0.582	SKODA XANTHI (5)	0.865	AEK (3)	0.66
IONIKOS (5)	0.619	AEK (3)	0.466	ARIS (7)	0.559	ARIS (9)	0.865	IONIKOS (14)	0.569
PROODEFTIKI (12)	0.509	ETHNIKOS ASTIR (12)	0.445	PANILIAKOS (14)	0.527	OFI (8)	0.751	ARIS (6)	0.552
ARIS (6)	0.49	OFI (4)	0.432	PANIONIOS (9)	0.523	IRAKLIS (6)	0.743	KALLITHEA (13)	0.507
PANILIAKOS (13)	0.453	ARIS (7)	0.431	IONIKOS (6)	0.522	ETHNIKOS ASTIR (14)	0.727	OFI (8)	0.505
PANELEFSINIAKOS (16)	0.445	PAOK (5)	0.429	PAOK (4)	0.499	AKRATITOS (11)	0.684	PAS GIANNENA (16)	0.497
KAVALA (10)	0.437	KALAMATA (9)	0.422	PANAHAIKI (11)	0.479	IONIKOS (12)	0.663	PAOK (4)	0.477
ETHNIKOS ASTIR (11)	0.436	IONIKOS (10)	0.4	ETHNIKOS ASTIR (10)	0.441	PAOK (4)	0.64	EGALEO (10)	0.469
IRAKLIS (9)	0.432	IRAKLIS (6)	0.392	ATHINAIKOS (16)	0.427	EGALEO (10)	0.628	IRAKLIS (7)	0.452
VERIA (17)	0.43	APOLLON ATHENS (17)	0.382	PAS GIANNENA (13)	0.417	PANAHAIKI (13)	0.56	SKODA XANTHI (9)	0.429
OFI (8)	0.409	TRIKALA (18)	0.36	OFI (12)	0.408			AKRATITOS (12)	0.414
PANIONIOS (15)	0.399	PANIONIOS (8)	0.349	KALAMATA (15)	0.394			PANAHAIKI (15)	0.298
APOLLON ATHENS (14)	0.393	PROODEFTIKI (16)	0.344						
ETHNIKOS PIRAEUS (18)	0.272	KAVALA (15)	0.272						

Source: Coelli's computer program (DEAP version 2.1-1996b) has been used for the resolution of the Data Envelopment Analysis.

[82] The number in the brackets represents team's final league ranking.

[83] Olympiacos S.F.P.

[84] Panathinaikos A.O.

Table 15: Operating efficiency of the defence (Continue) [85]

2003-04		2004-2005		2005-06		2006-07		2007-08 [86]	
PAO [87] (1)	1	OSFP (1)	1	OSFP (1)	1	OSFP (1)	1	PAO (3)	1
OSFP [88] (2)	1	PAO (2)	1	AEK (2)	1	AEK (2)	1	AEK (2)	0.936
EGALEO (5)	0.797	AEK (3)	0.85	PAO (3)	0.911	SKODA XANTHI (11)	1	ASTERAS TRIPOLIS (7)	0.796
PANIONIOS (6)	0.58	EGALEO (6)	0.781	SKODA XANTHI (5)	0.805	PAO (3)	0.846	ARIS (4)	0.722
CHALCEDON (7)	0.54	PANIONIOS (11)	0.641	LEVADIAKOS (14)	0.642	ARIS (4)	0.84	OSFP (1)	0.705
AEK (4)	0.534	IONIKOS (10)	0.636	IRAKLIS (4)	0.636	IRAKLIS (13)	0.793	ATROMITOS ATHENS (14)	0.528
IONIKOS (9)	0.489	SKODA XANTHI (4)	0.58	APOLLON KALAMARIAS (9)	0.563	LARISSA (10)	0.747	LARISSA (6)	0.492
KALLITHEA (12)	0.481	IRAKLIS (7)	0.526	OFI (13)	0.543	APOLLON KALAMARIAS (12)	0.738	PAOK (9)	0.434
PAOK (3)	0.475	KALLITHEA (9)	0.513	PAOK (6)	0.538	PANIONIOS (5)	0.71	IRAKLIS (10)	0.432
IRAKLIS (8)	0.398	CHALCEDON [89] (8)	0.504	EGALEO (10)	0.537	KERKIRA (14)	0.699	PANIONIOS (5)	0.425
PROODEFTIKI (16)	0.369	ARIS (14)	0.489	ATROMITOS ATHENS (7)	0.532	PAOK (6)	0.696	SKODA XANTHI (8)	0.386
ARIS (13)	0.367	KERKIRA (16)	0.471	PANIONIOS (11)	0.524	ERGOTELIS (9)	0.648	VERIA (15)	0.373
SKODA XANTHI (10)	0.347	APOLLON KALAMARIAS (12)	0.353	LARISSA (8)	0.521	ATROMITOS ATHENS (8)	0.644	ERGOTELIS (13)	0.346
AKRATITOS (14)	0.340	PAOK (5)	0.324	AKRATITOS (16)	0.483	EGALEO (15)	0.502	LEVADIAKOS (11)	0.304
OFI (11)	0.305	OFI (13)	0.316	IONIKOS (12)	0.465	IONIKOS (16)	0.41	OFI (12)	0.287
PANILIAKOS (15)	0.286	ERGOTELIS (15)	0.305	KALLITHEA (15)	0.457	OFI (7)	0.403	APOLLON KALAMARIAS (16)	0.267

Source: Coelli's computer program (DEAP version 2.1-1996b) has been used for the resolution of the Data Envelopment Analysis.

[85] The number in the brackets represents team's final league ranking.

[86] The 90-minute result of the football game APOLLON KALAMARIAS vs. OSFP (1-0) and not the, exogenously determined, official is incorporated in the study.

[87] Panathinaikos A.O.

[88] Olympiacos S.F.P.

[89] The football club CHALCEDON participated in the following league as ATROMITOS ATHENS.

Table 16: Operating efficiency of the offense [90]

1998-99		1999-2000		2000-01		2001-02		2002-03	
OSFP [91] (1)	1	OSFP (1)	1	OSFP (1)	1	OSFP (1)	1	AEK (3)	1
IONIKOS (5)	1	PANILIAKOS (13)	1	PANAHAIKI (11)	1	AEK (2)	1	PAOK (4)	1
APOLLON ATHENS (14)	1	OFI (4)	0.979	PAS GIANNENA (13)	1	OFI (8)	1	OFI (8)	1
PANIONIOS (15)	0.92	TRIKALA (18)	0.974	ATHINAIKOS (16)	0.979	AKRATITOS (11)	0.985	OSFP (1)	0.981
KAVALA (10)	0.879	PAO (2)	0.964	KALAMATA (15)	0.961	IONIKOS (12)	0.984	PAS GIANNENA (16)	0.944
AEK (2)	0.869	PANIONIOS (8)	0.961	OFI (12)	0.95	PAO (3)	0.979	PAO (2)	0.841
ETHNIKOS ASTIR (11)	0.818	PROODEFTIKI (16)	0.92	PAO (2)	0.869	PAOK (4)	0.868	PANIONIOS (5)	0.823
ARIS (6)	0.798	AEK (3)	0.9	PANIONIOS (9)	0.852	IRAKLIS (6)	0.856	AKRATITOS (12)	0.789
IRAKLIS (9)	0.765	KALAMATA (9)	0.852	AEK (3)	0.834	PANIONIOS (7)	0.84	ARIS (6)	0.772
PANILIAKOS (13)	0.748	IRAKLIS (6)	0.826	IONIKOS (6)	0.832	SKODA XANTHI (5)	0.731	IRAKLIS (7)	0.748
SKODA XANTHI (7)	0.728	PANAHAIKI (14)	0.786	PAOK (4)	0.828	PANAHAIKI (13)	0.682	PROODEFTIKI (11)	0.704
PROODEFTIKI (12)	0.717	ARIS (7)	0.781	ETHNIKOS ASTIR (10)	0.774	ARIS (9)	0.674	KALLITHEA (13)	0.684
PAO [92] (3)	0.665	PAOK (5)	0.776	IRAKLIS (5)	0.77	EGALEO (10)	0.614	SKODA XANTHI (9)	0.672
OFI (8)	0.664	IONIKOS (10)	0.739	PANILIAKOS (14)	0.718	ETHNIKOS ASTIR (14)	0.527	IONIKOS (14)	0.628
ETHNIKOS PIRAEUS (18)	0.648	ETHNIKOS ASTIR (12)	0.66	ARIS (7)	0.606			EGALEO (10)	0.57
PAOK (4)	0.607	APOLLON ATHENS (17)	0.658	SKODA XANTHI (8)	0.481			PANAHAIKI (15)	0.492
PANELEFSINIAKOS (16)	0.592	SKODA XANTHI (11)	0.596						
VERIA (17)	0.359	KAVALA (15)	0.561						

Source: Coelli's computer program (DEAP version 2.1-1996b) has been used for the resolution of the Data Envelopment Analysis.

[90] The number in the brackets represents team's final league ranking.

[91] Olympiacos S.F.P.

[92] Panathinaikos A.O.

Table 17: Operating efficiency of the offense (Continue) [93]

2003-04		2004-2005		2005-06		2006-07		2007-08 [94]	
PAO [95] (1)	1	SKODA XANTHI (4)	1	OSFP (1)	1	OSFP (1)	1	OSFP (1)	1
OSFP [96] (2)	1	KALLITHEA (9)	1	PAO (3)	1	PAOK (6)	1	AEK (2)	1
PANIONIOS (6)	1	AEK (3)	0.933	IRAKLIS (4)	1	OFI (7)	1	PAOK (9)	1
AKRATITOS (14)	1	ARIS (14)	0.931	PAOK (6)	1	PANIONIOS (5)	0.957	LEVADIAKOS (11)	1
IRAKLIS (8)	0.922	PAOK (5)	0.926	APOLLON KALAMARIAS (9)	1	PAO (3)	0.955	PAO (3)	0.957
EGALEO (5)	0.896	OSFP (1)	0.857	SKODA XANTHI (5)	0.969	KERKIRA (14)	0.946	LARISSA (6)	0.946
AEK (4)	0.894	CHALCEDON [97] (8)	0.846	LARISSA (8)	0.939	ATROMITOS ATHENS (8)	0.934	PANIONIOS (5)	0.911
PAOK (3)	0.887	EGALEO (6)	0.838	IONIKOS (12)	0.935	AEK (2)	0.924	ERGOTELIS (13)	0.875
IONIKOS (9)	0.883	PAO (2)	0.808	AEK (2)	0.902	LARISSA (10)	0.892	ARIS (4)	0.868
CHALCEDON (7)	0.881	KERKIRA (16)	0.808	KALLITHEA (15)	0.89	ERGOTELIS (9)	0.878	OFI (12)	0.812
KALLITHEA (12)	0.858	OFI (13)	0.804	LEVADIAKOS (14)	0.889	EGALEO (15)	0.826	IRAKLIS (10)	0.811
PROODEFTIKI (16)	0.857	IONIKOS (10)	0.786	ATROMITOS ATHENS (7)	0.866	SKODA XANTHI (11)	0.754	ASTERAS TRIPOLIS (7)	0.784
PANILIAKOS (15)	0.851	APOLLON KALAMARIAS (12)	0.76	OFI (13)	0.821	IRAKLIS (13)	0.714	APOLLON KALAMARIAS (16)	0.778
ARIS (13)	0.806	IRAKLIS (7)	0.744	PANIONIOS (11)	0.78	ARIS (4)	0.707	SKODA XANTHI (8)	0.728
SKODA XANTHI (10)	0.764	PANIONIOS (11)	0.642	EGALEO (10)	0.652	APOLLON KALAMARIAS (12)	0.672	ATROMITOS ATHENS (14)	0.719
OFI (11)	0.711	ERGOTELIS (15)	0.576	AKRATITOS (16)	0.64	IONIKOS (16)	0.454	VERIA (15)	0.7

Source: Coelli's computer program (DEAP version 2.1-1996b) has been used for the resolution of the Data Envelopment Analysis.

[93] The number in the brackets represents team's final league ranking.

[94] The 90-minute result of the football game APOLLON KALAMARIAS vs. OSFP (1-0) and not the, exogenously determined, official is incorporated in the study.

[95] Panathinaikos A.O.

[96] Olympiacos S.F.P.

[97] The football club CHALCEDON participated in the following league as ATROMITOS ATHENS.

Table 18: Effectiveness level of the athletic/on-field performance [98]

1998-99		1999-2000		2000-01		2001-02		2002-03	
PAO [99] (3)	1	OSFP (1)	1	OSFP (1)	1	OSFP (1)	1	PAO (2)	1
OFI (8)	1	PAO (2)	1	AEK (3)	1	AEK (2)	1	AEK (3)	1
ARIS (6)	0.982	AEK (3)	1	PAOK (4)	1	PAOK (4)	1	PAOK (4)	1
PAOK (4)	0.918	OFI (4)	1	SKODA XANTHI (8)	1	SKODA XANTHI (5)	0.991	IRAKLIS (7)	1
IRAKLIS (9)	0.873	PAOK (5)	0.943	PAO (2)	0.969	PAO (3)	0.969	ARIS (6)	0.949
AEK (2)	0.833	IRAKLIS (6)	0.887	ARIS (7)	0.935	ARIS (9)	0.742	OSFP (1)	0.911
IONIKOS (5)	0.778	PANIONIOS (8)	0.884	IONIKOS (6)	0.831	IRAKLIS (6)	0.735	PANIONIOS (5)	0.81
KAVALA (10)	0.771	ARIS (7)	0.853	IRAKLIS (5)	0.814	EGALEO (10)	0.73	OFI (8)	0.789
OSFP [100] (1)	0.764	SKODA XANTHI (11)	0.774	OFI (12)	0.791	PANIONIOS (7)	0.718	SKODA XANTHI (9)	0.777
ETHNIKOS ASTIR (11)	0.736	KAVALA (15)	0.77	PAS GIANNENA (13)	0.774	OFI (8)	0.595	EGALEO (10)	0.748
APOLLON ATHENS (14)	0.735	ETHNIKOS ASTIR (12)	0.764	ETHNIKOS ASTIR (10)	0.754	ETHNIKOS ASTIR (14)	0.556	AKRATITOS (12)	0.571
SKODA XANTHI (7)	0.691	IONIKOS (10)	0.744	PANIONIOS (9)	0.676	PANAHAIKI (13)	0.467	PROODEFTIKI (11)	0.548
PANILIAKOS (13)	0.673	KALAMATA (9)	0.731	PANAHAIKI (11)	0.674	AKRATITOS (11)	0.448	KALLITHEA (13)	0.54
PANIONIOS (15)	0.643	PANAHAIKI (14)	0.59	PANILIAKOS (14)	0.559	IONIKOS (12)	0.442	IONIKOS (14)	0.509
PROODEFTIKI (12)	0.638	PROODEFTIKI (16)	0.558	KALAMATA (15)	0.521			PAS GIANNENA [101] (16)	0.458
PANELEFSINIAKOS (16)	0.607	PANILIAKOS (13)	0.543	ATHINAIKOS (16)	0.458			PANAHAIKI (15)	0.279
VERIA (17)	0.576	APOLLON ATHENS (17)	0.476						
ETHNIKOS PIRAEUS (18)	0.236	TRIKALA (18)	0.4						

Source: Coelli's computer program (DEAP version 2.1-1996b) has been used for the resolution of the Data Envelopment Analysis.

[98] The number in the brackets represents team's final league ranking.

[99] Panathinaikos A.O.

[100] Olympiacos S.F.P.

[101] Not the exogenously determined official ranking (16th/-65 points), but the match-by-match summation of team's points, is considered in the study.

Table 19: Effectiveness level of the athletic/on-field performance (Continue) [102]

2003-04		2004-05		2005-06		2006-07		2007-08 [103]	
PAO [104] (1)	1	PAO (2)	1	AEK (2)	1	OSFP (1)	1	OSFP (1)	1
PAOK (3)	1	PAOK (5)	1	PAO (3)	1	OFI (7)	1	PAO (3)	1
OSFP [105] (2)	0.974	OSFP (1)	0.987	PAOK (6)	1	AEK (2)	0.945	PANIONIOS (5)	1
AEK (4)	0.893	AEK (3)	0.972	OSFP (1)	0.996	ARIS (4)	0.916	OFI (12)	1
IRAKLIS (8)	0.835	IRAKLIS (7)	0.895	IRAKLIS (4)	0.99	PAO (3)	0.864	AEK (2)	0.995
EGALEO (5)	0.776	SKODA XANTHI (4)	0.872	ATROMITOS ATHENS (7)	0.964	PANIONIOS (5)	0.804	LEVADIAKOS (11)	0.974
OFI (11)	0.753	APOLLON KALAMARIAS (12)	0.812	LARISSA (8)	0.885	PAOK (6)	0.8	SKODA XANTHI (8)	0.914
CHALCEDON (7)	0.738	OFI (13)	0.779	EGALEO (10)	0.815	ATROMITOS ATHENS (8)	0.766	LARISSA (6)	0.892
PANIONIOS (6)	0.686	EGALEO (6)	0.778	IONIKOS (12)	0.805	ERGOTELIS (9)	0.762	APOLLON KALAMARIAS[106](16)	0.873
SKODA XANTHI (10)	0.684	CHALCEDON [107] (8)	0.776	APOLLON KALAMARIAS (9)	0.802	APOLLON KALAMARIAS (12)	0.734	ARIS (4)	0.85
ARIS (13)	0.582	PANIONIOS (11)	0.765	SKODA XANTHI (5)	0.776	SKODA XANTHI (11)	0.672	ASTERAS TRIPOLIS (7)	0.816
PANILIAKOS (15)	0.581	IONIKOS (10)	0.705	PANIONIOS (11)	0.766	EGALEO (15)	0.653	IRAKLIS (10)	0.795
IONIKOS (9)	0.55	KALLITHEA (9)	0.671	OFI (13)	0.713	LARISSA (10)	0.64	ERGOTELIS (13)	0.795
AKRATITOS (14)	0.536	ERGOTELIS (15)	0.624	LEVADIAKOS (14)	0.619	KERKIRA (14)	0.634	PAOK (9)	0.752
KALLITHEA (12)	0.462	ARIS [108] (14)	0.542	KALLITHEA (15)	0.512	IRAKLIS (13)	0.631	VERIA (15)	0.605
PROODEFTIKI (16)	0.429	KERKIRA (16)	0.366	AKRATITOS (16)	0.483	IONIKOS [109] (16)	0.299	ATROMITOS ATHENS (14)	0.6

Source: Coelli's computer program (DEAP version 2.1-1996b) has been used for the resolution of the Data Envelopment Analysis.

[102] The number in the brackets represents team's final league ranking.

[103] The 90-minute result of the football game APOLLON KALAMARIAS vs. OSFP (1-0) and not the, exogenously determined, official is incorporated in the study.

[104] Panathinaikos A.O.

[105] Olympiacos S.F.P.

[106] The fact that APOLLON KALAMARIAS was punished (1-point removal) is not considered in the study.

[107] The football club CHALCEDON participated in the following league as ATROMITOS ATHENS.

[108] The fact that ARIS was punished (3-point removal) is not considered in the study.

[109] The fact that IONIKOS was punished (5-point removal) is not considered in the study.

Table 20: Correlations between alternative measures of effectiveness-points-DEA scores-outputs

	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Average
Points & GC/TOS [110]	-0.53	-0.61	-0.70	-0.08	-0.52	-0.77	-0.69	-0.67	-0.61	-0.82	-0.60
Points & GS/TS [111]	0.72	0.75	0.60	0.85	0.59	0.68	0.60	0.60	0.79	0.67	0.69
Points & GS/GC [112]	0.91	0.92	0.92	0.96	0.66	0.94	0.93	0.95	0.92	0.91	0.90
GC/TOS & GS/TS	-0.33	-0.32	-0.17	-0.13	-0.55	-0.43	-0.28	-0.35	-0.26	-0.55	-0.34
GC/TOS & GS/GC	-0.52	-0.68	-0.68	-0.22	-0.68	-0.68	-0.60	-0.56	-0.51	-0.80	-0.59
GS/TS & GS/GC	0.72	0.74	0.67	0.86	0.82	0.74	0.43	0.66	0.68	0.73	0.71
Points & defensive efficiency [113]	0.86	0.81	0.83	0.67	0.50	0.88	0.79	0.89	0.69	0.85	0.78
GC/TOS & defensive efficiency	-0.61	-0.78	-0.84	-0.52	-0.85	-0.73	-0.77	-0.64	-0.69	-0.84	-0.73
Points & offensive efficiency [114]	0.38	0.44	-0.01	0.56	0.22	0.56	0.39	0.61	0.72	0.64	0.45
GS/TS & offensive efficiency	0.89	0.83	0.59	0.58	0.78	0.71	0.77	0.62	0.78	0.49	0.71
Points & on-field effectiveness [115]	0.75	0.83	0.82	0.91	0.75	0.90	0.87	0.85	0.89	0.60	0.82
GS/GC & on-field effectiveness	0.47	0.61	0.59	0.82	0.72	0.79	0.73	0.73	0.74	0.50	0.67
Defensive & offensive efficiency	0.26	0.40	-0.17	0.33	0.41	0.62	0.18	0.42	0.20	0.35	0.30
Defensive & on-field effectiveness	0.37	0.39	0.63	0.60	0.45	0.62	0.46	0.53	0.41	0.24	0.47
Offensive & on-field effectiveness	0.18	0.15	-0.36	0.19	0.56	0.31	0.19	0.57	0.70	0.60	0.31
Points & Goals Scored	0.94	0.96	0.85	0.94	0.90	0.92	0.90	0.87	0.92	0.86	0.91
Points & Goals Conceded	-0.88	-0.88	-0.89	-0.74	-0.86	-0.91	-0.88	-0.94	-0.75	-0.83	-0.86
Goals Scored & Goals Conceded	-0.72	-0.77	-0.56	-0.55	-0.65	-0.77	-0.66	-0.71	-0.47	-0.54	-0.64

Source: www.galanissportsdata.com, Coelli's computer program (DEAP version 2.1-1996b) & own calculations.

[110] Goals Conceded/Total Opponent's Shots.
[111] Goals Scored/Total Shots.
[112] Goals Scored/Goals Conceded.
[113] DEA scores of operating efficiency of the defence.
[114] DEA scores of operating efficiency of the offense.
[115] DEA scores of on field performance effectiveness.