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Are football managers as efficient as coaches? Performance analysis with *ex-ante* and *ex-post* inputs in the Premier league

Fabíola Zambom-Ferraresi[a]; Belén Iraizóz[b] and Fernando Lera-López[c]*

[a]Department of Economics, Public University of Navarre, Pamplona, Spain; Email: fabiola.zambom@unavarra.es, fabiolahaole@hotmail.com

ORCID: 0000-0001-7068-5269

[b]Department of Economics, Public University of Navarre, Pamplona, Spain; and Institute for Advanced Research in Business and Economics (INARBE); Email: iraizoz@unavarra.es

ORCID: 0000-0002-9131-7323

[c]*(corresponding author) Public University of Navarre - Campus Arrosadia; Department of Economics - Los Madroños building, CP 31006 – Pamplona, Spain; Institute for Advanced Research in Business and Economics (INARBE); Email: lera@unavarra.es

ORCID: 0000-0002-9230-9405

Are football managers as efficient as coaches? Performance analysis with ex-ante and ex-post inputs in the Premier league

There is a controversy on sport performance literature about what type of inputs might explain more deeply the performance of sports clubs (inputs specification controversy). By one side, several papers have analysed sports teams' performance using the match-related statistics or wages as inputs, well-known as ex-post inputs. By other side, some authors have criticized the use of these ex-post inputs, and recommend the use of ex-ante inputs, as the market value of the players. We have analysed the performance of football teams estimating technical efficiency with three different inputs specification. The methodologies employed were data envelopment analysis (DEA) and a bootstrapped DEA. Our sample is composed by English Premier League football clubs, during three seasons (2012/13 - 2014/15). The DEA results indicate that the correlation between the three models is positive and significant. The DEA bootstrapped results help to restate the robustness of the estimations and endorsed the inputs choices. The correlations of the estimations with market value and match-related statistics are the most striking (90 and 94%, DEA and bootstrapped DEA), which indicate that the existent discussion related to the use of match-related statistics as input is unjustified, because it does not affect significantly the efficiency' estimations.

Keywords: Sports economics; controversy; input specification; DEA; English football

Subject classification codes: Z2; L21; C14; C15; L83

1. Introduction

Once upon a time, a modest team from a relatively small city returned, after a decade way, to the top level of football league competition in his country. After struggling to keep the category, unexpectedly, the next season won the competition with a lot of efforts and a little of fortune. This history might be described as a fairy tale to tell children loving football. However, this is not a story, it is a true history that happened in England with the Leicester City. From a scientific perspective, if we consider the squad' market value at the start of the season 2015/16, they should never have won. Leicester ranked nineteen, with a global market value equivalent to one-sixth of Chelsea's market value, for example. On the three previous seasons, the correlation among the market value and the sports performance of the teams was between 80 and 88% and in 2015/16 decreased to only 42%. By not considering the performance on-field of the teams this season, we would be making an important mistake.

In sports economics literature, is widely accepted that the on-field success is directly related to players' skills and abilities (i.e., Szymanski and Kuypers, 1999 and Carmichael et al., 2011). Considering this strong relationship, in open sports system like the European football, with less regulations related with salary caps than the North American sport system, the competition could be focus on getting money to hire the best players and wait to win the championship. Assuredly we should analyse the management of football clubs, but we must not forget what this sport is all about; basically, eleven against eleven kicking the ball. Consequently, to analyse the performance of football clubs by ignoring what players do on-field or consider it inappropriate, is minimally meaningless.

In professional sports team the output is conventionally measured in terms of team success, represented by winning performance. The players' talent is the input of this peculiar production process. This representation was defined more than four decades ago in Scully' (1974) seminal work. Subsequently different approaches were developed, varying the methodology employed, the units under analysis or the inputs specification. Currently is fairly accepted that the production function in football like in other activities have two or more stages. In a first stage, the players with his abilities and skills will produce some plays during the match. In the second stage, these plays will produce an output, which could be to win, to tie, or to lose (in the case of a single match). Regarding these stages, there is a controversy in the literature about the inputs specifications. In other words, what kind of inputs might explain and predict the best teams' performance. On the one hand, several works use ex-post input measures (e.g. game-related statistics) to analyse the performance in sports (Carmichael et al., 2000; Espitia-Escuer and García-Cebrián, 2006; Guzmán and Morrow, 2007; Zambom-Ferraresi et al., 2015). On the other hand, some authors assert (Lee, 2006; and Lee and Berri, 2008) that the only way to analyse the performance of football clubs must be done through ex-ante inputs that measured the players' skills and abilities before the start of the season; such as players' market value (Dawson et al., 2000; Lee and Berri, 2008; del Corral et al., 2015). Moreno and Lozano (2014) have analysed both stages and have found that there is a significant difference between what we expect of the players considering its skills and what players really do.

Motivated by this literature controversy, this paper attempts to fulfil this gap with empirical analysis, by utilizing a data set that contains information that allows analyse football clubs' performance following the two strands of research. We will estimate the efficiency in the English Premier league (EPL) by using three different models. The three models have the same output, but different inputs specifications. The input employed in the first model is the squad' market value (input ex-ante). This input, used to be the best accepted in literature, but as in the case of Leicester City, is not accurate in all the cases. In the second model, we used match statistics of the plays performed by clubs (input ex-post); and in the third one we used the squad' wages (input ex-post). This input is the most criticized on literature. That way, the main objective of this paper is to offer empirical results to contribute to this open discussion about sports team' performance analysis.

Currently, the EPL has the highest revenues, wages and profitability. From to 2016 to 2019 the EPL clubs will to share £8.3 billion TV windfall (Rumsby, 2016). The EPL is also the world's highest earning sports league from media rights in non-domestic markets

(Deloitte, 2016). These circumstances, jointly with seriousness that the EPL is managed since long time ago, make it one of the most important national football leagues in the world. So, to carry out our objective, the efficiency of EPL clubs will be estimated with DEA methodology. We have 60 observations and 25 different clubs, from 2012/13 to 2014/15 season. To verify the robustness of the estimations, we will also estimate a Bootstrapped DEA.

The reminder of this paper is structured as follows. First, the peculiarities of the football clubs' production function, the existent theory and the main empirical findings are exposed in the next section. On the methodology and data section we explain how the study was carried out. The main results were exposed on fourth section and finally, some conclusion thoughts were discussed.

2. Framework and background

2.1 Production function of sports teams

The transformation of inputs into outputs is called production process, which is described by a production function (PF). Scully (1974) was the first one to adapt this approach to measure performance of sport teams. He assumed that teams are engaged in the production of a constant number of games with a certain level of quality. This quality would be team success during a season (measured by per cent wins), which is related to two general categories of inputs: a vector of specific playing skills, and a vector of non-player inputs such as managers, coaches, capital, team spirit, etc. Summarizing, Cadenas et al. (2010) presents the production function of football clubs modelled as following:

$$Y_i = Y_i(X_i), i = 1,2, \dots, n, \qquad (1)$$

where Yi is the football output measured for team i (usually the percentage of points or victories obtained) and Xi is a vector of inputs. Usually, the inputs in the sport production function are variables that measure the technical abilities of the players.

<<Insert Figure 1 about here>>

Observing in more detail, this PF can be divided in two stages as is shown in Figure 1. The team produces in two stages, with output from the first stage becoming input to the second stage. In a first stage, a squad and coaching staff with their given skills (X) will train through their pre-match work (technical, tactical, and physical workouts) to produce attack and defense plays (Z). In the second stage, during the match, the combination of these plays will generate an outcome, the sports result (Y).

All these processes are related and also feedback. Studies such as Szymanski and Kuypers (1999) and Carmichael et al. (2011) indicate that on-field success can be directly related to players' skills and abilities, and that revenue is positively related to on-field success. Wage expenditure is also shown to systematically reflect player skills and performances (Frick, 2011).

2.2. Empirical evidence

We have considered two stages in the PF of sport football clubs. Different studies have followed this approach to analyse the performance in sports leagues. For example Yang et al. (2014) evaluates the efficiency of National Basketball Association (NBA) teams during six seasons. Kern et al. (2012) analysed off-field and on-field efficiency of the EPL while Sexton and Lewis (2004) estimated the efficiency of Major Baseball League considering intermediate products.

On the other hand, several papers have only considered a stage, analysing the relationship between the inputs (X) and the final output (Y) (e.g., Lee and Berri, 2008; del Corral, 2012; del Corral, 2015; Zambom-Ferraresi et al., 2016). Finally, other stream has analysed the second stage of the production process with inputs (Z), i.e. the play performed during the game, as resources to produce the output (Y) (Espitia-Escuer and García-Cebrián, 2006; Boscá et al., 2009; Zambom-Ferraresi et al., 2015, etc.).

Independently of the stages of the PF and which are the possibilities of input measures, there is a consensus in this point; the inputs in sports teams' performance analysis must represent the quality of the workforce, i.e. the players' skills and abilities. The ex-post inputs in sports economics literature used to be: sports statistics, e.g., shots, in soccer; rebounds, in basketball; batting, in baseball (Carmichael et al., 2000; Sexton and Lewis, 2003; Espitia-Escuer and García-Cebrián, 2006; Boscá et al., 2009; Tiedemann et al., 2011; Moreno and Lozano, 2012; and Zambom-Ferraresi et al., 2015); or wages/salaries (Haas, 2003; Frick and Simmons, 2008; Ribeiro and Lima, 2012). These ex-post inputs are employed to analyse the second stage of PF where intermediate inputs (Z) produced output (Y).

However, Dawson et al. (2000), Lee (2006), Lee and Berri (2008), del Corral (2012), and del Corral et al. (2015) criticised the use of ex-post inputs. Lee and Berri (2008) and Dawson et al., (2000) argued that to calculate the efficiency accurately, it is necessary to use ex-ante measures of players' quality. Also, Lee (2006) argued that the ex-ante inputs should be used to avoid endogeneity problems. In addition, some authors disparaged the use of ex-post financial expenditure (wages and salaries) as input measure. In particular, Dawson et al. (2000) have found that performance estimations are highly sensitive to the use of this kind of ex-post input. They recommended ex-ante input measures based on start-of-season players' characteristics or predicted transfer values as more appropriate on theorical and empirical grounds.

Usually, the ex-ante inputs employed are: the market value (Bell et al., 2013; and Zambom-Ferraresi et al. 2016); statistics from previous seasons (Lee and Berri, 2008); the valuation in fantastic leagues and virtual games (del Corral, 2012; and del Corral et al., 2015); and team budget (Moreno and Lozano, 2012). This input specification could be found when the analysis is focused on the overall production process, where a team or a manager employed inputs (X) to produce outputs (Y).

Considering that the two-stages of the production process is widely accepted in sports economics literature, this paper focus on the discussion about inputs specifications. In other words, we would like to offer empirical evidence about if the inputs choice affects the efficiency estimations of football teams.

3. Methodology and Data

3.1. Methodology

The methods to estimate efficiency used to be classified as parametric and nonparametric. To estimate the sports teams' efficiency, among the parametric methodology, stochastic frontier is the most employed (e.g.: Frick and Simmons, 2008; Lee and Berri, 2008; and del Corral, 2012) and the non-parametric methodology most used is data envelopment analysis (DEA) (e.g.: Espitia-Escuer and García-Cebrián, 2006; Guzmán and Morrow, 2007; and Tiedemann et al., 2011).

In this study, we have employed a DEA to estimate the technical efficiency (TE) of football teams because it provides a single measure in the case of multiple inputs and outputs and it is suitable when the correct weighting of inputs and outputs is unknown or cannot be derived (Cooper et al., 2011). The variable return to scale (VRS) model proposed by Banker et al. (1984) was employed because the EPL clubs have different sizes. Moreover, the models were oriented to output maximization (Espitia-Escuer and García-Cebrián, 2006; Zambom-Ferraresi et al., 2016). The formal expression of the model is:

$$\begin{aligned} & max_{\emptyset,\lambda}\emptyset, \\ st \quad & -\emptyset q_i + Q\lambda \geq 0, \\ & x_i - X\lambda \geq 0, \\ & I1'\lambda = 1 \\ & \lambda \geq 0, \end{aligned} \tag{2}$$

where 1≥φ, and φ-1 is the proportional increase in outputs that could be achieved by the i-th club, with input quantities held constant. Note that 1/φ defines a technical efficiency score that varies between zero and one.

In order to test the robustness of our estimations we also employed a bootstrapped DEA methodology (Simar and Wilson, 1998; 2000; 2013). This methodology enables to estimate bias-corrected DEA scores and obtain confidence intervals. The bootstrapped DEA estimates the efficiency through DEA with a pseudo data set, resampling the original DEA scores, and repeating the estimations many times.

3.2. Data

The EPL forms the upper level of England's professional football structure. It was established in 1992 to replace the First Division of the then four division English football leagues. It is regulated by the Football Association and run separately from the remaining three divisions comprising the football league. The EPL and the top division of the football league are linked by the system of promotion and relegation in the end of the season, whereby the bottom three EPL clubs are relegated and replaced by three football league clubs. The final ranking is determined by accumulated match points over regular season (3 for a win, 1 for a draw, and 0 for a loss). The tradition of the EPL combined with the actual quality of their stars, make it one of the most important national football leagues in the world and consequently one most watched and followed. Due the relegation and promotion system of the EPL, our sample is composed by 60 observations, 25 different clubs, for the seasons 2012/13, 2013/14 and 2014/15.

We estimate three different models to calculate efficiency of EPL teams. In all models, we consider the same output (Y). The difference between them is the alternative inputs choice. The inputs specifications also appoint the model, so the models are: ex-ante (X), ex-post (Z) and ex-postW (Z). Table 1 summarized the three models.

<< Insert Table 1 about here>>

The outputs were defined attempting to achieve more comprehensive analysis of football clubs' outcome (Andrikopoulos and Kaimenakis, 2009; Plumley et al., 2014; and Zambom-Ferraresi et al., 2016). On the one hand, the sports results and the total revenue are the most common measures of football clubs output (García-del-Barrio and Szymanski, 2009). In our case, the sports results are measured as the total points achieved in league. On the other hand, it is a fact that football clubs exist and survive thanks to the fans. They have impact on revenue, on the show, and also help to improve the teams' sports performance being a strong support for the team. To reflect the fan's impact, we incorporate two different variables. The first one is the stadium capacity utilization that measures the direct support of fans and it is an important situational variable (Haas, 2003; Mackenzie and Cushion, 2013). The second one is the fans impact on the social media, with growing importance in the context of a global market (McCarthy et al., 2014; Dima, 2015; and Deloitte, 2016). To measure it we used the Sport Social Media Index (SSMI, 2016), an index that ranked the clubs according how clubs manage its social media, from its official channels (e.g. Twitter, Facebook, Pintrest, Instagram, Vine, Google+ and LinkedIn).

In the ex-ante model, the input used was the squad market value. The community's market-value estimations are excellent predictors of actual transfer fees (Herm et al., 2014). This input measure is based on start of the season player characteristics (Dawson et al., 2000; del Corral, 2012). Following Zambom-Ferraresi et al. (2016), the market value was compiled from an online community (Transfermarket) at the start of each season. In the ex-post model, the inputs are three match-related statistics well known in available literature of performance analysis. These inputs represent the main three groups of performance indicators of football: (i) variables related to scoring (shots on target); (ii) variables related to attacking and passing (passes); and (3) variables related to defending (ball recoveries) (Liu et al., 2015). In the ex-postW model the input is the wages of the squad (Dawson et al., 2000; Haas, 2003; Ribeiro and Lima, 2012). Table 2 show the sources and a summary of descriptive statistics.

<< Insert Table 2 about here>>

We have a panel data of three seasons, and estimate the efficiency of all period as a whole. The clubs and leagues' contracts with sponsors and televisions change from periods of more than one year, and we cannot control this kind of changes, but we have normalized all monetary values to control the inflation. In the same way, in football leagues in one season the winner could achieved 60 points and in the follow season 90, we have employed the same normalization process with the points. We apply a max-min normalization to our raw data, scaling the total points between 0 and 1. This solution maintains the rankings and the variability of the data allowing to homogenize the monetary values and the points and allow to run an intertemporal analysis. The normalized indicator of ei for variable E in the ith row is calculated as:

$$Normalized\ (e_i) = (E_i - E_{min}) / (E_{max} - E_{min}) \quad (3)$$

where Emin denotes the minimum value for variable E, and Emax is the maximum value for variable E.

4. Results

Firstly, we will analyse the performance of the EPL clubs. The main results indicate that they have high efficiency level. The VRS estimations of the three models present very high efficiency scores and small standard deviations. To easily interpret the results, when a club cannot improve its outputs without employ more inputs, this club have an efficiency score of 1 and is consider efficient; any other result is considered inefficiency. The VRS bootstrapped estimations also present high efficiency scores and small standard deviations for the three models. The results of VRS and VRS bootstrapped for each one of the three models have a minimum correlation of 98% among them. These results indicated the robustness of the both methodologies' estimations.

Table 3 shows the main results of performance (VRS) for all the clubs of the sample. In this analysis, the only club that has been efficient in the three seasons analysed was Manchester United. This result means that for the inputs employed, in the three differ rent models, Manchester United achieved the most efficient level of outputs combination of all possible performances analysed. Namely, independent of the inputs considered (the market value, the plays developed on-field, or the squad' wages) Manchester United was efficient.

<< Insert Table 3 about here>>

In terms of efficiency, Chelsea, Arsenal, and Liverpool were the follow better overall performances. Swansea City, Tottenham Hotspur, and West Ham United also have performed of an efficient (or close) way during the period analysed. Sunderland and Aston Villa present lower results than the rest of the sample. Wigan Athletic highlighted among the clubs that underperformed, but at same time, when the efficiency was estimate with the wages as input surprisingly Wigan Athletic was efficient. From the clubs that didn't play the competition in all observed seasons, Burley and Leicester City were efficient in the seasons that they participated.

Observing the relation of efficiency with the sports results, all the league' champions (Manchester United in 2012/13, Manchester City in 2013/14, and Chelsea in 2014/15) was efficient in the respective season. Regarding the teams with the worst sports results, Burley (2014/15), Norwich City (2013/14) and Reading (2012/13) employed its scarce resources in efficient or really close way, in spite of they were relegated.

Secondly, we are going to analyse the three models comparatively. The efficiency scores of the three models could be observed graphically in figures 2 and 3. The 60 observations of the sample are represented in numerical order on the x axis of the graphs, and its efficiency changes among the models can be easily observed.

<< Insert Figure 2 about here>>

In Figure 2, it is shown that the efficiency scores are very similar independently of the kind of inputs applied. Only in the case of ex-postW model, the efficiency is slightly higher than the other two models, although there is no regular behaviour pattern. Analysing the observations, there are teams that obtain better results with the ex-ante inputs, others with the ex-post and ex-postW, while 25 observations do not change. In the case of the bootstrap method (Figure 3), the results are also very similar among the three models.

<< Insert Figure 3 about here>>

At a glance, the efficiency scores obtained by VRS and VRS bootstrapped in Figures 2 and 3 are very similar. In order to confirm this similarity, Table 4 shows the correlations between the three models and both methodologies. The most striking result indicate that there is a 90% positive and significant correlation ($p < 0.00$) between the models that estimates the efficiency of the EPL clubs using the players' market value (ex-ante) and the model that uses sports performance indicators (ex-post) as input. The correlation of the bootstrapped model was even higher, reaching a 91% of positive and significant correlation ($p < 0.00$). The correlation between the ex-ante and ex-postW financial expenditure models, attaining a 78 and 82% with the VRS and VRS bootstrapped, respectively. Finally, the correlations between the ex-post model (plays performed as input) and the ex-postW of financial expenditure model (wages as input) are of 66 and 74% for VRS and VRS bootstrapped, respectively. These are also significant moderate/high correlation values, but are not so high as the ex-ante and ex-post correlation.

5. Discussion and conclusions

We have analysed the performance of EPL clubs during three seasons, from 2012/13 to 2014/15, with three different models. The three models have the same outputs (points, revenues, attendance, and fans impact on social media) and three different inputs are: the market value (ex-ante); the plays performed during the match (ex-post); and the wages (ex-postW). To test the robustness of the efficiency estimations, we have applied two methodologies: DEA and DEA bootstrapped. All the estimations were highly correlated, positive and significant, except the correlation of the both ex-post models, which is moderate/high.

Considering the sample analysed, our results indicate that the controversy about the inputs specifications is unfounded, mainly in the case of the criticism with match-related statistics; suggesting that the inputs choice to represent players' skills is irrelevant. Knowing the productive process that is being analysed, the input selection will lead to similar results because they are measuring the same, the players' skills and abilities. In other words, to explain performance of football teams, we could use ex-ante inputs and match-related statistics. However, this does not mean that it could be not advisable the choice of the input which represent the best the unit and the stage of the PF under analysis.

In the case of inputs choice our results corroborate the empirical evidenced developed by Dawson et al. (2000). On the one hand, when comparing the ex-ante and ex-post inputs models, we could consider that both types of inputs are interchangeably because both represent faithfully the players' skills, not affecting significantly the efficiency' estimations. On the other hand, when using the ex-post financial expenditure (wages) our results have showed not so highly sensitive than Dawson et al. (2000), but it also should be taken with caution.

To explain our results we have analysed the relation between the players' skills and abilities and the measures used to represent it. As we highlighted before, all the production process of professional football clubs is related and feedback. Clubs with better players will archive better sports results that will report higher revenues, which in turn will enable to pay high wages and to hire better players, and so on (Szymanski and Kuypers, 1999; Carmichael et al., 2011).

The relation between market value, transfer fees and wages with sports results and revenue is fairly discussed in sports economics literature. By one side, the bargain' power in different stages of contracts, the players' high or under valuation (Weimar and Wicker, 2014), and the media impact of some players (Franck and Nüesch, 2012) are the aspects that muddier this relationship. By other side, we must consider that the management of the clubs is becoming more professional. Also, the football players' performance is being analysed so seriously as in other sports like basketball and baseball for example. Then, the players' market value, the performance on-field and the wages are becoming more similar. For example, Frick (2011) has found that more than 60% of the observable variance in players' salaries is related with their skills and abilities, and performance on-field. To test this argument, we have calculated the correlations between the three different inputs considering two different outputs, points and revenues. Table 5 in the Appendix shows these correlations. As we can observe in this table, the correlation between market value and wages is pretty high (95%, $p<0.000$), and also the correlation between wages and revenue (95%, $p<0.000$). The market value and the wages are also high correlated with the points (84%, $p<0.000$ and 81%, $p<0.000$) respectively, values only surpassed by the correlation of shots on target and the points (88%, $p<0.000$).

One important question to consider is the fact that we analysed the efficiency of the whole team, and the inputs are the sum of individual players' values, nor of the entire team. Ribeiro and Lima (2012) have found that a wider wage distribution within each team is associated with better performance. Their findings agree with the tournament theory, where the size of the difference in pay rank increases as contestants approach the top. Szymanski and Wilkinson (2016) also have found that most expensive players tend to have the largest impact on the game whereas the least expensive players have little impact; which reinforces the relationship between the different input measures. In this regard, coaches have many possible combinations of its players (inputs). Teams with different players could vary technically, tactically, physically, and psychologically. Squads could have twenty-five players in EPL, eleven players compose the first team and other five players will be on the bench, available to the coach that could substitute none or three players' maximum during the match. So, the relation between the different efficiency estimations and the teams' performance could be explained by the overall composition of teams. As it is commonly said, a team is more than the simple sum of 11 players.

Our results have some practical implications for the strategic decisions in football clubs. Recalling our title' question; are manager as efficient as coaches? We cannot answer this question, but our efficiency analysis of both units (managers and coaches), through the employ of different inputs; indicate that in the case of EPL clubs (from 2012/13 to 2014/15) his performances are strongly correlated. Probably because one's work directly impacts the work of the other, and vice versa. Traditionally, these two different agents are being considered as essential to an efficient management of the clubs. In some clubs, the manager takes the most important decisions about what football player should be hired and about the levels of wages, playing the coach a minor role in the decision-making. However, in other clubs, the coach assumes the responsibility for the team success. In these situations, his ability to manage the squad and the selection of the tactics required in each match are fundamental to get success. According to our results, this distinction lacks interest. So important and necessary is to hire the right players as the different tactics combinations on the field. Then, manager and coach should interact in the same direction to get the club success. For example, the coaches might be the best advisors to the manager for creating a promising roaster for the future, based on the limitations suffered by the team in the present. Also, a wide and adequate wage distribution made by the manager might be a helpful tool for the coach in order to introduce extra motivation and incentives among the squad in order to obtain a better performance. Managers and coaches may work together to activate the most productive inputs combinations (first and bench teams) in order to get an efficient team.

The main limitation of this study is related to the sample analysed, that lead us to suggest extend the sample in future research to generalize ours results. Also, although the relation between market value and salaries with the performance on-field was deeply analysed on sports economics literature, the analysis of the relationship between individual and the team performance is an interesting issue for further research and could help clubs' managers and coaches at time to hire players and compose powerful squads.

References

Andrikopoulos, A., and Kaimenakis, N. 2009. "Introducing FOrNeX: a composite index for the intangible resources of the football club." *International Journal of Sport Management and Marketing 5*(3): 251. https://doi.org/10.1504/IJSMM.2009.023236

Banker, R. D., Charnes, A., and Cooper, W. W. 1984. "Some models for estimating technical and scale inefficiencies in data envelopment analysis." *Management science 30*(9): 1078-1092. https://doi.org/10.1287/mnsc.30.9.1078

Bell, A., Brooks, C., and Markham, T. 2013. "The performance of football club managers: skill or luck?" *Economics & Finance Research 1*(1): 19-30. http://dx.doi.org/10.1080/21649480.2013.768829

Boscá, J. E., Liern, V., Martínez, A., and Sala, R. 2009. "Increasing offensive or defensive efficiency? An analysis of Italian and Spanish football." *Omega 37*(1): 63-78. https://doi.org/10.1016/j.omega.2006.08.002

Cadenas, J. M., Liern, V., Sala, R., and Verdegay, J. L. 2010. "Fuzzy linear programming in practice: an application to the Spanish football league". *Fuzzy Optimization* 254: 503-528. Springer Berlin Heidelberg.

Carmichael, F., McHale, I., and Thomas, D. 2011. "Maintaining market position: team performance, revenue and wage expenditure in the English premier league." *Bulletin of Economic Research 63*(4): 464-497. http://dx.doi.org/10.1111/j.1467-8586.2009.00340.x

Carmichael, F., Thomas, D., and Ward, R. 2000. "Team performance: the case of English Premiership football." *Managerial and Decision Economics 21*(1): 31–45. http://www.jstor.org/stable/3108117.

Cooper, W. W., Seiford, L. M., and Zhu, J. 2011. "Data envelopment analysis: history, models, and interpretations." In *Handbook on data envelopment analysis*: 1-39. Springer US.

Dawson, P., Dobson, S., and Gerrard, B. 2000. "Estimating coaching efficiency in professional team sports: Evidence from English association football." *Scottish Journal of Political Economy 47*(4): 399–421. http://dx.doi.org/10.1111/1467-9485.00170

del Corral, J., Maroto, A., and Gallardo, A. 2015. "Are Former Professional Athletes and Native Better Coaches?: Evidence From Spanish Basketball. *Journal of Sports Economics;* https://doi.org/10.1177/1527002515595266

del Corral, J. 2012. "Eficiencia en el deporte: Entrenadores en la Primera División del fútbol español 2009-2011." *Estudios de Economía Aplicada* 30(2): 545-564.

Deloitte. 2016. *Annual Review of Football Finance 2016*. https://goo.gl/POUaiB

Despotis, D. K., and Koronakos, G. 2014. "Efficiency assessment in two-stage processes: A novel network DEA approach". *Procedia Computer Science 31*: 299-307. https://doi.org/10.1016/j.procs.2014.05.272

Dima, T. 2015. "Social Media Usage In European Clubs Football Industry. Is Digital Reach Better Correlated With Sports or Financial Performance?" *The Romanian Economic Journal* (55): 117–128.

Espitia-Escuer, M., and García-Cebrián, L. I. 2006. "Performance in sports teams results and potential in the professional soccer league in Spain." *Management Decision 44*(8): 1020–1030. https://doi.org/10.1108/00251740610690595

Franck, E., and Nüesch, S. 2012. "Talent and/or popularity: what does it take to be a superstar?" *Economic Inquiry 50*(1): 202-216. http://dx.doi.org/10.1111/j.1465-7295.2010.00360.x

Frick, B. 2011. Performance, salaries, and contract length: empirical evidence from German soccer. *International Journal of Sport Finance 6*(2): 87. http://EconPapers.repec.org/RePEc:jsf:intjsf:v:6:y:2011:i:2:p:87-118

Frick, B., and Simmons, R. 2008. "The impact of managerial quality on organizational performance: evidence from German soccer." *Managerial and Decision Economics 29*(7): 593-600. http://dx.doi.org/10.1002/mde.1431

García-del-Barrio, P., and Szymanski, S. 2009. "Goal! Profit maximization versus win maximization in soccer." *Review of Industrial Organization 34*(1): 45-68. https://doi.org/10.1007/s11151-009-9203-6

Guzmán, I., and Morrow, S. 2007. "Measuring efficiency and productivity in professional football teams: Evidence from the English Premier League." *Central European Journal of Operations Research 15*(4): 309–328. https://doi.org/10.1007/s10100-007-0034-y

Haas, D. J. 2003. "Technical efficiency in the major league soccer." *Journal of Sports Economics 4*(3): 203-215. 10.1177/1527002503252144

Herm, S., Callsen-Bracker, H. M., and Kreis, H. 2014. "When the crowd evaluates soccer players' market values: Accuracy and evaluation attributes of an online community." *Sport Management Review 17*(4): 484-492. https://doi.org/10.1016/j.smr.2013.12.006

Kern, A., Schwarzmann, M., and Wiedenegger, A. 2012. "Measuring the efficiency of English Premier League football: A two-stage data envelopment analysis approach." *Sport, Business and Management: an International Journal* 2(3): 177-195. https://doi.org/10.1108/20426781211261502

Lee, Y. H. 2006. "Team sports efficiency estimation and stochastic frontier models." *The Handbook of Sports Economics Research*: 209–220.

Lee, Y. H., and Berri, D. 2008. "A re-examination of production functions and efficiency estimates for the National Basketball Association." *Scottish Journal of Political Economy 55*(1): 51–66. https://doi.org/10.1111/j.1467-9485.2008.00443.x

Liu, H., Yi, Q., Giménez, J. V., Gómez, M. A., and Lago-Peñas, C. 2015. "Performance profiles of football teams in the UEFA Champions League considering situational efficiency." *International Journal of Performance Analysis in Sport 15*(1): 371-390. 10.1080/24748668.2015.11868799

Mackenzie, R., and Cushion, C. 2013. "Performance analysis in football: A critical review and implications for future research." *Journal of sports sciences 31*(6): 639-676. http://dx.doi.org/10.1080/02640414.2012.746720

McCarthy, J., Rowley, J., Jane Ashworth, C., and Pioch, E. 2014. "Managing brand presence through social media: the case of UK football clubs." *Internet Research 24*(2): 181-204. https://doi.org/10.1108/IntR-08-2012-0154

Moreno, P., and Lozano, S. 2014. "A network DEA assessment of team efficiency in the NBA." *Annals of Operations Research 214*(1): 99-124. https://doi.org/10.1007/s10479-012-1074-9

Plumley, D., Wilson, R., and Ramchandani, G. 2014. "Towards a model for measuring holistic performance of professional Football clubs." *Soccer & Society*: 1–14. http://dx.doi.org/10.1080/14660970.2014.980737

Ribeiro, A. S., and Lima, F. 2012. "Portuguese football league efficiency and players' wages." *Applied Economics Letters 19*(6): 599-602. http://dx.doi.org/10.1080/13504851.2011.591719

Rumsby, B. 2017. "Premier League Clubs to Share £8.3 Billion TV Windfall." The Telegraph 2016. 4 February. Accessed February 14, 2017. https://goo.gl/unTiGu

Scully, G. W. 1974. "Pay and performance in major league baseball." *The American Economic Review 64*(6): 915-930. http://www.jstor.org/stable/1815242

Sexton, T. R., and Lewis, H. F. 2003. "Two-stage DEA: An application to major league baseball." *Journal of Productivity Analysis 19*(2): 227-249. https://doi.org/10.1023/A:1022861618317

Simar, L., and Wilson, P. W. 2013. "Estimation and inference in nonparametric frontier models: Recent developments and perspectives." *Foundations and Trends® in Econometrics 5*(3–4): 183-337. http://dx.doi.org/10.1561/0800000020

Simar, L., and Wilson, P. W. 2000. "Statistical Inference in Nonparametric Frontier Models: The State of the Art." *Journal of Productivity Analysis 13*(98): 49–78. https://doi.org/10.1023/A:1007864806704

Simar, L., and Wilson, P. W. 1998. "Sensitivity analysis of efficiency scores: How to bootstrap in nonparametric frontier models." *Management science 44*(1): 49-61. https://doi.org/10.1287/mnsc.44.1.49

SSMI. 2017. "Sport Social Media Index". Accessed February 2, 2017. http://www.sport.socialmediaindex.co.uk/.

Szymanski, S., and Wilkinson, G. 2016. "Testing the O-Ring theory using data from the English Premier League." *Research in Economics 70*(3): 468-481. https://doi.org/10.1016/j.rie.2016.04.001

Szymanski, S., and Kuypers, T. 1999. "Winners and Losers, the Business Strategy of Football." *London: Viking.*

Tiedemann, T., Francksen, T., and Latacz-Lohmann, U. Assessing the performance of German Bundesliga football players: a non-parametric metafrontier approach. *Central European Journal of Operations Research* 2011. *19*(4), 571-587. https://doi.org/10.1007/s10100-010-0146-7

Transfermarket. Accessed February 2, 2017. https://www.transfermarkt.co.uk/

Weimar, D., and Wicker, P. 2017. "Moneyball revisited: Effort and team performance in professional soccer." *Journal of Sports Economics 18*(2): 140-161. 10.1177/1527002514561789

Yang, C. H., Lin, H. Y., and Chen, C. P. 2014. "Measuring the efficiency of NBA teams: additive efficiency decomposition in two-stage DEA." *Annals of Operations Research 217*(1): 565-589. https://doi.org/10.1007/s10479-014-1536-3

Zambom-Ferraresi, F., García-Cebrián, L. I., Lera-López, F., and Iráizoz, B. 2017. "Performance Evaluation in the UEFA Champions League." *Journal of Sports Economics* 18(5): 448-470. 10.1177/1527002515588135

Zambom-Ferraresi, F., Lera-López, F., and Iraizoz, B. 2017 "And if the ball does not cross the line? A comprehensive analysis of football clubs' performance." *Applied Economics Letters* 24(17): 1259-1262. http://doi.org/10.1080/13504851.2016.1270408

TABLES

Table 1. Models

Model	Inputs	Production process
Ex-ante	Market value	X ⇒Y
Ex-post	Plays performed	Z ⇒ Y
Ex-postW	Wages	Z ⇒ Y

Note: W= wages (financial expenditure)

Table 2. Descriptive statistics

Variable			**Source**	**Mean**	**SD**
Inputs	**Ex-ante**	Squad market value	Transfermarket	199.82	148.60
	Ex-post	Shots on target	Opta Sports	168.43	37.05
		Passes	Opta Sports	17,731.28	2,967.65
		Ball recoveries	Opta Sports	2,172.65	191.01
	Ex-postW	Wages	The Guardian	95.07	55.60
Outputs		Points	EPL oficial website	52.35	17.56
		Total revenue	Deloitte, Companies House, Fame and The Guardian	187.73	126.54
		Stadium utilization	Deloitte	95.42	5.97
		Social media impact	Sport Social Media Index	58.37	5.68

Note: SD=standard deviation; W= wages.

Table 3. Efficiency scores (VRS)

	2012/13			2013/14			2014/15		
	Ex-ante	Ex-post	Ex-pW	Ex-ante	Ex-post	Ex-pW	Ex-ante	Ex-post	Ex-pW
Arsenal	1	1	1	1	1	1	0.994	0.994	0.994
Aston Villa	0.8550	0.8704	0.8574	0.8450	0.8456	0.845	0.9156	1	0.914
Burnley							1	1	1
Cardiff City				0.9864	0.9915	0.986			
Chelsea	1	1	1	0.9980	0.998	0.998	1	1	1
Crystal Palace				1	0.9285	1	0.9511	0.9720	0.9353
Everton	0.9663	0.919	1	1	0.9533	1	0.9860	0.986	0.986
Fulham	0.997	0.997	0.997	0.974	0.974	0.974			
Hull City				0.9780	0.9583	1	0.9271	0.9341	0.9271
Leicester City							1	1	1
Liverpool	1	1	1	1	0.997	1	1	0.956	0.956
Manchester City	0.9810	0.981	0.981	1	1	1	0.949	0.949	0.949
Manchester United	1	1	1	1	1	1	1	1	1
Newcastle United	0.966	0.966	0.966	0.965	0.965	0.965	0.976	0.9760	0.976
Norwich City	1	1	1	0.999	0.999	0.999			
Queens Park Rangers	0.9840	0.984	0.984				0.9726	0.974	0.9702
Reading	1	0.9953	1						
Southampton	0.9711	0.9651	1	1	0.9419	0.9874	0.9693	0.9555	0.9504
Stoke City	0.989	1	0.989	0.952	0.976	0.946	0.976	1	0.976
Sunderland	0.846	0.857	0.883	0.852	0.856	0.850	0.841	0.851	0.833
Swansea City	0.9960	0.996	1	0.992	0.992	0.992	0.9917	0.9944	0.991
Tottenham Hotspur	1	1	1	0.994	0.994	0.9945	0.9861	0.989	0.9862
West Bromwich Albion	0.9890	0.973	0.9817	0.9542	0.9521	0.9479	0.9647	1	0.9622
West Ham United	0.9960	0.996	1	0.9813	1	0.9783	0.9903	0.9908	0.9881
Wigan Athletic	0.7762	0.7718	1						
Mean	0.966	0.964	0.982	0.974	0.966	0.973	0.969	0.976	0.965
SD	0.063	0.062	0.040	0.045	0.045	0.046	0.039	0.036	0.040

Note: VRS=variable return to scale; SD=standard deviation; Ex-pW= Ex-post Wage.

Table 4. Correlation matrix (models and methodologies)

		Ex-ante	Ex-ante (b)	Ex-post	Ex-post (b)	Ex-postW	Ex-postW (b)
Ex-ante	PC	1	.984**	.905**	.913**	.784**	.816**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	60	60	60	60	60	60
Ex-ante (b)	PC	.984**	1	.921**	.940**	.767**	.821**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	60	60	60	60	60	60
Ex-post	PC	.905**	.921**	1	.985**	.662**	.717**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	60	60	60	60	60	60
Ex-post (b)	PC	.913**	.940**	.985**	1	.674**	.738**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	60	60	60	60	60	60
Ex-postW	PC	.784**	.767**	.662**	.674**	1	.979**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	60	60	60	60	60	60
Ex-postW(b)	PC	.816**	.821**	.717**	.738**	.979**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	60	60	60	60	60	60

Note: (b)= bootstrapped; W= wage; PC= Pearson Correlation;
**. Correlation is significant at the 0.01 level (2-tailed).

FIGURES

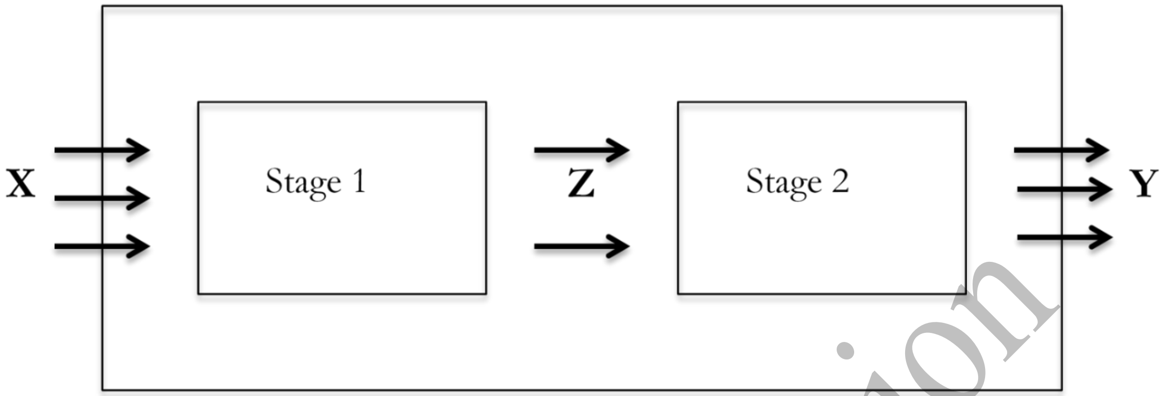
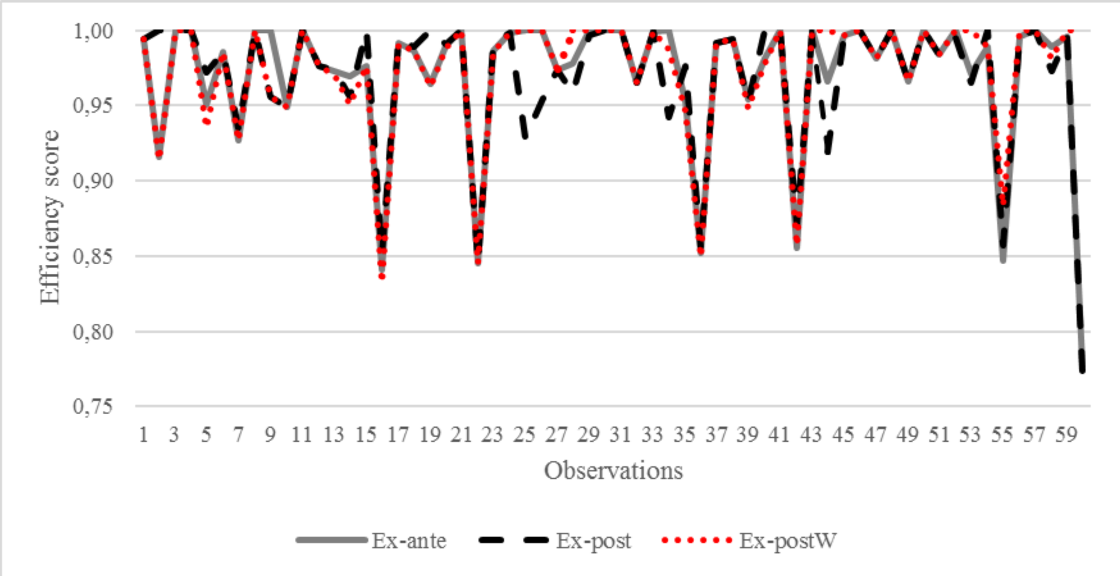


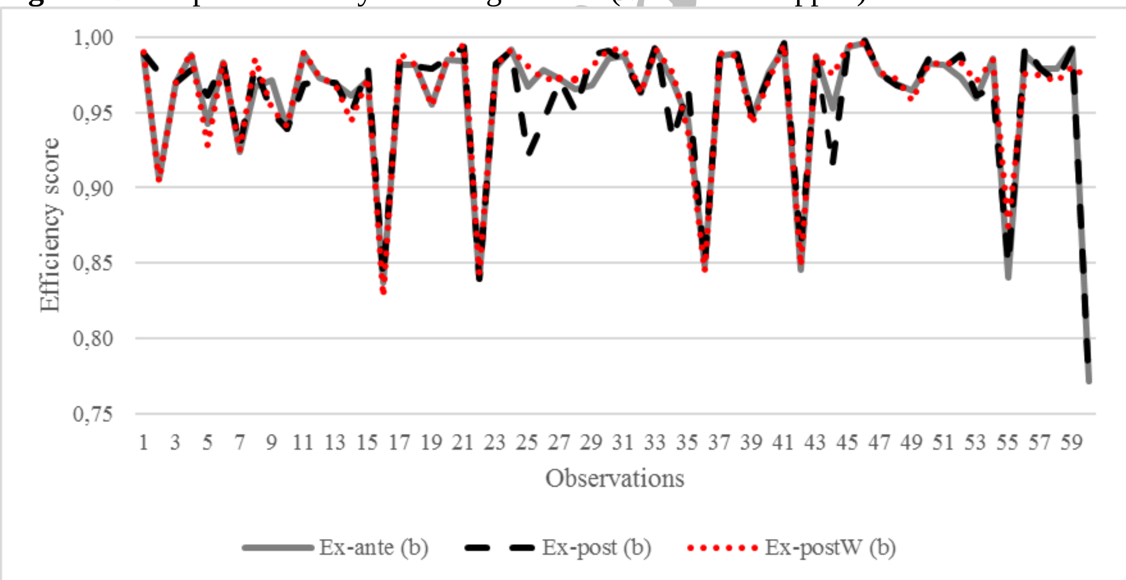
Figure 1. The two-stage production process in football (Adapted from Desposits and Koronakos, 2014).

Figure 2. Comparative analysis among models (VRS)



Note: VRS=variable return to scale.

Figure 3. Comparative analysis among models (VRS bootstrapped)



Note: VRS=variable return to scale, (b)=bootstrapped.

APPENDIX A

Table 5. Correlations between measures

		Market value	Shots on target	Passes	Ball recovery	Wages	Points	Revenue
Market value	PC	1	,769**	,701**	,270*	,950**	,836**	,946**
	Sig. (2-tailed)		,000	,000	,037	,000	,000	,000
	N	60	60	60	60	60	60	60
Shots on target	PC	,769**	1	,773**	,294*	,721**	,878**	,741**
	Sig. (2-tailed)	,000		,000	,023	,000	,000	,000
	N	60	60	60	60	60	60	60
Passes	PC	,701**	,773**	1	,383**	,701**	,756**	,715**
	Sig. (2-tailed)	,000	,000		,003	,000	,000	,000
	N	60	60	60	60	60	60	60
Ball recovery	PC	,270*	,294*	,383**	1	,365**	,303*	,321*
	Sig. (2-tailed)	,037	,023	,003		,004	,019	,012
	N	60	60	60	60	60	60	60
Wages	PC	,950**	,721**	,701**	,365**	1	,808**	,959**
	Sig. (2-tailed)	,000	,000	,000	,004		,000	,000
	N	60	60	60	60	60	60	60
Points	PC	,836**	,878**	,756**	,303*	,808**	1	,823**
	Sig. (2-tailed)	,000	,000	,000	,019	,000		,000
	N	60	60	60	60	60	60	60
Revenue	PC	,946**	,741**	,715**	,321*	,959**	,823**	1
	Sig. (2-tailed)	,000	,000	,000	,012	,000	,000	
	N	60	60	60	60	60	60	60

Note: PC= Pearson Correlation; **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).