Who is the best coach of all time? A network-based assessment of the career performance of professional sports coaches

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We consider two large datasets consisting of all games played among top-tier European soccer clubs in the last 60 years, and among professional American basketball teams in the past 70 years. We leverage game data to build networks of pairwise interactions between the head coaches of the teams, and measure their career performance in terms of network centrality metrics. We identify Arsène Wenger, Sir Alex Ferguson, Jupp Heynckes, Carlo Ancelotti, and José Mourinho as the top 5 European soccer coaches of all time. In American basketball, the first 5 positions of the all-time ranking are occupied by Red Auerbach, Gregg Popovich, Phil Jackson, Don Nelson, and Lenny Wilkens. We further establish rankings by decade and season. We develop a simple methodology to monitor performance throughout a coach’s career, and to dynamically compare the performance of two or more coaches at a given time. The manuscript is accompanied by the website coachscore.luddy.indiana.edu where complete results of our analysis are accessible to the interested readers.

I. INTRODUCTION

In a standard soccer league, teams are ranked on the basis of the total number of points they gather during the season. Points are assigned to teams depending on the outcome of individual games they take part in. All teams play the same total number of games in the league by generally facing each other twice thorough the season. This is a simple, effective, and fair method to measure team performance in a single season. However, this standard metric does not differentiate the quality of a result depending on the opponent faced in the game. For example, beating a championship contender team has the same importance as beating a team that is positioned low in the league standings. Also, the metric is not designed to properly measure performance over arbitrary time windows, e.g., a portion of a season or the aggregate of multiple seasons.

A simple way to partially address the above-mentioned issues and go beyond the mere counting of points is relying on a macroscopic perspective of the league, where individual games are not seen as events that are independent one from the other, rather they are all seen as elementary contacts forming a complex network of interactions. The importance of a team in the web of contacts is self-established by the very structure of the network. The spirit is similar to the one used in attempts of gauging the importance of web pages in information networks [1, 2], establishing the relevance of papers [3], scientists [4] and journals [5] in scientific networks, and measuring the influence of individuals [6, 7] in social networks. Standard metrics of performance, such as the counting of points and/or wins, can be easily reconciled with local centrality metrics, e.g., in-degree and in-strength [7, 10]. However, non-local metrics of centrality may allow to capture different aspects of performance [7]. In particular, metrics such as the Bonacich [11] and the PageRank [1] centralities allow to weigh the quality of wins and the quality of the opponents with simple, but reasonable self-consistent recipes.

Graph-based metrics of performance for teams and/or players have already been applied to soccer [12, 16], basketball [17, 19], and various other sports [20, 23]. The current paper explores the possibility of leveraging network centrality metrics to gauge career performance of coaches in two professional sports: soccer and basketball. There are no well-established metrics of performance for sports coaches, especially when the focus is on extended periods of time such those corresponding to entire careers. One possibility could be to simply count the number of trophies won by coaches. However, the importance of a trophy (e.g., an international cup) compared to another (e.g., a national championship) is hardly quantifiable, and, even for the same trophy, may vary from season to season depending on several factors. Also, the actual number of coaches with at least a trophy won during their career is a small fraction of the total number of coaches that managed professional teams, thus making trophy counting a recipe not very useful for the quantification of performance for the vast majority of coaches. One could evaluate performance on other events, e.g., number of wins, rank positions in leagues, etc. However, the difficulty of properly quantifying the relative importance of the various elementary events would be exacerbated by a multitude of potential factors, e.g., type of competition, season, strength of the team trained, etc. The motivation behind our approach is indeed avoiding to make any complicated choice about the specific value to be assigned to the elementary events, and measure the performance of individual coaches in a self-contained manner by leveraging the structure of the head-to-head contact network among coaches.

We are not the first to consider the problem of measuring the performance of sports coaches. However, the number of existing studies is quite limited. One of the most analyzed problems is the effect of sacking coaches, either during or at the end of a season, on the short- or long-term performance of teams [24, 27]. When it comes to analyzing career performances of coaches and comparing them with each other, we are aware of only two papers. Xu et al. use a Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) model to rank college basketball coaches [28]. Hu et al. consider data envelopment analysis and PageRank for ranking
coaches in college sports [29].

As in Hu et al. [29], here we also use PageRank as the main metric of performance for sports coaches. However, we differentiate from the work by Hu et al. in two main aspects. First, Hu et al. arbitrarily weigh the importance of games on the basis of exogenous factors. In our approach, each game has the same a priori importance; the effective value of a game is an emerging property of the system, depending on the quality of the opponents that are facing each other in the game. Second, Hu et al. consider datasets that permit the construction of networks consisting of less than 100 nodes. Our data allow to build networks composed of more than 1,000 nodes.

The paper is organized as follows. In section II, we provide details of data selection, acquisition and curation, we describe how the information from individual games is aggregated to form dynamic, directed, and weighted networks among coaches, and we illustrate the recipe at the basis of network centrality metric used to measure coach performance. In section III we present our rankings of coaches. We consider all-time rankings, and top coaches of decades and seasons. Also, we use dynamic rankings to monitor the career trajectories of individual coaches. In section IV we provide our final considerations. Robustness of our results to some of the ingredients used in our ranking recipe are provided in appendix B. Additional results are available on the website coachscore.luddy.indiana.edu. The website allows interested readers to generate custom rankings, and to visualize career trajectories of all coaches included in our set of data.

II. METHODS

A. Data

Our analysis for comparing the performances of sports coaches is focused on two sports, soccer and basketball.

Soccer

For soccer, our main source of data is transfermarkt.com. We collected publicly available information about the outcome of all games played by professional clubs in the top five national leagues of European soccer: Premier League (England) [30], Ligue 1 (France) [31], Bundesliga (Germany) [32], Serie A (Italy) [33], and La Liga (Spain) [34]. The top five national leagues are selected based on the most recent country coefficients released by UEFA [35]. We note that some of the league names changed during the period of time covered by our dataset. For example, the major English league was named “First Division” till season 1991/92 and named “Premier League” from season 1992/93 on. For each game, we collected information about the two teams playing the game, the outcome of the game, either a win by one of the two teams or a tie, and the day when the game was played. We uniquely identified all professional teams that took part in at least one edition of the above-mentioned leagues since season 1980/81. For some leagues, we were able to trace back matches played since 1960/61. Also, we included games of major European competitions that were played between the teams belonging to the top five European leagues. We considered the UEFA Champions League (previously named Champion Clubs’ Cup) and the UEFA Europa League (previously named UEFA Cup) (see Table X for abbreviations). For consistency with the data for the national leagues, we disregarded the results of extra times (or penalties), and only considered the results of the regular 90-minute time even if games went to the extra times. The last season included in the dataset for all competitions is the 2019/20 season.

Please note that we didn’t include matches for abolished European soccer competitions for clubs, e.g., the UEFA Cup Winners’ Cup [36]. Also, we didn’t include any games played for national cups. Finally, no games played between national teams are included in our data. We stress that our selection excludes very important national leagues, and glorious European soccer teams taking part in these leagues. The main reason behind our choice is due to the time coverage of the data from transfermarkt.com. For example, data for the Portuguese Primeira Liga [37] are reported only from season 1997/98 on.

Still relying on data from transfermarkt.com, we determined the coaches that managed the teams playing each of the individual games of our sample. To this end, we gathered the coaching histories of all soccer teams in our dataset, and accounted for eventual changes of managers throughout the season. We identified a few inconsistencies in the data from transfermarkt.com, i.e., individual games of a team managed either by more than two coaches or no coach at all. We corrected those inconsistencies manually by relying on other sources of information, such as bdfutbol.com and wikipedia.com. After data curation, we were able to find unique coach-to-team assignments for more than 99% of the games in our sample.

In total, we obtained information for 93,157 soccer matches. We identified 1,775 unique coaches who have man-
aged at least one game. If we restrict our attention only to matches played from season 1980/81 on, i.e., the period for which we have full information for all leagues considered in our study, then the total number of matches is 72,850 and the total number of unique coaches is 1,436 (see Table I for details). As Figure 1 shows, the number of games covered by our dataset consistently increases until 1980, and stays more or less constant after that season. The same trend is observed for the number of coaches, although one could notice a slight increase even after 1980. This fact indicates an increasing tendency of replacing coaches during the season.

Figure 1. Statistics of the soccer dataset. (a) Total number of matches in our dataset per season. We combined together games from all the national leagues and European cups. (b) Number of coaches in our dataset per season. Each season includes every coach that has managed at least one game in that season. Data combine all games of the national leagues and European cups. (c) Complementary cumulative distribution functions (ccdf) of the number of matches managed, won, lost, and tied by coaches in our dataset. The stretched exponential ccdfs that best fit the empirical data are displayed as dashed curves. The stretched exponential ccdf is defined as \( f(x) = \exp(-x^\beta) \). The parameter of the best fits are \( \beta = 0.695 \) for total matches, \( \beta = 0.592 \) for wins, \( \beta = 0.791 \) for losses, and \( \beta = 0.676 \) for ties. (d) Ccdf for the number of head-to-head matches played between pairs of coaches. The best fit curve to the empirical data is also shown. In this case, we used the lognormal ccdf \( g(x) = 1 - \frac{1}{\sqrt{2\pi}} \exp \left( -\frac{\log x - \mu}{\sigma} \right) \). The parameters for the best fit are \( \mu = 0.452 \) and \( \sigma = 0.945 \).

We used the total number of games managed by a coach as a proxy for the career length of the coach (Figure 1). Empirical data are well described by a stretched exponential distribution. The finding is robust against the specific quantity used to gauge career length, either total wins, losses or ties. It is, however, not compatible with findings about career lengths of professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athletes, such as soccer, basketball, tennis, and baseball players [20, 38, 39], that are usually well fitted by professional athlete...
parameters for the best fit are $\beta = 0.746$ for total matches, $\beta = 0.664$ for wins, and $\beta = 0.821$ for losses. (d) Ccdf for the number of head-to-head matches played between pairs of coaches. The best fit curve to the empirical data is also shown. In this case, we used the lognormal ccdf $g(x) = 1 - \frac{1}{2} \exp\left(\frac{x - \mu}{\sigma}\right)$. The parameters for the best fit are $\mu = 1.567$ and $\sigma = 1.098$.

### B. Networks of contacts among sports coaches

We take advantage of the datasets described above to construct directed and weighted networks of contacts between coaches. A node in the network corresponds to a coach; pairwise interactions among coaches represent h2h games. In particular, networks are obtained by aggregating data about individual h2h games between pairs of coaches. A single data point is given by the game $g$ in which coach $i_j$ has a h2h game against $j_g$ at time $t_g$ (recall that time accuracy is one day). The contribution $c_{g,i_j}(t)$ at time $t \geq t_g$ of such a data point to the weight of the edge $ij$ is

$$c_{g,i_j}(t) = \delta_{i_j} \delta_{j_g} e^{-\beta(t-t_g)} \left\{ \begin{array}{ll} 1 & \text{if } i_j \text{ and } j_g \text{ tie in game } g \\ 2 & \text{if } i_j \text{ loses against } j_g \text{ in game } g \end{array} \right.$$  \hspace{1cm} (1)

Clearly, $c_{g,i_j}(t) = 0$ if $t < t_g$. In Eq. (1), the Kronecker $\delta$ function (i.e., $\delta_{xy} = 1$ if $x = y$ and $\delta_{xy} = 0$, otherwise) tells us that a non-null contribution to the edge $ij$ requires that the game $g$ was indeed a h2h match between coaches $i$ and $j$. The factor $e^{-\beta(t-t_g)}$ is an aging term identical to one used in Ref. [12] for the dynamic ranking of tennis players. We consider two possible choices: $\beta = 0$, meaning that the contribution of a game never ages; $\beta = 1/365$, meaning that the contribution is suppressed by a factor $e^{-1} \approx 0.37$ every year. Under the choice of Eq. (1), a win counts twice as much as a tie (only for the directed edge loser to winner), but a tie is counted twice (for the edges in both directions). In appendix [A] we report results corresponding to the case in which a win counts three times as much as a tie, but still a tie is counted twice. This choice is in line with how points are currently assigned in soccer leagues; however, the different choice does not affect much the outcome of our analysis.

The actual weight $w_{ij}(t)$ of the edge $ij$ at time $t$ is given by the sum of all individual contributions of games in a given set $G$, i.e.,

$$w_{ij}(t) = \sum_{g \in G} c_{g,i_j}(t) . \hspace{1cm} (2)$$

We note that weights of edges are strongly dependent on the particular choice of the set of games $G$, as apparent from Eq. (2). As an example, in Figure 3 we display the networks of contacts restricted to subsets of top-tier soccer and basketball coaches. In what follows, we consider natural choices for such a set, as for example the set of all games played in specific national leagues and/or in specific seasons.

### C. CoachScore

Given a directed and weighted network composed of $N$ coaches and constructed according to the recipe of Eqs. (1) and (2), we rank the coaches using the PageRank algorithm [11]. In this context, we name the network centrality metric as CoachScore. Specifically, the CoachScore $p_i(t)$ of coach $i$ at time $t$ is computed as

$$p_i(t) = \alpha \sum_{j=1}^{N} w_{ji}(t) p_j(t) + \frac{1 - \alpha}{N} + \alpha \sum_{j=1}^{N} p_j(t) \delta_{j,i} . \hspace{1cm} (3)$$

The equation is valid for all nodes $i = 1, \ldots, N$, with the constraint that $\sum_{i=1}^{N} p_i(t) = 1$. $\delta_{j,i} = \sum_{q=1}^{N} w_{jq}(t)$ is the so-called out-strength of coach $i$, i.e., the sum of the weights of all edges departing from node $j$. The scores of the coaches are computed by iteration, starting from the suitable
initial condition \( p_i(t) = 1/N \) (although convergence of the algorithm does not require to start from such an initial condition). Intuitively, each coach in the network carries a unit of “prestige” or “credit,” and we imagine that this quantity flows in the graph along the weighted connections. At each iteration of the algorithm, each coach \( j \) distributes the entire credit to all its neighbors. The amount of credit given by coach \( j \) to coach \( i \) is proportional to the weight \( w_{ji}(t) \). The term \( \alpha \sum_{j=1}^{N} \frac{w_{ji}(t)}{\sum_{j'=1}^{N} w_{j'i}(t)} \) represents the portion of score received by coach \( i \) from the immediate neighbors. In addition, each coach distributes part of the prestige equally to all the other coaches in the system, i.e., the term \( \frac{1}{N} \). Finally, the term \( \sum_{j=1}^{N} p_j(t) \delta_{i,j}(t) \) on the rhs of Eq. (3) serves a correction for the case of dangling nodes, i.e., nodes with null out-strength, which otherwise would behave as sinks in the diffusion process. The system of Eq. (3) converges (within a priori fixed precision \( \epsilon \), here set \( \epsilon = 10^{-6} \)) after a certain number of iterations of the algorithm. The resulting score \( p_i(t) \) quantifies the relative prestige that coach \( i \) has at time \( t \). The factor \( 0 \leq \alpha \leq 1 \) determines the relative importance between local diffusion of prestige among immediate neighbors, and global redistribution of prestige to the entire network. In our calculations, we choose the customary value \( \alpha = 0.85 \).

CoachScore is highly correlated with the number of wins (see Figure 7). High correlation between CoachScore and local centrality metrics, e.g., the in-strength (sum of the weights of the incoming connections of a node) is apparent too [20]. With respect to local centrality metrics, however, CoachScore has the advantage of giving high importance to wins (and ties) against quality opponents, where quality is self-consistently quantified by CoachScore. We do not claim that CoachScore is a better metric of performance than other metrics. It just provides a way of measuring the performance of sports coaches different from the simple enumeration of wins.

### III. RESULTS

We present results obtained by ranking coaches on the basis of their CoachScore values. The subset of games used to construct the weighted network that serves for the computation of the centrality metric is the main ingredient we play with. Most of our results are obtained by setting \( \beta = 0 \) in Eq. (1) while aggregating games to build the network. Also, we consider the setting \( \beta = 1/365 \) as a simple way to define a dynamical score useful to monitor the career evolution of coaches over time. In the following, we present first results for soccer coaches, and then for basketball coaches.

#### A. Soccer

**Top coaches of all time**

First, we report on the all-time rankings at the national level. We consider all games of the national leagues listed in Table I and construct weighted networks using games of national leagues only. In particular, we set \( \beta = 0 \) in Eq. (1) while computing edge weights.

The top 10 all-time coaches of each national league are reported in Table I. In the English Premier League, Sir Alex Ferguson, the legendary coach of Manchester United FC for more than 25 years and winning 13 national championships, is at the top of the ranking. For the French Ligue 1, Guy Roux is ranked number 1. He was the coach of AJ Auxerre for roughly 40 years, winning 1 championship in 1995/96. Otto Rehhagel, winner of 3 league titles, sits in the first place of the German Bundesliga. Giovanni Trapattoni tops the ranking of the Italian Serie A. “Il Trap” won 7 Italian championships. Finally, in the Spanish La Liga, Luis Aragonés turns out to be the best performing coach. He was the manager of several teams in Spain, and won 1 championship with Atlético Madrid in 1976/77.

We note that career length is a quite important factor in this type of ranking. This is a natural consequence of the fact that all games are aggregated together in a memory-less fashion, and coaches that managed teams for tens of seasons are represented by nodes that are very well connected, thus highly central, in the graph of contacts. Carlo Mazzone, Luciano Spalletti, and Francesco Guidolin, for example, all managed Italian Serie A teams for 20 years or more, but they never won a national championship in Italy. We believe that performance is a multidimensional metric, and career length should be seen as one of its dimensions. Indeed, the ability of a coach to remain active for many years is certainly an uncommon skill (see Figure 1). We stress that this type of ranking based on the aggregation of multiple decades of data clearly penalizes coaches that had short, even if successful, careers. Coaches, whose careers are only partially covered by the datasets (either because they are today still coaching or they managed teams earlier than the starting date of the matches covered by our datasets), are penalized too.

Also, we establish the ranking of soccer coaches based on their overall careers, by considering the so-called “combined” dataset, which consists of all national and international games since season 1980/81 (see Table I). Maybe surprisingly, Arsène Wenger comes at the top of this ranking. He has been the coach of AS Nancy and AS Monaco FC, and, more notably, of Arsenal FC, with which he achieved many successes for more than 20 years. He is followed by Sir Alex Ferguson. Jupp Heynckes occupies the third place. Heynckes has coached important clubs such as Real Madrid CF and FC Bayern Munich, winning 4 national league titles and 2 Champions Leagues. As for the overall national rankings, still here career length is extremely valued. However, the international nature of careers is valued too. We see that the top 10 positions are occupied by several coaches who successfully managed teams in different European countries. A paradigmatic example is Claudio Ranieri, who started his career in the late 1980s and coached teams in all major leagues considered in this study except for the German Bundesliga, winning the Premier League title in 2015/16 with Leicester City FC. Finally, a special mention is necessary for José Mourinho. Our results are based on a dataset that doesn’t include any of his games for seasons 2002/03 and 2003/04, when he was the head coach of...
FC Porto. We stress that he won the national championships in both seasons; he further won the UEFA Cup in 2002/03 and the UEFA Champions League in 2003/04. Given the importance of the coach for European soccer, we performed a separate analysis by including in the combined dataset all games of the Portuguese Primeira Liga [37] and games of the European competitions involving Portuguese teams for the two aforementioned seasons. The actual value of the score for José Mourinho increases by more than 15%. However, the increment is not sufficient to let him gain any position in the all-time ranking.

### Top coaches of the decade

We repeated a similar analysis by dividing game data in decades. These sets of games are subsamples of the sets considered in the section above when establishing the all-time rankings. For example, the 1960s decade of Serie A consists of all games played in the Italian Serie A in the 10 consecutive seasons ranging from 1960/61 to 1969/70. We couldn’t consider some combinations of league/decade for lack of data, e.g., Ligue 1 in the 1960s. For the Bundesliga in the 1960s, the ranking is established only on the seven seasons at our disposal. We remark that the specific choice made here for the selection of the games that contribute to the creation of the networks still favors some coaches with respect to others. For example, the 1970s performance of a coach with career spanning 10 consecutive seasons from 1965/66 till 1974/75 is unavoidably penalized compared to the performance of a coach with a career of identical length but spanning from season 1970/71 to season 1979/80.

With those considerations in mind, we first constructed networks by setting the parameter $\beta = 0$, and then evaluated the CoachScore of each coach in the network. Top coaches by decade are reported in Table III. Several of the coaches already present in the all-time top 10 ranking appear here too. At the continental level, Jupp Heynckes tops the 1980s ranking, Sir Alex Ferguson is elected as the best coach of the 1990s and 2000s, and Pep Guardiola is identified as the best coach of the past decade.

![Figure 4. CoachScore vs. number of points](image)

Figure 4. **CoachScore vs. number of points.** We report the rank positions for the 20 soccer coaches who managed teams in the 2018/19 English Premier League. We rank coaches on the basis of their CoachScore and compare those ranks with those obtained with the number of points they gathered in the league. Spearman rank correlation coefficient is $\rho = 0.973$, and Kendall rank correlation coefficient is $\tau = 0.896$. The line stands for perfect agreement between the two rankings.

Finally, we establish rankings for individual seasons. Networks are built by selecting games played in a given season only. Weights of the network edges are still calculated by setting the parameter $\beta = 0$ in Eq. (1). In Tables IV and VI we list the top coaches for all seasons covered by our dataset. We see many of the coaches already listed in the top rankings of all time and by decade. Some of them are elected as the best coach for multiple seasons. In general, we note that the coach of the team winning the national league tops the CoachScore ranking of the season too. Points made in

| Rank | England | France | Germany | Italy | Spain | Combined |
|------|---------|--------|---------|-------|-------|----------|
| 1    | Sir Alex Ferguson | Guy Roux | Otto Rehhagel | Giovanni Trapattoni | Luis Aragonés | Arsène Wenger |
| 2    | Arsène Wenger | Claude Puel | Jupp Heynckes | Carlo Mazzone | Miguel Munoz | Sir Alex Ferguson |
| 3    | Brian Clough | Jean Fernandez | Udo Lattek | Nils Liedholm | Javier Irureta | Jupp Heynckes |
| 4    | Sir Bobby Robson | Joel Muller | Thomas Schaaf | Carlo Ancelotti | Ernesto Valverde | Carlo Ancelotti |
| 5    | Harry Redknapp | Frédéric Antonetti | Ottmar Hitzfeld | Fabio Capello | Víctor Fernandez | José Mourinho |
| 6    | José Mourinho | Rolland Courbis | Felix Magath | Nereo Rocco | Diego Simeone | Claudio Ranieri |
| 7    | David Moyes | Jean Claude Suaudeau | Eric Ribbeck | Luciano Spalletti | Joaquín Caparrós | Otto Rehhagel |
| 8    | Ron Atkinson | Elie Baup | Hennes Weisweiler | Francesco Guidolin | John Toshack | Pep Guardiola |
| 9    | Sam Allardyce | Rudi Garcia | Christoph Daum | Luigi Radice | Javier Clemente | Jurgen Klopp |
| 10   | Sir Kenny DalGLISH | Jacques Santini | Dieter Hecking | Helenio Herrera | Gregorio Manzano | Guy Roux |

Table III. **Top 10 coaches in European soccer of all time.** We report the 10 best coaches for each of the national leagues we consider in this paper (see Table I). In the rightmost column, we report the top 10 coaches obtained on the basis of the combination of all games, national and international, at our disposal since season 1980/81.
the league and CoachScore are indeed highly correlated, as for instance shown in Figure 4 for the 2018/19 English Premier League. There are, however, several seasons where the elected best coach according to CoachScore is not the one who actually won the national championship. Examples from the Italian Serie A are Giancarlo De Sisti in 1981/82, Sven-Göran Eriksson in 1985/86, Fabio Capello in 2001/02, and Claudio Ranieri in 2009/10 whose teams ranked second in the league only one point behind the season champions. Similar “anomalies” are present in the other national leagues too. In the rankings based on the combination of national and European games of a season, we see that the top coach is generally the Champions League winner (in some cases, the winner of the Europa League too). Also, here there are some anomalies, in the sense that the top European coach of the season won only the national championship and reached the final stages of a European competition without winning it. Examples are Diego Simeone in 2013/14, Luis Enrique in 2015/16, and Ernesto Valverde in 2018/19. There are also cases where the top European coach neither won the national league nor a European competition, such as Héctor Cúper in 1999/00, and Julian Nagelsmann in 2019/20.

Dynamic ranking

We now turn our attention on the dynamical version of the ranking by building weighted networks where we account for the aging of the contribution of individual games. To this end, we set $\beta = 1/365$ in Eq. (1). At each point in time $t$, we reconstruct the network, and recompute the CoachScore rank of a coach.

We use dynamic ranking to first establish the best coaches at time of writing of this paper. Please note that no games of season 2020/21 are included, thus our current ranking is based on games played till August 2020. In Table VI, we list the top 10 coaches at the national and continental levels. Jürgen Klopp is the best coach in the English Premier League and in Europe. Christophe Galtier, Julian Nagelsmann, Gian Piero Gasperini, and Diego Simeone top their national rankings.

Also, we take advantage of dynamic CoachScore to monitor performances of coaches throughout their careers. We use the combination of all national and continental games to construct networks. In Figure 5 we display the career trajectories of Pep Guardiola and José Mourinho.

Guardiola started his career at FC Barcelona in 2008/09. According to our metric, he enters in the top 10 ranking at the end of his first season, in the top 5 list at the end of the second season, and tops the ranking during the 2011/12 season. During the “sabbatical” 2012/13 season, he loses rank positions. From 2013/14 till 2015/16 he was the coach of FC Bayern Munich. In spite of being consistently ranked in the top 10, he never reaches the actual top of the ranking during that period. Finally, he started coaching Manchester City FC in 2016/17. His dominant performance in the English Premier League makes him consistently ranked in the top 5 coaches in Europe. He is ranked at the top position for a great part of season 2017/18, and currently sits at position number 2 right behind Jürgen Klopp.

| Decade | Premier League | Ligue 1 | Bundesliga | Serie A | La Liga | Combined |
|--------|----------------|--------|------------|---------|---------|----------|
| 1960s  | -              | -      | Helmuth Johannsen | Hélenio Herrera | Miguel Munoz | -        |
| 1970s  | Dave Sexton    | -      | Udo Lattek   | Nils Liedholm | Carriega     | -        |
| 1980s  | Brian Clough   | Aimé Jacquet | Jupp Heynckes | Giovanni Trapattoni | Javier Clemente | Jupp Heynckes |
| 1990s  | Sir Alex Ferguson | Guy Roux | Otto Rehhagel | Marcello Lippi | Javier Irureta | Sir Alex Ferguson |
| 2000s  | Sir Alex Ferguson | Claude Puel | Thomas Schaaf | Carlo Ancelotti | Joaquín Caparrós | Sir Alex Ferguson |
| 2010s  | Arsène Wenger  | Christophe Galtier | Dieter Hecking | Massimiliano Allegri | Diego Simeone | Pep Guardiola |

Table IV. Top European soccer coaches by decade. For each decade, we report the best coach of each of the national leagues we consider in this paper (see Table I). Empty cells indicate that no data are at our disposal for the specific combination of league/decade. In the rightmost column, we report the best coach of each decade obtained on the basis of the combination of all data at our disposal, including national and international competitions.
| Season | England | France | Germany | Italy | Spain | Combined |
|--------|---------|--------|---------|-------|-------|----------|
| 1960/61 | -       | -      | -       | Paolo Todeschini | Miguel Munoz | -        |
| 1961/62 | -       | -      | -       | Nereo Rocco | Miguel Munoz | -        |
| 1962/63 | -       | -      | -       | Hélenio Herrera | Miguel Munoz | -        |
| 1963/64 | -       | -      | Georg Knöpfle | Hélenio Herrera | Miguel Munoz | -        |
| 1964/65 | -       | -      | Willi Muthaup | Hélenio Herrera | Roque Olsen | -        |
| 1965/66 | -       | -      | Max Merkel | Bruno Pesaola | Roque Olsen | -        |
| 1966/67 | -       | -      | Helmut Johannsen | Heriberto Herrera | José Kalmar | -        |
| 1967/68 | -       | -      | Max Merkel | Nereo Rocco | Salvador Artigas | -        |
| 1968/69 | -       | -      | Branko Zebec | Bruno Pesaola | Miguel Munoz | -        |
| 1969/70 | -       | -      | Hennes Weisweiler | Manlio Scopigno | Marcel Domingo | -        |
| 1970/71 | Don Revie | -      | Hennes Weisweiler | Nereo Rocco | Alfredo di Stefano | -        |
| 1971/72 | Don Revie | -      | Udo Lattek | Cestmir Vycpalek | Alfredo di Stefano | -        |
| 1972/73 | Bertie Mee | -      | Udo Lattek | Cestmir Vycpalek | José Santamaria | -        |
| 1973/74 | Don Revie | -      | Udo Lattek | Cestmir Vycpalek | Rinus Michels | -        |
| 1974/75 | Dave Mackay | -      | Kuno Klötzer | Carlo Parola | Miljan Miljanic | -        |
| 1975/76 | Dave Sexton | -      | Udo Lattek | Luigi Radice | Miljan Miljanic | -        |
| 1976/77 | Bob Paisley | -      | Friedel Rausch | Luigi Radice | Luis Aragonés | -        |
| 1977/78 | Brian Clough | -      | Hennes Weisweiler | Giovanni Trapattoni | Luis Molowny | -        |
| 1978/79 | Bob Paisley | -      | Jürgen Sundermann | Nils Liedholm | Luis Molowny | -        |
| 1979/80 | Bob Paisley | -      | Branko Zebec | Eugenio Bersellini | Alberto Ormaetxea | -        |
| 1980/81 | Ron Atkinson | Jean Vincent | Pál Csernai | Giovanni Trapattoni | Vujadin Boskov | Sir Bobby Robson |
| 1981/82 | Sir Bobby Robson | Gérard Banide | Ernst Happel | Giancarlo Di Sisti | Alberto Ormaetxea | Giancarlo Di Sisti |
| 1982/83 | Bob Paisley | Jean-Claude Suauadeau | Otto Rehhagel | Nils Liedholm | Alfredo di Stefano | Ernst Happel |
| 1983/84 | Joe Fagan | Aimé Jacquet | Jupp Heynckes | Giovanni Trapattoni | Alfredo di Stefano | Otto Rehhagel |
| 1984/85 | Howard Kendall | Aimé Jacquet | Udo Lattek | Osvaldo Bagnoli | Terry Venables | Aimé Jacquet |
| 1985/86 | Sir Kenny Dalglish | Gérard Houllier | Erich Ribbeck | Sven-Göran Eriksson | Luis Molowny | Luis Molowny |
| 1986/87 | Howard Kendall | Aimé Jacquet | Udo Lattek | Ottavio Bianchi | Terry Venables | Leo Benhakker |
| 1987/88 | Sir Kenny Dalglish | Arsène Wenger | Otto Rehhagel | Arrigo Sacchi | Leo Benhakker | Leo Benhakker |
| 1988/89 | George Graham | Arsène Wenger | Jupp Heynckes | Giovanni Trapattoni | Leo Benhakker | Ottavio Bianchi |
| 1989/90 | Sir Kenny Dalglish | Gérard Gili | Jupp Heynckes | Arrigo Sacchi | John Toshack | John Toshack |
| 1990/91 | George Graham | Arsène Wenger | Jupp Heynckes | Vujadin Boskov | Javier Irureta | Jupp Heynckes |
| 1991/92 | Howard Wilkinson | Arsène Wenger | Dragošlav Stepanovic | Fabio Capello | Luis Aragonés | Fabio Capello |
| 1992/93 | Sir Alex Ferguson | Arsène Wenger | Otto Rehhagel | Fabio Capello | Johan Cruyff | Johan Cruyff |
| 1993/94 | Sir Alex Ferguson | Artur Jorge | Friedel Rausch | Fabio Capello | Arsenio Iglesias | Fabio Capello |
| 1994/95 | Sir Kenny Dalglish | Jean-Claude Suauadeau | Otto Rehhagel | Marcello Lippi | Jorge Valdano | Marcello Lippi |
| 1995/96 | Sir Alex Ferguson | Patrice Bergues | Ottmar Hitzfeld | Fabio Capello | Radomir Antić | Ottmar Hitzfeld |
| 1996/97 | Sir Alex Ferguson | Jean Tigna | Giovanni Trapattoni | Marcello Lippi | Fabio Capello | Fabio Capello |
| 1997/98 | Arsène Wenger | Daniel Leclercq | Otto Rehhagel | Marcello Lippi | Bernd Krauss | Jupp Heynckes |
| 1998/99 | Arsène Wenger | Elie Baup | Ottmar Hitzfeld | Alberto Zaccheroni | Louis van Gaal | Sir Alex Ferguson |
| 1999/00 | Sir Alex Ferguson | Claude Puel | Christoph Daum | Sven-Göran Eriksson | Txetxu Rojo | Héctor Cúper |
| 2000/01 | Sir Alex Ferguson | Jacques Santini | Huub Stevens | Fabio Capello | Luis Aragonés | Ottmar Hitzfeld |
| 2001/02 | Arsène Wenger | Jacques Santini | Ottmar Hitzfeld | Fabio Capello | Rafael Benítez | Javier Irureta |
| 2002/03 | Sir Alex Ferguson | Paul Le Guen | Ottmar Hitzfeld | Marcello Lippi | Vicente del Bosque | Vicente del Bosque |
| 2003/04 | Arsène Wenger | Vahid Halilhodzic | Thomas Schaaf | Carlo Ancelotti | Rafael Benítez | Javier Irureta |
| 2004/05 | José Mourinho | Paul Le Guen | Falko Götz | Roberto Mancini | Frank Rijkaard | Carlo Ancelotti |
| 2005/06 | Sir Alex Ferguson | Gérard Houllier | Thomas Doll | Fabio Capello | Frank Rijkaard | Frank Rijkaard |
| 2006/07 | Sir Alex Ferguson | Gérard Houllier | Armin Veh | Roberto Mancini | Fabio Capello | Roberto Mancini |
| 2007/08 | Sir Alex Ferguson | Laurent Blanc | Ottmar Hitzfeld | Roberto Mancini | Bernd Schuster | Sir Alex Ferguson |
| 2008/09 | Rafael Benítez | Eric Gerets | Ralf Rangnick | José Mourinho | Pep Guardiola | Pep Guardiola |
| 2009/10 | Carlo Ancelotti | Jean Fernandez | Louis van Gaal | Claudio Ranieri | Pep Guardiola | José Mourinho |
| 2010/11 | Sir Alex Ferguson | Rudi Garcia | Jürgen Klopp | Massimiliano Allegri | Pep Guardiola | Pep Guardiola |
| 2011/12 | Roberto Mancini | René Girard | Jürgen Klopp | Antonio Conte | José Mourinho | Pep Guardiola |

Table V. **Top European soccer coaches of the season.** For each season, we report the best coach of each of the national leagues we consider in this paper (see Table I). Empty cells indicate that no data are at our disposal for the specific combination of league/season. In the rightmost column, we report the best coach of each season obtained on the basis of the combination of all data at our disposal, including national and international competitions.
England

| Season | Rank | Premier League | Ligue 1 | Bundesliga | Serie A | La Liga | Combined |
|--------|------|----------------|--------|------------|---------|---------|----------|
| 2012/13 | 1 | Jürgen Klopp | Christophe Galtier | Julian Nagelsmann | Gian Piero Gasperini | Diego Simeone | Jürgen Klopp |
| 2013/14 | 2 | Pep Guardiola | Thomas Tuchel | Lucien Favre | Simone Inzaghi | Zinédine Zidane | Pep Guardiola |
| 2014/15 | 3 | Ole Gunnar Solskjaer | David Guion | Peter Bosz | Maurizio Sarri | Ernesto Valverde | Diego Simeone |
| 2015/16 | 4 | José Mourinho | Michel Der Zakarian | Christian Streich | Stefano Pioli | José Luis Mendilibar | Julian Nagelsmann |
| 2016/17 | 5 | Sean Dyche | Rudi Garcia | Hans-Dieter Flick | Antonio Conte | Quique Setién | Thomas Tuchel |
| 2017/18 | 6 | Nuno Espírito Santo | Stéphane Moulin | Marco Rose | Sinisa Mihajlovic | Pepe Bordalás | Lucien Favre |
| 2018/19 | 7 | Roy Hodgson | Leonardo Jardim | Adi Hütter | Roberto De Zerbi | Javier Calleja | Maurizio Sarri |
| 2019/20 | 8 | Ralph Hasenhüttl | Thierry Laurey | Dieter Hecking | Gennaro Gattuso | Paco López | Carlo Ancelotti |
| 2020/21 | 9 | Frank Lampard | Julien Stéphan | Florian Kohfeldt | Massimiliano Allegri | Imanol Alguacil | José Mourinho |
| 2021/22 | 10 | Mauricio Pochettino | Patrick Vieira | Niko Kovac | Walter Mazzarri | Gaizka Garitano | Zinédine Zidane |

Table VI. Top European soccer coaches of the season. Continuation of Table V.

The career trajectory of José Mourinho doesn’t include any of the seasons prior to 2004/05, when he started coaching Chelsea FC. We remind the reader that he was the head coach of FC Porto in seasons 2002/03 and 2003/04. He won the national championships in both seasons; he further won the UEFA Cup in 2002/03 and the UEFA Champions League in 2003/04. The very fact that these data points are not included in our dataset clearly penalizes his performance as measured in the all-time and 2000s rankings. Also, it affects the effective performance measured by the dynamic CoachScore at the beginning of his tenure as the head coach of Chelsea FC. We see, however, that thanks to his excellent performance at Chelsea he is ranked in the top 10 between 2005 and 2007. While coaching FC Internazionale Milano, Real Madrid CF, and, for the second time, Chelsea FC, he is steadily ranked in the top 10. He is ranked in the top 10 also during his recent tenures at Manchester United FC and Tottenham Hotspur FC. Clear drops in rank positions are visible only during the three breaks he had in part of the seasons 2007/08, 2015/16 and 2018/19.

Dynamic scores can be used to compare the performance of coaches at any given point in time. In Figure 6 for example, we display dynamic rank positions of five selected coaches. We see that Jupp Heynckes and Sir Alex Ferguson top the ranking for long periods of time. After retirement, rank positions are lost exponentially fast due to choice we made for the kernel function of Eq. (1). The most recent seasons are instead dominated by José Mourinho, Pep Guardiola, and Jürgen Klopp, who is ranked number one by the end of season 2019/20.

B. Basketball

We repeat a similar analysis on the basketball dataset. First, we establish the all-time ranking by aggregating all games in our dataset. We considered two different sets of games: the union of ABA and NBA games, and NBA games only. We use $\beta = 0$ in Eq. (1). The list of the top 10 coaches of all time is re-
ported in Table VIII. As already stressed for the all-time ranking of soccer coaches, also here we note that career longevity is strongly correlated with overall performance (see Figure 9). The inclusion/exclusion of ABA games slightly modify the rank position of some coaches, although the names appearing in the top 10 are basically the same irrespective of the particular dataset considered. Red Auerbach is elected as the best coach of all time. He was the head coach of the Boston Celtics for more than 15 seasons winning 9 NBA titles. Auerbach is followed by Gregg Popovich, who is the current coach of the San Antonio Spurs. He has been coaching the same team for more than 20 years. Under Gregg Popovich, except for his first and last seasons, the Spurs always made the playoffs, they never fell below 50% win percentage, and won 5 NBA championships. In the third place is Larry Brown, who had a long career both in the ABA and NBA. He coached in both leagues for more than 25 seasons, winning 1 NBA championship, and reaching 2 NBA and 1 ABA Finals. When we consider NBA games only and exclude ABA, Larry Brown drops from the third to the tenth place in the ranking. The third place in the all-time ranking based on NBA games only is occupied by Phil Jackson, head coach of the Chicago Bulls during the 1990s and of the Los Angeles Lakers in two separate periods, winner of 11 NBA titles.

| Rank | ABA + NBA | NBA only |
|------|-----------|----------|
| 1    | Red Auerbach | Red Auerbach |
| 2    | Gregg Popovich | Gregg Popovich |
| 3    | Larry Brown | Phil Jackson |
| 4    | Don Nelson | Don Nelson |
| 5    | Phil Jackson | Lenny Wilkens |
| 6    | Lenny Wilkens | Jerry Sloan |
| 7    | Jerry Sloan | Pat Riley |
| 8    | Pat Riley | George Karl |
| 9    | George Karl | John Kundla |
| 10   | John Kundla | Larry Brown |

Table VIII. Top 10 coaches in American basketball of all time. We report the 10 best coaches using ABA + NBA games, and then using NBA games only. The difference between the two networks considered are games played in the ABA between seasons 1967/68 and 1975/76 (see Table IV). In both cases, the games considered in the analysis were played from the 1946/47 season till the 2019/20 season. Weighted networks of contact among coaches are constructed by setting $\beta = 0$ in Eq. (1).

The top coaches of the decade are: Red Auerbach in the 1950s, Alex Hannum in the 1960s, Dick Motta in the 1970s, Pat Riley in the 1980s, Phil Jackson in the 1990s, and Gregg Popovich in the 2000s and 2010s.

The top coaches of the season are reported in Table IX. We see that coaches making in the all-time top 10 ranking are topping the ranking in several seasons. Generally, the top coach of the season corresponds to the coach of the NBA champion team. The one-to-one map is more apparent in basketball than in soccer due to the structure of the NBA basketball tournament. Top-performing basketball teams play a high number of post-season games; in national soccer championships, the number of games is the same for all teams.

| Season | NBA   | Season | NBA   |
|--------|-------|--------|-------|
| 1946/47 | Red Auerbach | 1983/84 | K.C. Jones |
| 1947/48 | Buddy Jeannette | 1984/85 | K.C. Jones |
| 1948/49 | John Kundla | 1985/86 | K.C. Jones |
| 1949/50 | John Kundla | 1986/87 | K.C. Jones |
| 1950/51 | Les Harrison | 1987/88 | Pat Riley |
| 1951/52 | John Kundla | 1988/89 | Chuck Daly |
| 1952/53 | John Kundla | 1989/90 | Rick Adelman |
| 1953/54 | John Kundla | 1990/91 | Mike Dunleavy |
| 1954/55 | Al Cervi | 1991/92 | Phil Jackson |
| 1955/56 | George Senesky | 1992/93 | Phil Jackson |
| 1956/57 | Red Auerbach | 1993/94 | Rudy Tomjanovich |
| 1957/58 | Red Auerbach | 1994/95 | Rudy Tomjanovich |
| 1958/59 | Red Auerbach | 1995/96 | Phil Jackson |
| 1959/60 | Red Auerbach | 1996/97 | Phil Jackson |
| 1960/61 | Red Auerbach | 1997/98 | Phil Jackson |
| 1961/62 | Red Auerbach | 1998/99 | Gregg Popovich |
| 1962/63 | Red Auerbach | 1999/00 | Phil Jackson |
| 1963/64 | Red Auerbach | 2000/01 | Phil Jackson |
| 1964/65 | Red Auerbach | 2001/02 | Phil Jackson |
| 1965/66 | Red Auerbach | 2002/03 | Gregg Popovich |
| 1966/67 | Alex Hannum | 2003/04 | Phil Jackson |
| 1967/68 | Bill Russell | 2004/05 | Gregg Popovich |
| 1968/69 | Bill Russell | 2005/06 | Avery Johnson |
| 1969/70 | Red Holzman | 2006/07 | Gregg Popovich |
| 1970/71 | Larry Costello | 2007/08 | Doc Rivers |
| 1971/72 | Bill Sharman | 2008/09 | Phil Jackson |
| 1972/73 | Red Holzman | 2009/10 | Phil Jackson |
| 1973/74 | Larry Costello | 2010/11 | Rick Carlisle |
| 1974/75 | K.C. Jones | 2011/12 | Erik Spoelstra |
| 1975/76 | Tom Heinsohn | 2012/13 | Gregg Popovich |
| 1976/77 | Jack Ramsay | 2013/14 | Gregg Popovich |
| 1977/78 | Dick Motta | 2014/15 | Steve Kerr |
| 1978/79 | Lenny Wilkens | 2015/16 | Steve Kerr |
| 1979/80 | Billy Cunningham | 2016/17 | Steve Kerr |
| 1980/81 | Bill Fitch | 2017/18 | Steve Kerr |
| 1981/82 | Billy Cunningham | 2018/19 | Nick Nurse |
| 1982/83 | Billy Cunningham | 2019/20 | Frank Vogel |

Table IX. Top NBA coaches of the season. We consider NBA games only. We report the name of the top coach of the season according to our ranking. Weights of the network connections are obtained by setting $\beta = 0$ in Eq. (1).

We finally take advantage of dynamic weights to establish the list of top 10 coaches currently managing NBA teams. Erik Spoelstra is at the top of the list. As the coach of Miami Heat, he reached the NBA Finals in the 2019/20 season. The rest of the ranking is: Doc Rivers, Brad Stevens, Mike D’Antoni, Mike Malone, Frank Vogel, Gregg Popovich, Mike
Budenholzer, Nick Nurse, and Terry Stotts.

Dynamic weighted networks are further used to monitor the career evolution of coaches, as done for example in Figure 7, where we display the career trajectories of Phil Jackson and Steve Kerr.

Phil Jackson started his career at the Chicago Bulls, where he won 6 NBA titles. Later, he won 5 more NBA titles with the Los Angeles Lakers in two separate periods. Throughout his career, he is consistently ranked in the top 5 (very often at the very top), according to his dynamic score. The only period when he drops out of the top 5 ranking, except for the periods he was not coaching, is around 1994/95, the second season of the Michael Jordan’s first retirement from basketball.

The career trajectory of Steve Kerr, although short, is very successful. In his 6 seasons with Golden State Warriors, he reached 5 NBA Finals and won 3 NBA titles. According to dynamic CoachScore, he enters in the top 5 ranking at the start of his second season and does not drop out of the top 5 ranking until his last season.

Figure 7. Monitoring the career performance of basketball coaches. (a) We visualize the dynamic rank of Phil Jackson throughout his career. Rank positions are updated after each game day. Red lines indicate when a coach takes over a new team, dashed green lines indicate the start of a new season with his current team, and grey shaded areas represent periods of time when the coach is not managing any team. CHI stands for Chicago Bulls, and LAL for Los Angeles Lakers. (b) Same as in panel a, but for Steve Kerr. GSW stands for Golden State Warriors.

Dynamic rank is also used to compare the performance of different coaches at the same instant of time, as done for example in Figure 8. Here, we see Pat Riley at the top of the ranking around the mid 1980s and the mid 1990s. Phil Jackson and Gregg Popovich both have long runs at the top of the ranking for around 20 years. Rick Carlisle and Erik Spoelstra reach the top 5 ranking in the 2010s. Rick Carlisle won a NBA title in 2010/11 with Dallas Mavericks. Erik Spoelstra won 2 titles in 2011/12 and 2012/13 with Miami Heat.

IV. CONCLUSIONS

The proper evaluation of the career of a professional soccer coach should account for a myriad of factors, e.g., the strength of the teams coached and the level of difficulty of the competitions where the coach participates in. However, these factors are hardly measurable, making the task of gauging performance on the basis of trophies or other achievements very challenging. For instance, should one value more a title in the Italian Serie A in the early 2000s, in the Spanish La Liga in the mid 2010s, or in the English Premier League today? Also, the challenge is exacerbated by the fact that a career may span tens of seasons, and involve multiple teams and leagues. Cases like Sir Alex Ferguson, who managed the same team for 20+ years, are quite rare. Even for these special cases, the high variability of the rest of the system makes extremely difficult to account for all the potential factors that one should quantify when assessing their career performance.

As only one league exists, gauging the performance of a coach in professional American basketball seems easier than it is for coaches of European soccer clubs. However, also in American basketball, factors that are important to measure the career performance of a coach vary on a time scale much shorter than the duration of the coach’s career. Thus, attempts to compare coaches on the basis of simple counting strategies – e.g., number of wins, number of trophies – may not be completely fair, as the value of individual events may not be comparable from season to season, especially over extended periods of time.

In this paper, we avoid to explicitly give values to specific events. We just let the system decide the importance of the events in a self-consistent manner. Our approach is based on a macroscopic perspective of sports competitions. A game between two teams is seen as an elementary interaction among their respective coaches, with the direction of the interaction depending on the game outcome. The aggregation of data from many games allows us for the construction of a web of contacts among coaches. We use a network centrality metric, named CoachScore, to self-consistently determine the relative performance of a coach in the system.

We do not claim that our way of quantifying performance is better than others. Rather, we believe that no single metric should be used to make direct comparisons among coaches, as performance is a multidimensional object. Our proposed CoachScore can be seen as one of these dimensions. With these considerations in mind, we hope that sports fans could
enjoy exploring additional results from the companion website coachscore.luddy.indiana.edu that is integral part of the present work.

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Appendix A: List of abbreviations

In Table X we report full forms of abbreviations used in the paper.

| Abbreviation | Full form (or translation)                  |
|--------------|--------------------------------------------|
| UEFA         | Union of European Football Associations    |
| FC/CF        | Football Club                              |
| AJ           | Youth Association                          |
| AS           | Sport Association                          |
| NBA          | National Basketball Association            |
| ABA          | American Basketball Association            |
| h2h          | head-to-head                               |

Table X. List of abbreviations used in the paper. From left to right, we report the abbreviation and the corresponding full form.

Appendix B: Additional results

In Figures 9, 10, and 11 we report on additional results from our analysis. Specifically, we consider rank correlation plots between: CoachScore and number of wins (Fig. 9); CoachScore computed on networks with different ratios of win/tie (Fig. 10); CoachScore computed for different values of the parameter α (Fig. 11).

Figure 9. Comparison of rankings by CoachScore and number of wins. (a) We report the rank position of all soccer coaches in our combined dataset (see Table I). Rankings are performed by either relying on the CoachScore values or the number of wins. Each point in the plot is a coach. Spearman correlation coefficient is \( \rho = 0.989 \), while Kendall correlation coefficient is \( \tau = 0.923 \). (b) Similar to panel a, but for basketball coaches. Rank correlation coefficients are \( \rho = 0.979 \) and \( \tau = 0.888 \).

Figure 10. Comparison of rankings by CoachScore while using different weights for win in soccer. We report the rank position of all soccer coaches of our combined dataset. The ranking on the x-axis relies on the network where a win has twice the weight of a tie. The ranking on the y-axis relies on a network where a win has three times the weight of a tie. Spearman correlation coefficient is \( \rho = 0.999 \), while Kendall correlation coefficient is \( \tau = 0.983 \).

Figure 11. Comparison of rankings by CoachScore while using different damping factors. (a) We report the rank position of all soccer coaches of our combined dataset. The ranking on the x-axis is for CoachScore with damping factor \( \alpha = 0.85 \), and the ranking on the y-axis with \( \alpha = 0.95 \). Spearman correlation coefficient is \( \rho = 0.999 \), while Kendall correlation coefficient is \( \tau = 0.972 \). (b) Same as in panel a, but basketball coaches in NBA. Spearman correlation coefficient is \( \rho = 0.996 \), while Kendall correlation coefficient is \( \tau = 0.954 \).
[42] S. Motegi and N. Masuda, “A network-based dynamical ranking system for competitive sports,” *Scientific reports*, vol. 2, p. 904, 2012.