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A model for competitiveness level analysis in sports competitions: Application to basketball

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ABSTRACT

The degree of overall competitiveness of a sport league is a complex phenomenon. It is difficult to assess and quantify all elements that yield the final standing. In this paper, we analyze the general behavior of the result matrices of each season and we use the corresponding results as a probably density. Thus, the results of previous seasons are a way to investigate the probability that each team has to reach a certain number of victories. We developed a model based on Shannon entropy using two extreme competitive structures (a hierarchical structure and a random structure), and applied this model to investigate the competitiveness of two of the best professional basketball leagues: the NBA (USA) and the ACB (Spain). Both leagues' entropy levels are high (NBA mean 0.983; ACB mean 0.980), indicating high competitiveness, although the entropy of the ACB (from 0.986 to 0.972) demonstrated more seasonal variability than that of the NBA (from 0.985 to 0.990), a possible result of greater sporting gradients in the ACB. The use of this methodology has proven useful for investigating the competitiveness of sports leagues as well as their underlying variability across time.

1. Introduction

Any sport is governed by a sequence of confrontations in response to a specific competition pattern. The type of confrontation and the degree of equality among the competitors determine the level of competitiveness. Competitiveness is a comparative concept of the ability to strive for a goal. The more balanced the competition, the greater the degree of competitiveness, and vice versa. This is interesting, because it reflects the reality of the competitive system, e.g. higher budgets allow signing players of better quality, whereas tighter budgets do not allow signing big stars, given their high cost. One of the most widespread ideas to explain the phenomenon of equality among the competitors of the same championship is the concept of competitive balance, which tries to measure the degree of global competitiveness in a given league.

The concept of competitive balance has been used frequently in studies of sport economics, as indicated by the extensive literature on the subject [1–4]. This has been applied in sports such as baseball [5,6], football [7], basketball [8,9], ice hockey [10], soccer [11], and golf [12]. It is generally accepted that a competition with more competitive balance is a more attractive one [13,14]. Indeed, the most competitive leagues tend to be more attractive and generate more revenue (tickets,

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Table 1
Example of a confrontation matrix with $N = 4$ teams (**a**, **b**, **c**, and **d**). The rows represent the games played (won or lost) by a team at home. The columns represent the won or lost games played by a team away. **HW** (Home Wins) represents the total number of games won by the teams at home. **AL** (Away Lost) is the games lost away. **AW** represents the total number of games won away. The final score R is the sum of the home and away wins, $R = \mathbf{HW} + \mathbf{AW}$.

	a	**b**	**c**	**d**	**HW**	**R**
a	x	1	0	1	2	4
b	0	x	0	0	0	1
c	1	1	x	1	3	5
d	0	0	1	x	1	2
AL	1	2	1	2		
$\mathbf{AW} = (\mathbf{N-1}) - \mathbf{AL}$	2	1	2	1		

sponsors, TV, etc.) [15]. Szymanski [16] considers three kinds of competitive balance. First, there can be match uncertainty. Second, there is season uncertainty, which looks at the uncertainty within one season. The third kind is the dominance of a few teams over seasons, called championship uncertainty.

The aim of our study was to develop a model for competitiveness level analysis in team sport competitions, which would be useful to assess their competitiveness level based on the uncertainty level that might exist for each confrontation. We studied the results from different seasons of two of the main professional basketball leagues: the (National Basketball Association (NBA, USA) and the Basketball Clubs Association (ACB, Spain)) Data have been obtained from the official NBA and ACB webpages (www.nba.com and www.acb.com).

As the methodological approach, we use a matrix of confrontations (for each season) for which the competitive record (number of victories and defeats) may be different for each team. Based on these matrices, we calculated the extreme values. One extreme scenario is that of highest competitiveness (maximum equality between competitors; random structure). The other is that of minimum competitiveness (marked inequality between competitors; hierarchical structure). Thus, the actual values will remain between these extreme values. We calculated the value of the Shannon entropy to determine the degree of uncertainty. Other measures may be used, such as proposed by Vaz de Melo et al. [17], Shiner et al. [18], Humphreys [19], or the measure based on the notion of disequilibrium proposed by López-Ruiz [20].

We chose as a measure of uncertainty the Shannon entropy, which quantifies the information contained by a variable. This theoretical model will serve as reference limits for the study of the level of competitiveness in the NBA and ACB league seasons that we analyzed (NBA: 1992–2009; ACB: 1996–2009).

With this model, we try to understand what the competitiveness of the NBA and ACB is, and to what extent they can be compared. We could expect that the differences between them may be because sports gradients in the ACB are more marked than in the NBA. If so, then the ACB would be predicted to demonstrate a more hierarchical structure as compared to the NBA, which would be expected to demonstrate a more random structure.

We believe the proposed model could shed light on issues such as those related to competitive reality, especially with the mechanisms that give rise to behaviors and new patterns of dominant structure through their equipment and critical environment. For example, the NBA has developed mechanisms to ensure equity among its components, such as a salary cap, the draft, and the fact of being a closed model. In contrast, the ACB does not have such mechanisms and, moreover, there are also promotions and demotions (open model).

2. Confrontation matrices

Our interest is to focus on studying sport leagues, where each team usually plays twice against each other team (once at home, once away) in matches according to a prearranged schedule.

A series of games between a number N of teams can be defined by its matrix of confrontation $\mathbf{A} = [A_{i,j}]_{N\times N}$, with the same number of rows and columns. This is a double entrance matrix in which each row and each column corresponds to the results of each game between any two teams. We shall use the subscript i or j for teams, $i \neq j$, so we use $A_{ij} = 1$ if team i beats team j, and $A_{ij} = 0$ otherwise. Other options such as ties or different values than 0 or 1 are not considered in this introduction at present, without loss of generality. From this matrix, at the end of the competition, we obtain the final score **R**. See Table 1 for an example of the matrix $N = 4$.

Row i of matrix **A** represents the points for games won or lost by team i at home, while column j represents the away games won or lost by the same. Therefore the horizontal sum

$$\sum_{j=1}^{N} A\,(i,j) = n_i \tag{1}$$

represents the number of games won by team i at home (n_i), where N is the total number of teams. Note that $A(i,j) = 0$ if $i = j$. Likewise, the vertical sum

$$\sum_{j=1}^{N} A\,(j,i) = m_i \tag{2}$$