Exploring Dominance Hierarchy in Cricket Team Rankings

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Abstract

In the realm of sports, rankings serve as vital tools for evaluating team and individual performances, enabling informed decisions and driving improvements. Cricket, a prominent sport globally, relies heavily on rankings to guide selections, tournaments, and talent identification. While traditional ranking systems have their merits, they can sometimes yield non-transitive results, challenging the accuracy of team hierarchies. This study explores an alternative approach, dominance ranking, to uncover cricket team rankings' underlying structure. Utilizing data from T20 and ODI matches spanning four years, we construct dominance matrices and apply dominance hierarchy analysis. Intriguingly, our findings reveal a substantial disparity between dominance-based rankings and traditional ICC rankings. This research highlights the need for reevaluating ranking methodologies and encourages a nuanced discussion in the cricket community to enhance the precision and equity of team standings.

Introduction

In the world of sports, ranking plays a crucial role in assessing and comparing the performance of teams and individuals. It provides a quantitative measure of success, reflecting the consistency and impact of their performances over time. Rankings are essential in various sports, including cricket, as they help enthusiasts, selectors, and coaches make informed decisions about team selection, tournament participation, and talent identification. Additionally, rankings serve as benchmarks for teams and players, motivating them to improve their performance and achieve higher positions.

While rankings are meant to objectively represent the hierarchy of teams based on their performances, there are instances where the current ranking systems face challenges. Some teams may strategically manipulate their match schedules to secure higher rankings. For example, certain teams might prefer playing against lower-ranked opponents where the likelihood of winning is higher, thereby ensuring a consistent winning streak and staying at a higher rank. This sort of possibility can lead to non-transitive rankings, where Team A > Team B, Team B > Team C, but surprisingly, Team C > Team A, indicating a lack of a linear hierarchy.

To address the non-transitive rankings problem, exploring alternative ranking methodologies that can better capture the true hierarchy in sports competitions becomes essential. One potential solution lies in adopting a dominance ranking approach, which focuses on investigating the linearity of hierarchy based on pair-wise interactions between teams. By analyzing the dominance relationships between teams, this method seeks to uncover any inconsistencies called circular triads that might exist, providing a more accurate representation of team rankings.

This research embarks on a quest to shed light on the intricacies of cricket rankings, delving into non-transitive rankings. The primary aim is to critically assess the current cricket ranking system's validity and explore the potential for a more comprehensive and accurate representation of team standings. By applying the dominance ranking approach to an extensive dataset of cricket match outcomes, we seek to unravel the underlying hierarchical patterns in team performances. Interestingly, our findings reveal a distinct set of dominance rankings that differs substantially from the traditional ICC rankings. Through the dominance-based evaluation, we have identified intriguing shifts in the rankings, showcasing the emergence of teams in unforeseen positions. Notable ranking differences were observed between the ICC rankings and dominance rankings for countries highlighted in the above table. This research sheds light on the disparities between dominance rankings and ICC rankings in cricket, revealing non-transitive patterns and a non-linear hierarchical structure, challenging the adequacy of traditional ranking methods. The findings underscore the need for a critical reevaluation of existing ranking methodologies to comprehensively represent team standings. By utilizing the statistical strength of the dominance approach, this study highlights the significance of a transformative shift in cricket rankings, encouraging a stimulating discussion among cricket statisticians and data scientists. The aim is to better understand the sport's competitive dynamics and promote continuous refinement in ranking methodologies for a more accurate and equitable representation of team performances.

Literature Review

Existing Ranking method in Cricket

The ICC Team Rankings is a rating method developed by David Kendix to rank men's and women's teams playing across Test, ODI, and T20I formats. In the Men's ODI Team Ranking, the two teams involved receive points based on a mathematical formula after every ODI match. Each team's points total is divided by their total number of matches played to give a rating, and all the teams are ranked in a table in order of rating.

The points for winning an ODI match are always greater than the team's rating, increasing the rating, while the points for losing an ODI match are always less than the rating, reducing the rating. A drawn match between higher and lower-rated teams will benefit the lower-rated team at the expense of the higher-rated team.

To calculate the Men's ODI Team Ranking, each team scores points based on the results of their matches over the last 3-4 years. Matches played in the 12-24 months since the May before last, and all matches played in the 24 months before that count, but with half the weighting. Each May, matches and points earned between 3 and 4 years ago are removed and matches and points earned between 1 and 2 years ago switch from 100% to 50% weighting.

The points earned by teams depend on the opponent's ratings. For example, if the gap between the ratings of the two teams before the match is less than 40 points, the points earned for a win are the opponent's rating + 50, for a tie it's the opponent's rating, and for a loss, it's the opponent's rating - 50. If the gap is at least 40 points, the points earned are different based on the match result and whether the team is stronger or weaker.

Each team's rating is equal to its total points scored divided by the total matches played. Series are not significant in these calculations, and the new rating after a particular match is determined by adding the match points scored to the points already scored and then recalculating the rating based on the new total points and matches played. (timesofsports.com)

Dominance Hierarchy

Dominance ranking is a mathematical approach used to explore and analyze hierarchical relationships or preferences among interacting objects. It was developed independently by two researchers, M. G. Kendall, and Landau. M. G. Kendall and Babington-Smith proposed a method for investigating preference ranking, and their work led to the calculation of a coefficient of consistency K (ζ). Landau, on the other hand, introduced the hierarchy index represented by h. Both methods, based on transitivity, generally produce similar results, but it has been shown that Landau's coefficient h is a better measure of linear hierarchy under certain circumstances, especially in cases involving ties and missing values.

Dominance ranking is a method used to study the hierarchy among interacting objects. The process begins with an asymmetric matrix representing the interactions between the objects.

The main goal is to explore the linearity of the hierarchy by examining pairwise interactions. In a true linear hierarchy, dominance is transitive, meaning if A > B and B > C, then A should also dominate C. However, inconsistencies like circular triads can exist, such as A > B, B > C, but C > A. The process starts off by first constructing a dominance matrix by assessing an asymmetric matrix between ‘n’ interacting objects. The dominance matrix assigns values of 1 if one object dominates the other, 0 if the opposite occurs, and 0.5 in case of a tie. Row totals (Si) are then calculated, representing the number of individuals dominated by each object (i = 1 to n). The number of circular triads (d) can be calculated using:

$$d = \frac{n(n-1)(2n-1)}{12} - \frac{\Sigma(S_i)^2}{2} \qquad (1)$$

The number of circular triads indicates the level of inconsistency in interactions among the n objects. If there are more circular triads, it implies a higher level of inconsistency in the hierarchy. Conversely, when there are no circular triads, it signifies that the interactions follow a perfectly hierarchical structure. Kendall established that the maximum possible number of circular triads is $\frac{n^3-n}{24}$ for odd values of n and $\frac{n^3-4n}{24}$ for even values of n. Since d represents the number of circular triads, Kendall's coefficient of consistence (K) is calculated using:

$$K = 1 - \frac{24d}{(n^3-n)}\ when\ n\ is\ odd. \qquad (2)$$

$$K = 1 - \frac{24d}{(n^3-4n)} when\ n\ is\ even. \qquad (3)$$

In situations where the dominance matrix is mostly or all ties, the K value becomes negative due to Kendall’s assumption of strict dominance between n interacting objects, it is suggested to use Landau’s coefficient of hierarchy h. The index is calculated using:

$$h = \frac{12}{n^3-n} \sum_{i=1}^{n} \left[\frac{V_i-(n-1)}{2}\right]^2 \qquad (4)$$

Here, (V_i) is row total. According to deVries (1995), in the presence of tied dominance relationships, the concept of a circular triad becomes invalid. Therefore, it is suggested to use the number of individuals dominated, particularly when n is even. This is because both K and h have equal values in the presence of ties when n is odd. Therefore, when ties are present, the formula for K when n is odd should be used, irrespective of the value of n.

Kendall (1962) showed that as n increases, the distribution of d reaches $\chi 2$ distribution, the degrees of freedom (df) and $\chi 2$ test statistic can be calculated using:

$$df = \frac{n(n-1)(n-1)}{(n-4)^2} \qquad (5)$$

$$\chi 2 = \frac{8}{n-4}\left[\frac{n(n-1)(n-2)}{24} - d + \frac{1}{2}\right] + df \qquad (6)$$

Appleby (1983) mentioned that $\chi 2$ test statistic should be avoided for small values of n (less than 6) as it may overestimate significance. He further pointed out that the likelihood of finding a linear hierarchy by chance is quite low (.001) for n ≥ 8. Therefore, for larger values of n, the test statistic offers evidence of linearity. Given that K and h are generally equivalent, and h is preferred in situations with ties (Appleby, 1983; H. de Vries, 1995; H. A. N. de Vries, 1998; Nelissen, 1986), we will utilize Landau's hierarchy index, h, in the subsequent sections.

Method

Data Collection

The data collection for this research starts with howstat.com, a reliable cricket statistics website. The dataset comprises information from T20 matches involving 8 countries and ODI matches involving 10 countries, spanning a period of 4 years from 2016 to 2019. The data collected includes details such as the date of the match, the teams involved (Team A vs. Team B), and the winner of each match.

Based on this data, an asymmetric matrix was constructed, representing the interactions between the countries. The matrix has rows and columns representing the countries, while the diagonals remain empty as a team does not play against itself. The matrix captures the wins of each row team against the teams in the corresponding columns, this allows us to build the dominance matrix by comparing pair-wise interaction between n objects. (Howstat.com/t20, Howstat.com/odi)

Analysis

The following Table 1 is an asymmetric matrix capturing wins between involved countries in T20 International matches, the row represents the winning team, and the column represents the opposition. From this table, the dominance matrix was constructed which is presented in Table 2.

Table 1: T20 team wins data from Howstat.com

Countries	Australia	England	India	New Zealand	Pakistan	South Africa	Sri Lanka	West Indies	Row Totals (Vi)
Australia	-	2	4	3	4	2	6		21
England	1	-	2	5	1	3	3	3	18
India	6	4	-	3	2	3	8	8	34
New Zealand	1	3	5	-	4	0	5	2	20
Pakistan	5	1	0	6	-	1	4	9	26
South Africa	2	3	2	1	2	-	5	0	15
Sri Lanka	2	0	2	1	3	3	-	0	11
West Indies		3	4	0	1	1	1	-	10
Totals (∑)	17	16	19	19	17	13	32	22	155

Table 2: T20 Dominance Matrix

Countries	Australia	England	India	New Zealand	Pakistan	South Africa	Sri Lanka	West Indies	Row totals (Vi)	(Vi-(n-1)/2)^2

Australia	-	1	0	1	0	0.5	1	0.5	4	0.25
England	0	-	0	1	0.5	0.5	1	0.5	3.5	0
India	1	1	-	0	1	1	1	1	6	6.25
New Zealand	0	0	1	-	0	0	1	1	3	0.25
Pakistan	1	0.5	0	1	-	0	1	1	4.5	1
South Africa	0.5	0.5	0	1	1	-	1	0	4	0.25
Sri Lanka	0	0	0	0	0	0	-	0	0	12.25
West Indies	0.5	0.5	0	0	0	1	1	-	3	0.25
Totals (∑)	3	3.5	1	4	2.5	3	7	4	28	20.5

The interaction between Australia and West Indies is missing in Table 1. To address this, a tie was assigned to the dominance relationship. For the T20 dominance matrix, the number of circular triads, denoted as d, was computed using Equation (1). With n=8 teams, obtained d=10.75. Followed by calculating Kendall's coefficient of consistence (K) using Equation (3) for even value of n. For the T20 dominance matrix, K was found to be 0.4625. Additionally, Landau's coefficient of hierarchy (h) was computed using Equation (4) and resulted in a value of 0.4881.

The next step involved assessing the significance of the linear hierarchy. By using Kendall's approach, we determined that the distribution of d tends towards a $\chi 2$ distribution as n increases. The degrees of freedom (df) were calculated as 21, and the $\chi 2$ test statistic was obtained as 28.5. The corresponding p-value was found to be 0.126532137, which exceeds the significance level (α=0.05) set at a 95% confidence level. Therefore, we cannot reject the null hypothesis, suggesting the absence of a significant linear hierarchy in the T20 rankings from the dominance matrix.

Similarly, the data obtained from ODI international matches is presented in the below Table 3. Followed by dominance matrix for ODI data in Table 4.

Table 3: ODI team wins data from Howstat.com

Countries	Afghanistan	Australia	Bangladesh	England	India	New Zealand	Pakistan	South Africa	Sri Lanka	West Indies	Row Totals (Vi)
Afghanistan	-	0	2	0	0	0	0	0	1	3	6
Australia	1	-	1	2	9	5	10	2	5	4	39
Bangladesh	4	0	-	1	0	2	1	1	3	8	20
England	1	11	4	-	4	6	8	5	6	10	55
India	2	9	4	3	-	9	4	7	8	11	57
New Zealand	1	4	8	2	5	-	8	3	5	4	40
Pakistan	2	1	1	3	1	2	-	4	8	5	27
South Africa	1	9	3	4	1	3	3	-	15	1	40
Sri Lanka	2	0	6	2	2	0	0	2	-	2	16

West Indies	5	1	2	2	3	0	2	2	1	-	18
Totals (∑)	19	35	31	19	25	27	36	26	52	48	318

Table 4: ODI Dominance Matrix										
Countries	Afghanistan	Australia	Bangladesh	England	India	New Zealand	Pakistan	South Africa	Sri Lanka	West Indies
Afghanistan	-	0	0	0	0	0	0	0	0	0
Australia	1	-	1	0	0.5	1	1	0	1	1
Bangladesh	1	0	-	0	0	0	0.5	0	0	1
England	1	1	1	-	1	1	1	1	1	1
India	1	0.5	1	0	-	1	1	1	1	1
New Zealand	1	0	1	0	0	-	1	0.5	1	1
Pakistan	1	0	0.5	0	0	0	-	1	1	1
South Africa	1	1	1	0	0	0.5	0	-	1	0
Sri Lanka	1	0	1	0	0	0	0	0	-	1
West Indies	1	0	0	0	0	0	0	1	0	-
Totals (∑)	9	2.5	6.5	0	1.5	3.5	4.5	4.5	6	7

Countries	Row totals (Vi)	$(\frac{Vi-(n-1)}{2})^2$
Afghanistan	0	20.25
Australia	6.5	4
Bangladesh	2.5	4
England	9	20.25
India	7.5	9
New Zealand	5.5	1
Pakistan	4.5	0
South Africa	4.5	0
Sri Lanka	3	2.25
West Indies	2	6.25
Totals (∑)	45	67

From Table 4, the number of circular triads (d) was computed as 9.75, indicating a bit lower level of inconsistency compared to the T20 dataset. Kendall's coefficient of consistence (K) calculation yielded a value of 0.75625. Additionally, Landau's coefficient of hierarchy (h) was calculated and resulted in a value of 0.8121.

To determine the significance of the linear hierarchy, $\chi 2$ test statistic was calculated using Equations (5) and (6). The degrees of freedom (df) were calculated as 20, and the $\chi 2$ test statistic was found to be 47.6666. The corresponding p-value was 0.000473665, which is well below the significance level (α=0.05) set at a 95% confidence level.

Results

The p-value for the ODI dominance matrix indicates the existence of consistent ranking order between the selected countries. Upon analyzing the ODI dominance matrix, we encountered a tie between South Africa and Pakistan for the 5th and 6th positions. To address ties, we followed the approach suggested by Appleby (1983), where we compared the tied rank countries and assigned a higher rank to the dominating country. Based on the individual interactions in the dominance matrix, Pakistan has won 4 matches against South Africa out of 7 matches. Consequently, Pakistan retains the 5th position, while South Africa remains in the 6th position in the final rankings.

The following Table 5 consists of countries in the order of ranking per dominance ranking method.

Table 5: Dominance Rankings	
Countries	Row Totals (V_i)
England	9
India	7.5
Australia	6.5
New Zealand	5.5
Pakistan	4.5
South Africa	4.5
Sri Lanka	3
Bangladesh	2.5
West Indies	2
Afghanistan	0

Discussion

In summary of our study, we undertook an extensive analysis of cricket T20 and ODI international matches spanning four years from 2016 to 2019. By collecting match data from Howstat.com and constructing n*n asymmetric matrices with eight countries for T20 and ten countries for ODI matches, we aimed to establish dominance rankings using the dominance hierarchy approach.

We found that in the T20 dataset, there was a missing interaction between Australia and West Indies. And a comparably lower number of actual interactions compared to the ODI dataset. The chi-square test for the T20 dominance matrix did not yield statistical significance based on the available data.

In contrast, our analysis of the ODI dataset unveiled statistically significant results. The chi-square test indicated consistent ranking orders among the selected countries. Intriguingly, a comparison between our dominance rankings and the ICC rankings as of January 15th, 2020 is presented in the following table, revealing notable shifts in position for several countries. These differences raise questions about the current ICC ranking methodology as well as the need for true dominance in cricket team rankings and deserve thorough analysis.

Table 6: ODI Ranking differences	
ICC	Dominance
England	England

India	India
New Zealand	Australia
Australia	New Zealand
South Africa	Pakistan
Pakistan	South Africa
Bangladesh	Sri Lanka
Sri Lanka	Bangladesh
West Indies	West Indies
Afghanistan	Afghanistan

While our study sheds light on these rankings, certain limitations should be acknowledged. One significant limitation lies in the absence of an exact ICC ranking source from the ICC website, necessitating the utilization of data from a third-party resource. Additionally, the limited interactions in the T20 matches dataset, including the absence of certain interactions such as Australia and West Indies, hindered a comprehensive analysis. Furthermore, as we collected data spanning a four-year period, determining an optimal time window for capturing statistically significant results for T20 and accurately reflecting cricket team dominance remains a challenge. Lastly, our study relied on data sourced from 'howstat.com,' which may introduce variability in the number of matches available for constructing the dominance matrix. While 'howstat.com' provided valuable data, it is acknowledged that more reliable sources such as ESPN Cricinfo or official ICC ranking statistics could enhance the robustness of future analyses.

Looking ahead, our research paves the way for future investigations. A comprehensive exploration into the reasons behind the observed ranking discrepancies and the potential impact of different ranking methods could enhance our understanding of team rankings in cricket. Moreover, efforts to acquire a more comprehensive and up-to-date ICC ranking dataset would provide a stronger basis for comparison and analysis.

In conclusion, our study offers insights into the intricate world of cricket rankings, uncovering disparities between dominance-based rankings and the traditional ICC rankings. The observed ranking shifts between the two methodologies highlight the need for continued research and discussions on refining cricket ranking systems to ensure accurate, fair, and transparent representations of team standings.

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