Thai Ling   179048887

*The Probability of Relegation according to league position at Christmas
in the Premier League*

April 2020

Abstract:

This paper analyses a team's probability of relegation if the team is either 18th, 19th or 20th in the Premier League on Christmas Day. The paper then discusses a team's probability of relegation from each league position on Christmas and investigates the hypothesis that a lower league position at Christmas means a higher probability of relegation from the Premier League at the end of the season.

Introduction:

The English Premier League is arguably one of the most competitive and most-watched football leagues in the world. Since its formation in 1992, a total of 49 different clubs have played in the league and only a hand-full of teams have never been relegated: Arsenal, Chelsea, Everton, Liverpool, Man Utd, and Spurs [3].

Every season, teams in the bottom of the table fight for survival in the Premier League with varying success. Some factors which can change a team's chance of relegation are with transfers, managerial changes or a change in strategy, (such as playing a weaker team in games which are difficult to win while playing a stronger team against struggling oppositions). The paper discusses the success of the bottom three teams on Christmas Day at preventing relegation. The paper will also be evaluating if finishing lower down in the table on Christmas Day actually increases the probability of relegation.

Overview:

Although the Premier League began in 1992, due to there being 22 teams for the first few seasons, only the data from the 1995/96 season onwards will be used, where the number of teams were reduced from 22 to 20 [1]. At the end of the 1994/95 season 4 teams were relegated and only two teams were promoted. From then onwards 3 teams were promoted and relegated at the end of each season [3].

At the beginning of the season, all teams start on zero points and gain points by either winning or drawing games; losing a game will result in zero points. A win results in three points and a draw results in both teams receiving one point each. Each team plays every other team in the league twice, once home and once away. Each team plays exactly 38 games and the three team with the lowest number of points will be relegated. If teams are equal on points, then goal difference will be considered. Every team relegated from the Premier League has been decided by this criterion [4].

There are a series of factors which can change a club's success in avoiding relegation. The January transfer window opens where new players can be signed. New managers can be

appointed if the club believes that the current manager is not capable of preventing relegation and there may be a change in form after the Christmas period as well as a change in strategy.

Traditionally, media and fans exaggerate the league position on 25th December and treat it as the midpoint of the season even though the number of games played before Christmas is not necessarily 19, (ranging from 16-19). The anticipation of the Boxing Day fixtures suggests a new beginning for struggling sides. Teams see this as an opportunity to change their form for the better and start the second half of the season positively. Teams at the opposite end of the table hope to keep their form and continue a strong campaign to win the Premier League.

There is a massive financial gain in staying in the Premier League. The current domestic rights deal by Sky Sports, BT Sports and Amazon pays the Premier League a total of £1,665,000,000 each season from 2019-2022 [3]. In comparison to the English Football League, (2nd, 3rd and 4th tier), the broadcasting rights deal is around £119,000,000 each season. Huddersfield Town, (who finished last and relegated at the end of the 2018/19 season), was paid £96,628,865 by the Premier League so it is very easy to see the financial benefit of staying in the Premier League [5].

In a regular season, teams do not always play the same number of games each week. This is because there are other competitions such as the League Cup, FA Cup, Europa League and Champions League which are played in-between the regular league fixtures. Other factors such as unplayable weather, may force fixtures to be postponed.

1. *The probability of relegation of teams in the bottom three of the Premier League at Christmas*

The Premier League official website has a record of the table after each game week for every season [1]. However, a different number of games are played before Christmas. The number of games played before Christmas can range from sixteen to nineteen from the 1995/96 season to the 2018/19 season. The following table shows whether the teams in 18th, 19th or 20th on Christmas were relegated.

Table 1:

Season	League Position at Christmas		
	18	19	20
1995/96	0	0	1
1996/97	1	0	1
1997/98	0	0	1
1998/99	1	0	1
1999/00	0	1	1
2000/01	1	0	1
2001/02	1	1	1
2002/03	1	0	1
2003/04	0	1	1
2004/05	1	1	0
2005/06	0	1	1
2006/07	0	1	1
2007/08	0	0	1
2008/09	0	0	1
2009/10	0	0	1
2010/11	0	0	1
2011/12	0	1	1
2012/13	1	1	1
2013/14	0	1	0
2014/15	1	1	0
2015/16	0	0	1
2016/17	1	0	1
2017/18	0	1	1
2018/19	0	1	1

Shows whether 18th, 19th and 20th on Christmas day were relegated (1) or not relegated (0)

In the 2001/02 and 2012/13 seasons the bottom three teams at Christmas were all relegated at the end of the season. However, since the 1995/96 season, this has only happened twice out of the twenty-four seasons. Table 1 also shows that there has never been a season where the bottom three teams at Christmas have all prevented relegation suggesting that at least one of the bottom three is expected to be relegated when the season ends.

Table 2:

League Position at Christmas	18	19	20
Number of Teams Relegated	9	12	21
Number of Seasons	24	24	24
Probability of Relegation	0.375	0.5	0.875

The probability of relegation for 18th 19th and 20th

According to the 24 Seasons of the Premier League, (since the number of teams were reduced from 22 to 20), there is an 87.5% chance of being relegated if a team is 20th at Christmas. The only teams to prevent relegation while being bottom of the table on 25th December are West Bromwich Albion, Sunderland and Leicester City in 2004/05, 2013/14 and 2014/15 seasons respectively. West Bromwich Albion finished in 17th position with 34 points, only one point more than Crystal Palace, whereas Sunderland and Leicester City both finished in 14th

position, climbing six places. Sunderland won four out of their last five league games taking them from 20th to 14th. Leicester City has the record for staying bottom of the league for the longest consecutive days while managing to not get relegated at the end of the season winning seven of nine last league games.

Exactly twelve out of twenty-four teams that were positioned 19th on Christmas Day were relegated suggesting there is a 50% chance of relegation. Lastly nine out of twenty-four teams were relegated from 18th position resulting in a 37.5% probability. Table 2 shows that the probability of relegation increases the lower down the table you are at Christmas for the bottom three.

In twenty-four seasons, a total of seventy-two teams have been relegated, (three every season). Forty-two out of the seventy-two teams were in the bottom three at Christmas when relegated. As a result, 58.3% of relegated teams finished in the relegation places before boxing day. On the other hand, 31.7% of relegated teams are positioned 17th or above. Later, this paper discusses the likelihood of relegation from different league positions and if finishing further down the table means a higher chance of relegation.

There are a limited number of Premier League seasons, (24), so the probabilities are not the most representative. A better way of analysing the data would be to find confidence intervals. With binary data, the proportional values are used to calculate confidence intervals instead of using the sample mean [2].

$$\bar{x} \pm z.\frac{\sigma}{\sqrt{n}} \ where \ \bar{x} \ is \ the \ sample \ mean, \sigma \ is \ the \ standard \ deviation$$
$$z = 1.96 \ for \ a \ 95\% \ confidence \ interval$$
$$\bar{x} = \frac{\sum x_i}{n} \ for \ i = 1,2,...,n \ where \ n \ is \ the \ number \ of \ variables$$
$$\sigma = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n}} \ for \ i = 1,2,...,n \ (for \ population)$$

The sample size is less than 30, (24), so using the standard deviation for a population is a better representation than using the standard deviation of a sample.

Table 3:

Confidence Interval			
Position	18	19	20
Proportion (Sample Mean)	0.375	0.5	0.875
Standard Deviation	0.484122918	0.5	0.33071891
Interval distance from Mean	0.193689507	0.200041662	0.13231512
Lower 95%	0.181310493	0.299958338	0.74268488
Upper 95%	0.568689507	0.700041662	1.00731512

The 95% confidence interval for the probability of relegation for 18th 19th and 20th

Table 3 presents the 95% confidence interval of the probability of relegation of a team in the bottom three at Christmas. The findings suggest there is 95% confidence that the probability

of relegation is $[0.181, 0.569]$ implying that at eighteenth position at Christmas a team has between 18.1% to 56.9% chance of relegation. Similarly, at nineteenth there is a confidence interval of $[0.300, 0.743]$ implying a 30.0% to 74.3% chance of relegation and finally, at twentieth position the confidence interval is $[0.742, 1.01]$ which suggests that there is at least a 74.2% chance of relegation. The upper bound can be limited to 1, (100%), because the probability cannot ever be more than 1. Therefore, with 95% confidence, the probability of relegation lies between these bounds.

Table 4:

Confidence Interval	
Position	Bottom 3
Proportion (Sample Mean)	0.583333333
Standard Deviation	0.496466387
Interval Distance from Mean	0.115482652
Lower 95%	0.468655449
Upper 95%	0.698011218

The 95% confidence interval for the probability of relegation for the bottom three combined

Regardless of position, 58.3% of all teams in the bottom three are relegated. Forty-two out of seventy-two bottom three teams have been relegated. According to the 24 seasons, with 95% confidence, between 46.9% and 69.8% of teams relegated are teams which were 18th, 19th and 20th in the league at Christmas. This suggests that between 30.2% and 53.1% of teams relegated from the Premier League are teams not in the bottom three at Christmas. The paper looks at the probability of relegation from other league positions later.

2. The probability that 1, 2 or 3 teams in the bottom three of The Premier League at Christmas are relegated at the end of the season

The following section discusses the number of teams relegated at the end of the season who were in the bottom three at Christmas. In every season since 1995/96 season, at least one bottom three teams, has been relegated therefore the data suggests that it is expected that at least one of the bottom three teams will be relegated. Another way to interpret this data is that there has not been a season yet where each team in 18th, 19th and 20th at Christmas have all successfully finished 17th and above at the end of the season.

Table 5:

Season	Number of Teams Relegated		
	At least 1	At least 2	At least 3
1995/96	1	0	0
1996/97	1	1	0
1997/98	1	0	0
1998/99	1	1	0
1999/00	1	1	0
2000/01	1	1	0
2001/02	1	1	1
2002/03	1	1	0
2003/04	1	1	0
2004/05	1	1	0
2005/06	1	1	0
2006/07	1	1	0
2007/08	1	0	0
2008/09	1	0	0
2009/10	1	0	0
2010/11	1	0	0
2011/12	1	1	0
2012/13	1	1	1
2013/14	1	0	0
2014/15	1	1	0
2015/16	1	0	0
2016/17	1	1	0
2017/18	1	1	0
2018/19	1	1	0

The number of bottom three teams relegated each season, (1) relegated (0) not relegated

Table 6:

Confidence Interval	Number of Teams Relegated		
	At least 1	At least 2	At least 3
Number of Seasons	24	16	2
Total Number of Season	24	24	24
Proportion (Mean)	1	0.666666667	0.08333333
Standard Deviation	0	0.471404521	0.2763854
Interval Distance from Mean	0	0.188601088	0.11057719
Lower 95%	1	0.478065579	-0.0272439
Upper 95%	1	0.855267755	0.19391052

The 95% confidence interval for the number of bottom three teams relegated

Table 5 suggests that it is expected that at least one bottom three team will be relegated because there has not been a season where 18th, 19th and 20th at Christmas have all successfully finished 17th and above. There is a 66.7% probability that at least two of those teams will be relegated. However, there is only an 8.3% probability that all three teams will be relegated in the same season.

Evaluating the probability of 18th, 19th and 20th being relegated, the data suggests that it is unlikely that all three teams will be. With 95% confidence, at least two out of the three teams in 18th 19th or 20th have a probability of between 47.8% and 85.5% of being relegated and between 0% and 19.4% chance that all three teams are relegated at the end of the season.

According to Table 6, the confidence intervals for the number of team relegated do not overlap, [0%, 19.4%], [47.8%, 85.5%] and [100%, 100%], for at least one team, at least two teams and three teams in the bottom three being relegated at the end of the season. This suggests that there is a statistically significant difference in the number of bottom three teams relegated at the end of the season. This can be said with 95% confidence.

3. The probability of relegation according to league positions (10th-20th) at Christmas

Since the format changed in 1995/96, a team has never been relegated from The Premier League when positioned 9th or above before the Boxing Day fixtures. In 2010/11, Blackpool were 10th on Christmas Day but were relegated at the end of the season in 19th position with 39 points. (This is the highest position a team has ever finished on Christmas Day and get relegated.) In the same season, Birmingham City were relegated in 18th also with 39 points, however finished above Blackpool because they had a better goal difference of -21 compared to Blackpool's -23. West Ham United finished last with 33 points and Wolverhampton Wanderers survived in 17th with 40 points.

Table 7:

League Position at Christmas	Number of Teams Relegated
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	1
11	0
12	2
13	1
14	6
15	2
16	7
17	11
18	9
19	12
20	21
Total	72

The number of teams relegated from each league position

Table 8:

Confidence Interval	17th and 18th Comparisson	
	17	18
Number of Seasons	11	9
Total Number of Season	24	24
Proportion (Mean)	0.458333333	0.375
Standard Deviation	0.498260864	0.48412292
Interval Distance from Mean	0.199345863	0.19368951
Lower 95%	0.25898747	0.18131049
Upper 95%	0.657679196	0.56868951

The 95% confidence interval of 17th and 18th

Unsurprisingly, teams 20th at Christmas had the highest number of relegations and the general trend show that the higher a team is in the table the fewer number of relegations. Seventeenth and eighteenth are interesting positions because this is the border of staying in The Premier League or dropping down into the English second division. Table 7 shows that more teams have been relegated from 17th than 18th. However, to justify the findings, a test to find out if there is any statistical significance needs to be executed.

The 95% confidence intervals, from Table 8, suggest that there is no statistical significance when finishing seventeenth or eighteenth in the probability of relegation. This is because the intervals, [0.258, 0.658] and [0.181, 0.569] overlap. A team is just as likely to be relegated from 17th as a team in 18th.

Table 9:

Confidence Intervals				
League Position	Lower 95%	Upper 95%	Lower 80%	Upper 80%
10	-3.83	12.16	-1.0543734	9.38770672
11	0.00	0.00	0.00	0.00
12	-2.72	19.39	1.11196586	15.5547008
13	-3.83	12.16	-1.0543734	9.38770672
14	7.68	42.32	13.6862915	36.3137085
15	-2.72	19.39	1.11196586	15.5547008
16	10.98	47.35	17.2907651	41.0425682
17	25.90	65.77	32.814828	58.8518387
18	18.13	56.87	24.8508894	50.1491106
19	30.00	70.00	36.9360547	63.0639453
20	74.27	100.73	78.8590124	96.1409876
Bottom 3	46.87	69.80	50.7916092	65.8750575

The 80% and 95% confidence interval for 10th position and below

No team has been relegated from 9th and above so only 10th and below are considered. Analysing the confidence intervals for league positions at Christmas, from 10th onwards, with 95% confidence, any team finishing above 20th has a statistically significant higher probability of not being relegated compared to 20th. This can be seen in Table 4 where the lower bound for the 95% confidence interval at 20th position is 74.3% which is higher than the upper boundary for any other league position.

Similarly, 19th at a 95% confidence level, has a statistically significant higher probability of relegation with bounds [30.0%, 70.0%] compared to 10th, 11th, 12th, 13th and 15th – who all fall outside those bounds. On the other hand, 14th, 16th, 17th and 18th does not have a statistically significant lower probability of relegation compared to 19th. Finally, 10th, 11th and 13th are the

only league positions with a statistically significant lower probability of relegation than 18th at Christmas at a 95% confidence interval.

Collating the results for the bottom three, it produces a 95% confidence interval of [46.9%, 69.8%]. Anything 15th and above at Christmas has a lower probability of relegation than the combined probability of relegation for the bottom three.

At an 80% confidence interval, 19th and above has a statistically lower chance of relegation than 20th. 15th and above have a lower probability of relegation compared to 19th at Christmas. This includes 14th which is not statistically significant at a 95% confidence but is at an 80% confidence interval. 14th is bounded by [13.7%, 36.3%] with 18th bounded by [36.9%, 63.1%]; the bounds do not overlap. 10th, 11th, 12th, 13th and 15th are all statistically significant to 18th, [24.9%, 50.1%].

At an 80% confidence interval 15th and above at Christmas, excluding 14th has a statistically significant lower probability of being relegated compared to 18th, 19th and 20th. And 14th has statistically significant lower probability of relegation compared to 19th and 20th. There is no statistical advantage in finishing 16th and 17th compared to 18th and 19th.

Results:

The initial analysis from Table 4 suggests that the probability of relegation for teams in the bottom three is 0.583 which is the combined probability of relegation from 18th, 19th and 20th position. The paper further explores the probability of relegation for each position suggesting that there is a much higher probability of being relegated from 20th than 19th and 18th with 0.875, 0.5, 0.375 probabilities respectively.

With 95% confidence, 20th position at Christmas has a statistically significant higher probability of relegation compared to every other position with bounds [0.743, 1]. All other probabilities fall outside the calculated boundary. This is not surprising because Table 1 shows that twenty-one out of twenty-four 20th position teams being relegated at the end of the season. This is expected because they need to gain more points than the three teams directly above them who are also trying to gain as many points as possible to stay in The Premier League.

On the other hand, finishing 18th rather than 19th does not decrease your chances of relegation with 95% confidence because the bounds overlap, [0.181, 0.589] and [0.300, 0.700]. Even though the probability of relegation is higher from 19th position, it is not statistically significant at a 95% confidence level.

At an 80% confidence level, every other team has a lower chance of relegation compared to 20th. And only 16th and 17th are not statistically significant compared to 18th and 19th. This suggests that two relegation positions are challenged by 16th-19th, (20th with the final position).

Tables 5 and 6 suggest that it is more likely for two or more teams to be relegated than three teams, this is because only two out of the bottom three teams will need to be relegated at

the end of the season compared to all three. Further, these results suggest that it is actually unlikely for all of the bottom three to be relegated and it is likely that at least one team in 17th or above will be relegated.

20th at Christmas has the highest statistical probability of relegation. No other position has near as many relegations. This can be explained by the fact that 18th only needs to climb one position to prevent relegation, 19th needs to climb two positions and 20th needs to climb three positions which means they need to gain more points than 17th, 18th and 19th plus the difference at Christmas. This supports the 95% statistically significant confidence interval of the probability of relegation [0.742, 1].

As a result, the findings suggest that one of the bottom three at Christmas will be relegated at the end of the season. 20th has the highest probability of relegation. If we consider the scenario where 20th is expected to be relegated, the other two relegation places are contested by 16th-19th because 16th and 17th are not statistically significant to 18th and 19th at an 80% confidence level.

Also, at least one of the bottom teams at Christmas will be relegated. This is expected because if all teams escape relegation it means 18th, 19th and 20th will all have to move up three places and 15th, 16th and 17th will all have to fall three places each. A total of at least nine position changes are required in order for every team in the bottom three to escape relegation.

Finally, football clubs finishing in 15th or above at Christmas know that they have a statistically significant lower probability of relegation at an 80% confidence level compared to 16th and below. And 13th and above have a statistically lower probability of relegation at a 95% confidence level.

Conclusion

The use of confidence intervals is a good mathematical method because it is used to find statistical differences. It produces an upper and lower bound around the mean of where to expect the values to lie with a certain level of confidence. This is a good method of deciding which position are statistically significant from each other. It is likely, (but not guaranteed), that 20th will be relegated, so teams only need to focus on two relegation places. This paper suggests that football clubs finishing 14th and below should consider the possibility of relegation. With 95% confidence, 14th is not statistically significant from 18th and 20th should be prepared to be relegated. Clubs in this position should consider financial changes when entering the second division or make transfers in January to off load high wage players. 20th should not consider new transfers with high costs as they are unlikely to finish 17th and above.

References

[1]. Premier League Official Website. (2020)- Available at:
https://www.premierleague.com/tables
[Accessed 5th February 2020]
[2]. Confidence Interval: How to Find a Confidence Interval: The Easy Way! 2020 Statistics How To - Available at:
https://www.statisticshowto.datasciencecentral.com/probability-and-statistics/confidence-interval/
[Accessed 6th February 2020]
[3]. Premier League Official Website, History (2020)- Available at:
https://www.premierleague.com/history
[Accessed 6th April 2020]
[4]. English Football League System
https://en.wikipedia.org/wiki/English_football_league_system
[Accessed 6th April 2020]
[5]. Premier League value of central payments to clubs 2018/19- Available at
https://www.premierleague.com/news/1225126
[Accessed 6th April 2020]