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Probability Theory Predicts That Winning Streak Is a Shortcut for the Underdog Team to Win the World Series

Motohisa Osaka

Department of Basic Science, Nippon Veterinary and Life Science University, Tokyo, Japan
Email: osaka@nms.ac.jp

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Abstract

It is common for two teams or two players to play a game in which the first one to win a majority of the initially determined number of matches wins the championship. We will explore the probabilistic conditions under which a team (or player) that is considered weak may win the championship over a team (or player) that is considered strong, or a game may go all the way to the end, creating excitement among fans. It is unlikely to occur if the initially estimated probability remains constant when the weaker one wins each game against the stronger one. The purpose of this study is to identify probabilistically what conditions are necessary to increase the probability of such an outcome. We examine probabilistically by quantifying momentum gains to see if momentum gains by a weaker team (or player) winning a series of games would increase the likelihood of such an outcome occurring. If the weaker one gains momentum by winning a series of games and the probability of winning the next game is greater than the initial probability, we can see that such a result will occur in this study. Especially when the number of games is limited to seven, the initial probability that a weaker one will beat a stronger one in each game must be 0.35 or higher in order to win the championship and excite the fans by having the game go all the way to the end.

Keywords

Game, Sports, Underdog, World Series, Upset Championship

1. Introduction

Baseball is a very popular sport in the United States. In particular, the World Series, which determines the best team of the year, is the most exciting event of the year. The team that wins four games first wins the championship. According to Nahin, the World Series has been decided in an average of 5.8 games under this current rule [1]. The most exciting pattern of this event is when a team with a weak record wins the championship, or (more likely) when the game goes down to the last game. This can be generalized not only to baseball, but also to other sports, such as when two winning teams play each other and the team that wins the majority of the games decided first is declared the winner. The probability that the weaker team will win each game against the stronger team will be less than 0.5, but it is clear that the greater the number of games played, the further away from the championship. So what conditions are necessary for a team that is considered weak to increase its chances of winning the championship? The first condition is that the probability that a team considered weak will beat a strong team is not constant, but varies depending on the situation. This could happen, for example, when a weaker team beats a stronger team once and gains momentum to show unexpected strength in the next match. In this case, it is assumed that the probability of the weaker team beating the stronger team is several times greater than the initial probability. Even such a probability theory problem that cannot be formulated can be programmed and solved by numerical computation [2]-[8].

The two objectives of this study are: 1) to determine the number of games in which the weaker team (or player) has the highest probability of winning the majority of all games when the probability of the weaker one beating the stronger one is constant, and 2) to determine the relationship between the probability of the weaker one winning the championship and the number of games in which it wins the majority of the games, when the initial probability p is A (>1) times larger in case, it wins a series of games.

2. Methods

To calculate the probability P of the weaker team W (a team with a weak record is hereafter referred to as the weaker team) winning the championship, the details are set as follows. The probability p of the weak team is assumed to be in the range $0 < p < 0.5$. The maximum number of games N is assumed to be an odd number, and the team that wins the majority of these games, *i.e.* $(n + 1)/2$ games, first, is assumed to be the winner. The game ends at the moment the winning team is determined, even if the maximum number of games has not been reached.

First, calculate P when p is constant. When W is determined to win the championship, the winner of the last match is W.

$$P = \sum_{n=M}^{N} \binom{n}{m} p^{M-1} (1-p)^{n-M} p. \text{ Then } M \equiv (N+1)/2 \tag{1}$$

P was computed with $N = 3, 5, 7, \ldots, 11$, and $p = 0.1, 0.15, 0.25, \ldots, 0.4$.

Next, calculate P when p varies with the situation. Assume that p is A (>1) times larger when W wins a series of games. A team with a strong record is hereafter denoted as the strong team S.

The following specific example shows how to calculate the probability that W will win. Example 1) Suppose $N = 7$ and the final result of winning or losing the game is SWWWSW: the probability of W winning in the second game is p, the probability of winning in the third game is $p \times A$, the probability of winning in the fourth game is $p \times A \times A$, and the probability of winning in the sixth game is equal to $p \times A \times A$ in the fourth game since the fifth game was lost. $p \times A \times A$ is 0.95 if $p \times A \times A$ is greater than 1. Hence the probability of SWWWSW occurring is $(1 - p) \times p \times (p \times A) \times (p \times A \times A) \times (1 - p \times A \times A) \times (p \times A \times A)$.

Example 2) Suppose $N = 7$ and the final result of winning or losing the game is WWWSSW: the probability of W winning in the second game is $p \times A$, and the probability of winning in the third game is $p \times A \times A$. In this case, if $p \times A \times A \geq 1$, $p \times A \times A$ is replaced by 0.95. The probability of losing in the fourth game and the fifth game is 0.05, and the probability of winning in the sixth game is 0.95. Hence the probability of WWWSSW occurring is $p \times (p \times A) \times 0.95 \times 0.05 \times 0.05 \times 0.95$.

Finally, P is computed with $N = 3, 5, 7, \ldots, 11$, $p = 0.1, 0.15, 0.25, \ldots, 0.4$, and $A = 1.25, 1.5, 2$. P was obtained by programming and numerical computation.

3. Results

1) A case of $A = 1$ corresponds to the case where p does not depend on the outcome of every match. The probability of W winning always decreases as the number of games increases (**Figure 1**). Moreover, P is always less than p.

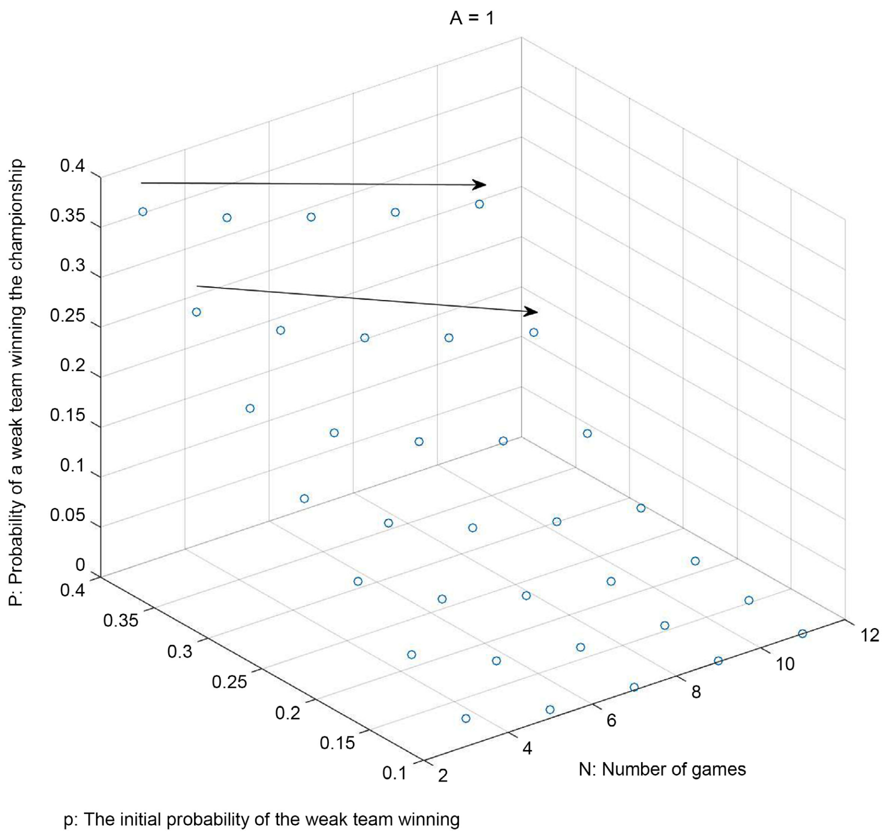

Figure 1. 3D plot in case $A = 1$.

2) The following results are for the case where p increases A-fold when W wins consecutively.

a) A case of $A = 1.25$ (**Figure 2**)

When $p \leq 0.35$, P decreases as the number of matches N increases; when $p = 0.4$, P is almost constant, and $P < p$.

b) A case of $A = 1.5$ (**Figure 3**)

When $p \leq 0.25$, P decreases as the number of matches N increases, and $P < p$. When $p = 0.3$, P is almost constant. When $p \geq 0.35$, P increases as the number of matches N increases, and $P > p$. Especially, when $p = 0.4$ and $N = 7$, $P = 0.475$.

c) A case of $A = 2$ (**Figure 4** & **Figure 5**)

When $p \leq 0.15$, P decreases as the number of matches N increases, and $P < p$. When $p = 0.25$, P is almost constant. When $p \geq 0.3$, P increases as the number of matches N increases, and $P > p$. Especially, when $p = 0.35$ and $N = 7$, $P = 0.437$, and when $p = 0.4$ and $N = 7$, $P = 0.4833$.

4. Discussion

The rest of the public as well as baseball fans will be excited during the season when a weaker team W wins the World Series against a stronger team S, or when the game goes down to the last minute with no one knowing which way the game will go. Such exciting championship games are not limited to baseball. For

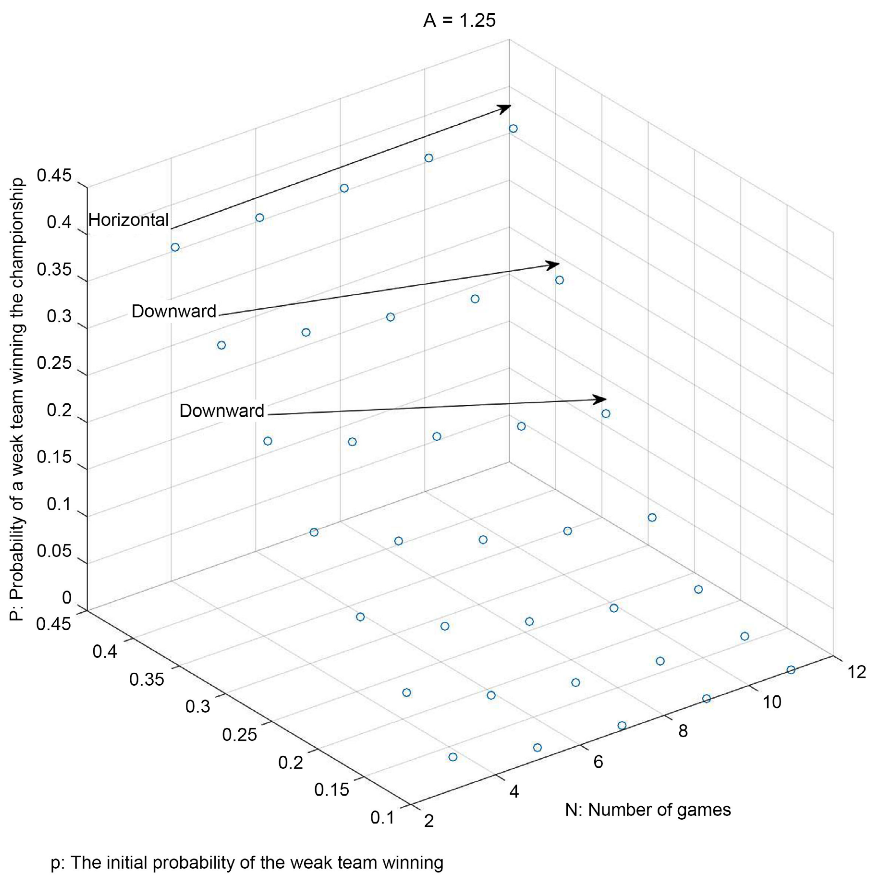

Figure 2. 3D plot in case $A = 1.25$.

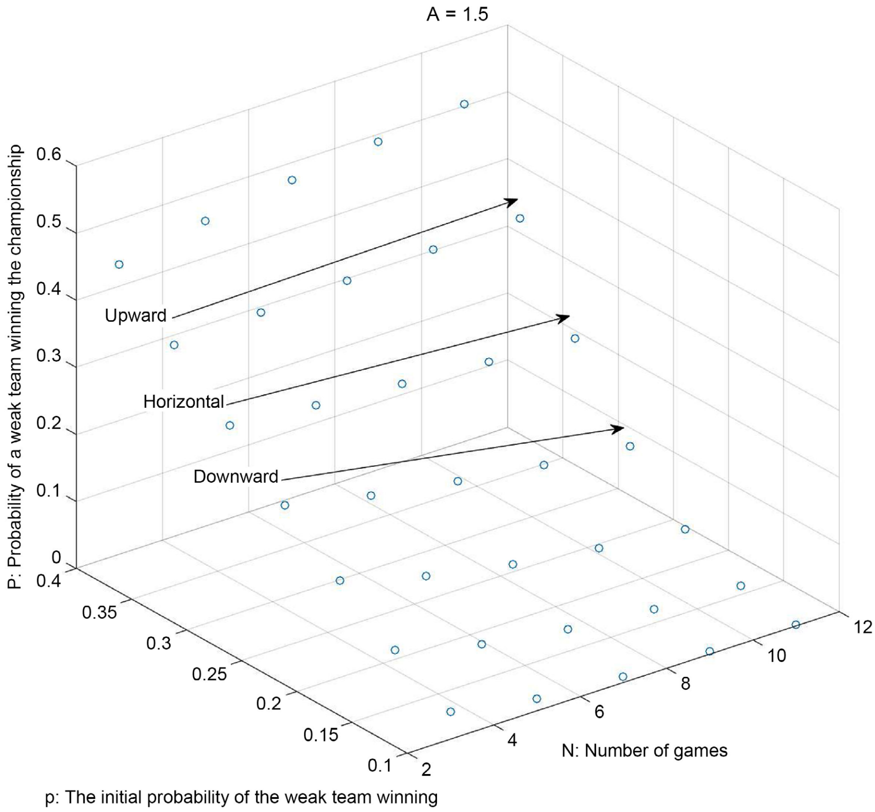

Figure 3. 3D plot in case $A = 1.5$.

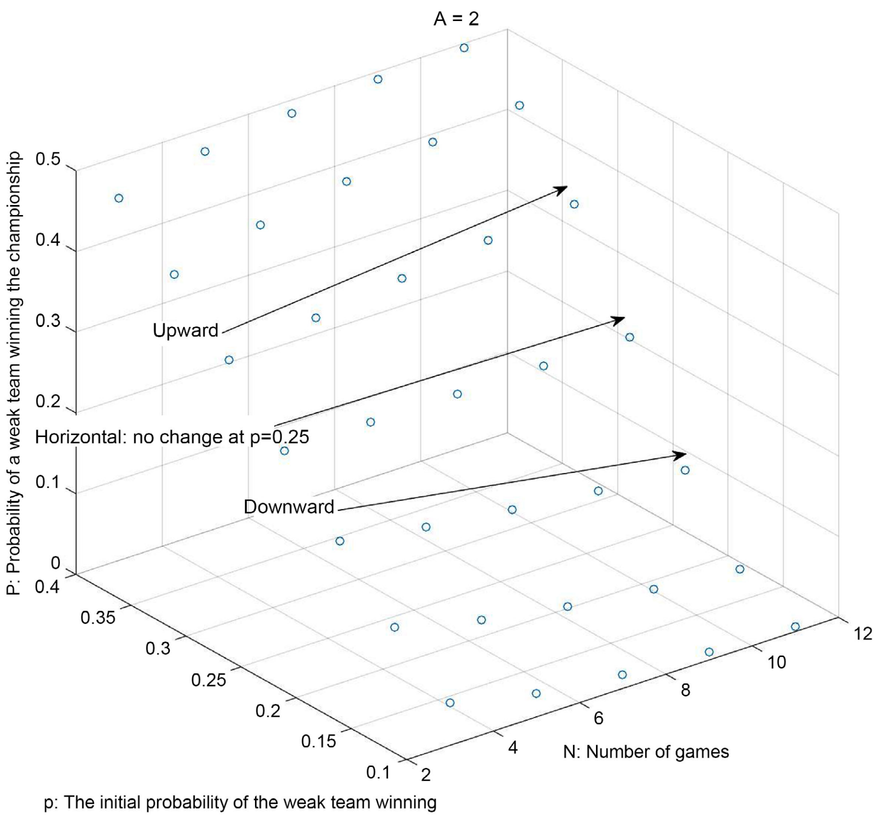

Figure 4. 3D plot in case $A = 2$.

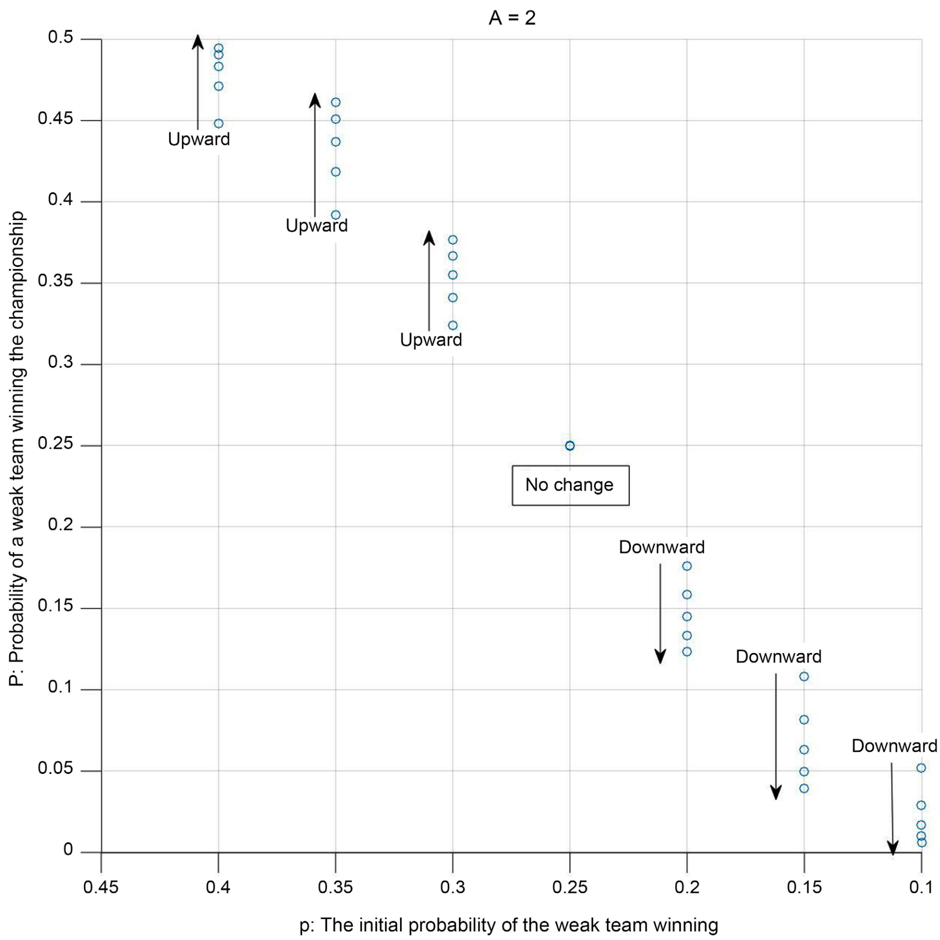

Figure 5. 2D plot in case $A = 2$.

example, in the championship game of the Japanese chess title, the first four winners out of seven games are awarded the title. When p does not depend on the outcome of every match, however, we find that such things are much less likely to happen. Moreover, as the number of games N increases, it becomes more and more difficult for such a thing to happen. Therefore, the answer to the first objective of this study is that if the probability p per game of the weaker team W is constant, the team with a smaller number of games N initially determined still has a chance to win the championship.

The answer to the second objective of this study is as follows: 1) when $A = 1.25$ and $p \leq 0.35$, the probability P of W winning decreases with the number of games regardless of the value of p; 2) when $A = 1.5$ and $p \geq 0.35$, P increases with the number of games, and $P > p$; 3) when $A = 2$ and $p \geq 0.3$, P increases with the number of games, and $P > p$, and 4) when $A = 1.5$, $p = 0.4$, and $N = 7$, $P = 0.475$, and when $A = 2$, $p = 0.35$, and $N = 7$, $P = 0.437$. Hence, even if $p = 0.35$, we would expect W to win or have a close and exciting game. If $p < 0.3$, it will still be difficult to win the championship even if the winning streak gains momentum.

The question is how to interpret this A in the real world. If the supposedly weaker team (or player) wins again, it will probably gain momentum and have a greater chance of beating the supposedly stronger team in the next game, or the supposedly stronger team (or player) will lose confidence and have a greater chance of losing in the next game. In this study, the degree to which the weaker team (or player) gains momentum is expressed as A. The number of games initially determined for the World Series and the Japanese chess title decisive matches is $N = 7$, and the results of this study can be interpreted as follows: comparing the cases $p = 0.35$ and $p = 0.4$, a consecutive win at $p = 0.35$ would give the team more momentum than at $p = 0.4$. As a result, the value of P when $p = 0.35$ and $A = 2$ is almost comparable to the value of P when $p = 0.4$ and $A = 1.5$. In other words, these results suggest that the lower the initial probability of a weaker team (or player) to win, the more momentum it will gain when it wins again against a stronger team (or player). From the opposite perspective, a stronger team (or player) will be further away from the championship if it loses a series of games. The difficulty in quantifying the degree to which the weaker team (or player) gains momentum is a limitation of this study.

5. Conclusion

The results of this study apply to all cases where two teams (or players) play multiple games and the first one to win the majority of the determined number of games wins the championship. In order for a weaker team (or player) to win a majority of the games against a stronger team (or player), or for a game to go all the way to the end, the shortcut is to increase the probability of winning by winning a series of games. Especially when the number of games is limited to seven, the initial probability that a weaker team (or player) will beat a stronger team (or player) in each game must be 0.35 or higher in order to win the championship and excite the fans by having the game go all the way to the end.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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