Adjusting Winning-Percentage Standard Deviations and a Measure of Competitive Balance for Home Advantage

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Abstract: One measure of sports-league competitive balance uses a ratio: the standard deviation of team winning percentages is divided by the so-called ideal standard deviation, which assumes either team is equally likely to win any game. In fact, teams playing at home win more than they lose. The extent of this advantage differs across sports. Ignoring this pattern makes the traditional ideal standard deviation too large; the ratio of standard deviations is therefore improperly small. The authors derive a standard-deviation formula that accounts for home advantage, and consider how the adjustment affects comparisons of competitive balance across leagues.

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Introduction

The degree of competitive balance across the teams in a sports league can be an important issue to both team and league executives and outside analysts. Both groups may, for example, want to know how the degree of competitive balance among teams affects game attendance, or how imbalance in a given league has changed (perhaps in response to changes in league rules) over time. Analysts may also want to compare competitive balance across various leagues.

Many methods of measuring competitive balance have been proposed; both Quirk and Fort (1992) and Humphreys (2002) review many of these methods.[1] One common approach uses a measure of the dispersion (typically, the standard deviation) of the end-of-season winning percentages across the teams in a league.[2]

One complication in using this method arises from the fact that the number of games that make up a "season" differs across leagues. In North American professional leagues, for example, Major League Baseball (MLB) teams currently play a 162-game schedule, while National Football League (NFL) teams play 16 games. It would therefore be inappropriate to directly compare winning-percentage standard deviations between such leagues — the shorter a league's season, the greater the likelihood that random variation alone will produce winning percentages that substantially differ from .500.

To address this concern, researchers can compare a league's actual winning-percentage standard deviation (typically averaged over a number of years) with the standard deviation that would theoretically exist over the same number of games in (one particular version of) a perfectly-balanced league. This approach first appeared in the work of Noll (1988) and Scully (1989), and was made popular by Quirk and Fort (1992). Using Fort's (2007) notation, a league's actual standard deviation (ASD) of winning percentage is divided by a (so-called) ideal standard deviation (ISD) to produce a ratio of standard deviations (i.e.,

[1]For other methods, see Depken (1999) and Mizak, Neral, and Stair (2007), as well as the discussion and citations in Sanderson and Siegfried (2003).

[2]The standard-deviation approach holds a prominent place in the competitive-balance literature; the relevant chapters in both the leading sports-economics textbooks (Fort, 2006; Leeds and von Allmen, 2008) present that measurement before any other.

RSD = ASD/ISD).[3] A larger value for RSD indicates a wider spread of outcomes, adjusted to control for the dispersion that could be expected from random variation, and thus a greater degree of competitive imbalance.

In the articles noted above, the ideal standard deviation is defined as that expected from a league in which any two opposing teams have an equal probability of winning any game. With a binomial outcome — a team either wins or loses — this assumption means that probability of any team winning (or losing) any given game equals $P(W) = P(L) = 1 - P(W) = 0.5$. With a season consisting of n games, the calculation of the traditional theoretical ideal standard deviation simplifies to $0.5/\sqrt{n}$. For example, the ISD in a 162-game MLB season equals $0.5/\sqrt{162} = 0.0393$, while in a 16-game NFL season it equals $0.5/\sqrt{16} = 0.1250$. Since the National Basketball Association (NBA) and National Hockey League (NHL) both now have 82-game schedules, the traditional ISD when those leagues play their full schedules equals 0.0552.

Normalizing standard deviation by using RSD allows competitive balance to be compared across leagues with differing season lengths. Doing so also makes it possible for competitive-balance comparisons to account for changes in season length. For instance, MLB increased (in 1961) its regular number of games from 154 to 162, while the NFL has increased its official season from 12 to 14 (in 1961) and then to 16 contests (in 1977). Calculations using RSD also facilitate comparisons of a league's winning-percentage dispersion during periods in which some season was shortened due to a strike or lockout (e.g. MLB in 1994 and 1995 and the NBA in 1998-99).

In this paper, we argue that existing calculations of ISD — and therefore of RSD — are flawed because they fail to account for the fact that even two "perfectly-balanced" athletic teams are not equally likely to win any particular contest. Rather, the results of nearly all sporting events show that teams (or, in many cases, individuals) playing in the location to which they are accustomed (i.e., playing at home) are more likely to win than are teams

[3] In this usage, the "ideal" standard deviation is defined as one that arises from a league in which all teams have equal skill levels. It is unclear whether such a characteristic would in fact be an ideal outcome from, for example, the perspective of league-wide profit maximization.

playing on the road (see, for example, the results summarized in Courneya and Carron (1992).)

Since actual sporting results arise from a world in which home advantage exists, it is improper to compare empirical outcomes to a baseline in which that advantage is ignored. As is shown below, neglecting home advantage means that traditional ISDs are inappropriately large, which implies that calculated RSDs are improperly small. The size of this bias increases with the extent of a league's home advantage. Since home advantage differs by sport, the errors also differ — a league in which teams have a relatively large home advantage will appear, in traditional RSD calculations, to have a relatively greater degree of competitive balance than is really the case.

This paper proceeds by first briefly describing the sizable literature that considers home advantage. It next explains why the presence of such an advantage causes the traditional method of computing ideal standard deviation to be biased. The paper then shows how the ISD calculation can be modified to account for the presence of home advantage. Finally, it illustrates the extent to which the correction affects calculated measures of competitive balance.

Home Advantage

Courneya and Carron (1992) define home advantage as the consistent finding that sports teams playing in their regular surroundings (and assuming that each team's schedule is balanced between home and road games) win more games than they lose. This pattern implies that a game played between two evenly-matched teams in a location in which only one is playing at home is not a 50/50 proposition. Rather (assuming that a team either wins or loses), the home team's probability of winning h exceeds .5 (but is obviously less than 1), while the visiting team's probability of winning $1 - h < .5$.

Following the seminal formal work on the subject by Schwartz and Barsky (1977), the concept and existence of home advantage in sports contests has been well documented in the sport-science and sport-psychology literatures.

Courneya and Carron (1992) synthesize the findings on the major team sports and report historical home winning percentages of 53.5% for baseball, 57.3% for football, 61.1% for ice hockey, 64.4% for basketball, and 69.9% for soccer. Leifer (1995) calculates the home advantage for each of the four major North American professional team-sport leagues from their inceptions to 1990 and reports similar results. Data from Pollard and Pollard (2005) — who consider trends in home advantage in the four major North American team sports and English soccer from 1876 to 2003 — can be used to compute the following home advantages over (for example) the period 1990-2002: 53.5% in MLB, 55.7% in the NHL, 58.7% in the NFL, 61.0% in the NBA, and 60.8% in the (English) Premier League.[4]

The above authors, and many others, have also sought to determine why home advantage exists and why it varies systematically across sports. Courneya and Carron (1992) and Leifer (1995) provide thorough reviews of this literature, with an update by Carron et al (2005).[5]

Courneya and Carron (1992) organize their discussion of home advantage around what they call game-location factors and psychological or behavioral states. Location factors that may affect home and road teams differently include the effects on participants of crowds, familiarity with the playing field and surroundings, travel, and rules that explicitly differentiate between home and road teams.[6] These four factors can in turn influence the psychological or behavioral states of the participating athletes, coaches, and/or officials.

[4]The five most significant European soccer leagues appear to have relatively similar degrees of home advantage. Pollard (2006) shows that the home advantage in the highest league in the major European soccer nations (over the 1996/97–2001/02 seasons) are 60.7% (England), 63.3% (Germany), 63.9% (Spain), 64.2% (Italy), and 65.0% (France). Less prestigious soccer leagues, however, can display much wider variation. Among European soccer leagues, Pollard (2006) notes home advantages that range (over a six-season period) from 53% (Estonia and Latvia) to 77–79% (Bosnia and Albania).

[5]While most studies of home advantage focus on game results, Jones (2007) considers how home advantage evolves over the course of NBA games. He shows that home teams do particularly well in the first quarter, and that a home team that enters a quarter with the lead does not on average extend its lead, but that a home team that enters a quarter trailing on average gains.

[6]In addition to the rigors of travel itself, Entine and Small (2008) consider the fact that NBA teams playing on the road typically have fewer days of rest between games than do teams in the midst of a home stand. On the issue of game rules, Turocy (2008) — who models baseball as a zero-sum Markov game — investigates the requirement that road teams bat first. He concludes (given his modeling assumptions) that "there is no significant quantitative advantage conferred by the order in which teams bat." Note though that Turocy's simulations show that the introduction of one particular strategy — the sacrifice bunt, a strategy that can be modeled in a straightforward way — does give a slight advantage to the team that bats second.

It is not surprising that the degree of home advantage varies across sports. Crowds sit closer to players and officials in arena sports such as basketball and ice hockey than they do in (primarily) outdoor sports. Football teams travel to a game on average once every other week, while basketball or hockey players may play three or four road games in a week. Playing surfaces and typical weather conditions differ across football and baseball stadiums, while baseball stadiums also have differing playing-field dimensions.

Table 1 shows the home advantage — measured as the league-wide home winning percentage — for each of the four major North American professional sports leagues from 1990–2007. Over all games in these seasons, the home winning percentages are MLB — 53.7%, NHL — 55.6%, NFL — 58.4%, and NBA — 60.8%.[7]

Note that in some sports leagues, games can end in a tie (also known as a draw). Such leagues often rank teams on a point system, in which a team's reward for tying a game is one-half or one-third as large as the reward for winning. The winning percentages given above treat ties as half-wins.[8]

Over this period, home teams record more wins than do road teams in each year in each league. The home advantages are remarkably consistent — the standard deviation of the yearly home winning percentages over the period is less than 0.01 for one league, less than .02 for two others, and under .03 for the fourth.

[7]These overall percentages are not the averages of the yearly home winning percentages; rather, they are the percentages found by totalling all wins, losses, and ties in the league over the eighteen seasons.

[8]Note that rule changes in the NHL have caused some adjustments in the calculation of game results. For much of its history, NHL teams played a sixty-minute game, and the league awarded two points to winning teams, one point to each team for a draw, and no points to a losing team. Starting with the 1983–1984 season, however, NHL teams that are tied at the end of regulation time play a five-minute overtime period. Points were originally still awarded on 2W-1T-0L basis. [Most world soccer leagues instead use a 3W-1D-0L system.] Since the start of the 1999–2000 season, however, an NHL team that loses either in overtime or (starting with the 2005–06 season) in a shootout is awarded one point. Teams that win under any circumstances continue to receive two points. In some games, therefore, the teams share a total of three points rather than two. Through the 2003–2004 season, games could still end in ties. After a labor dispute cancelled the 2004–2005 season, however, league rules were altered by the addition of a shootout (which takes place after the overtime period); as a result, every game now has a winner. To maintain data consistency throughout the relevant time period, and so that all NHL games are valued equally, the empirical work presented in this paper in based on NHL results in which (since the 1999–2000 season) the point awarded for an overtime or shootout loss has been removed. In the data used in this paper, in other words, a team either wins, ties (prior to 2005–2006), or loses; a tie is counted as half a win, and any kind of loss is counted as having no value.

In spite of the many investigations into home advantage, few researchers have considered any link between home advantage and issues of competitive balance. Koning (2000) is one who has. His approach — which incorporates the trinomial outcomes possible in soccer — uses an adjustment for home advantage when employing an ordered probit specification to estimate a strength parameter for each team in Dutch professional soccer. In one of his measures of competitive balance, Koning measures the standard deviation of these strength parameters. However, when Koning directly calculates the standard deviation of season-end team point totals, he does not appear to make any direct adjustment for home advantage.

Forrest, et al (2005) take a different approach by describing a process by which an increase in what would commonly be called competitive balance — i.e., a reduction in the range of skill differences across a league's teams — could possibly decrease fan interest in a sport. The rationale is that if teams become more closely balanced in skill levels, the expected winner of some games would be more likely to be determined by home advantage. For some fraction of a league's contests, this would reduce outcome uncertainty, which could cause aggregate attendance to fall.

The present paper links the issues of home advantage and competitive balance in a very different way. It argues that the traditional standard-deviation measure of competitive balance, which ignores home advantage, is flawed. The following section explains the bias created by existing techniques, describes a way to modify the measure of ideal standard deviation to account for home advantage, and explains how this adjustment affects judgments about relative competitive balance.

Home-Advantage-Corrected Ideal Standard Deviation

Before addressing the ISD calculation in depth, a potential complication should first be considered. Some authors have proposed a modification of the traditional ISD method for sports where trinomial outcomes — win, loss, and draw — are common. In the major North American sports, the binomial model is proper for studies of MLB, the NBA, and the NFL as league rules require that ties be settled through extended play.[9] In the NHL (through the 2003-2004 season) and soccer, however, matches frequently end in a draw. Cain and Haddock (2006) argue that that the various point systems used by leagues in which draws can occur produce differing ideal standard deviations. They suggest ways to revise ISD for soccer leagues given different point assignment schemes. Fort (2007) critiques their conclusions and counters that when point totals are converted to winning percentages, with a tie defined as half a win, their method offers no innovation. The calculations reported in the present paper treat ties as half-wins.

Returning to the issue at hand, many previous researchers into competitive-balance questions have, as noted above, used as a benchmark the so-called ideal standard deviation of winning percentage that would be expected in a league in which all games are equally likely to be won by either team.

The evidence cited above, however, implies that a perfectly-balanced league is more correctly viewed as one in which (assuming no ties) every team has a probability $h > .5$ of winning a game played at home and a probability $(1 - h) < .5$ of winning an game on the road.

Since a sport league's actual results occur in a world in which home teams have an advantage, comparing those results to a baseline that assumes no such advantage is improper.

In a hypothetical league made up of equally-skilled teams, allowing h to be greater than one-half makes extreme won-loss records less likely.

Intuition for this effect can be developed using an extreme example. Consider a simplified sports league that consists of only two equally-skilled teams that play each other twice — once at each team's home location. If the teams have no home advantage, so that each of the (evenly-balanced) teams has a a .5 probability of winning each game, then each game is mathematically equivalent to a fair coin flip. A team's most likely two-game record — one

[9] The NFL instituted an overtime policy in 1974. Games are extended by an additional fifteen minute period. The "sudden death" method determines that the team scoring first the winner. However, if neither team scores in the overtime the game is recorded as a tie. In practice, tie game are extremely rare under this system. Between the institution of the overtime rule and 2008, only 13 games were tied after the overtime period (including only four from 1990-2008).

win, one loss — occurs with probability .5. A team in such a situation ends with a two-win, no-loss record with probability .25; a no-win, two-loss record is equally likely.

In contrast, consider two equally-matched teams that each win at home with probability .95 (and, of course, lose on the road with the same probability). A team is again most likely to end with one win and one loss, but the probability it does so is now $((.95\times.95)+(.05\times.05) =)$ .905. The extreme records — two wins and no losses, or no wins and two losses — now each occur only with probability $(.95 \times .05 =)$ .0475.

More generally, in a perfectly-balanced league in which all teams win at home with probabilty h, the probability that a team will be undefeated (or winless) after n games ($n/2$ played at home) is $h^{n/2}(1-h)^{n/2}$. This probabilty falls continuously as h rises above .5.

Unsurprisingly, the existence of home advantage doesn't affect a team's most likely won-loss record. In a perfectly-balanced league, with games equally divided between home and away, it remains most likely that a team finishes with a .500 winning percentage. The disadvantage of playing half its games on the road exactly offsets the advantage it gets from playing at home. A home advantage does, however, reduce the probability of disproportional outcomes in which a team in an equally-balanced league wins many more games than it loses, or loses many more than it wins.

In the aggregate, taking this effect into account for a hypothetical perfectly-balanced league means that the league's home-advantage-corrected ideal standard deviation (HISD) will be smaller than is the traditionally-calculated ideal standard deviation.

In turn, the upward bias in the traditional ideal standard deviation means that ignoring home advantage produces a value for a league's ratio of standard deviations that is improperly small. The larger is the home advantage in a given league, the greater the extent of this bias. Analysts who have ignored this effect have therefore concluded that leagues have a greater degree of competitive balance than is truly justified. In addition, the fact that the extent of home advantage differs across leagues means that the bias will also affect any cross-league comparison of competitive balance.

Fortunately, the existing bias in this sort of analysis can be easily eliminated — the standard deviation of an equally-balanced league in which a home advantage exists can be computed with a relatively straightforward, albeit somewhat complicated, formula. Suppose that the teams in a sports league play n (an even number of) games, playing $n/2$ games at home and the rest on the road. Furthermore, assume that teams in the league have equally-balanced talent levels, but that the probability of the home team winning any particular game equals $h > .5$.

Computation of such a league's expected end-of-season standard deviation proceeds by considering the probability of a team achieving any particular season-long record. For example, a team can win all of its games only by winning every game at home (probability $h^{(n/2)}$) and every game on the road (probability $(1-h)^{(n/2)}$). There's only one way of winning every game. Since this performance results in a winning percentage of 1 (which is compared to the league-average winning percentage, which must equal .5), computing the expected standard deviation of winning percentage requires that the above term be multiplied by $(1 - .5)^2$.

A team has two ways to win all but one of its games. The first method is to win all but one of its home games (probability $h^{((n/2)-1)}(1-h)$ — there are $(n/2)$ different ways to do this — and to win all of its road games $((1-h)^{(n/2)})$. The second method is to sweep at home $(h^{(n/2)})$ and win all but one on the road $((n/2)\cdot(1-h)^{((n/2)-1)}h)$. The total probability that the team will win all but one of its games is thus $(n/2)h^{((n/2)-1)}(1-h)\cdot(1-h)^{(n/2)} + h^{(n/2)}\cdot(n/2)(1-h)^{((n/2)-1)}h$. This term is then multiplied by a term that incorporates the team's winning percentage: $(((n-1)/n) - .5)^2$.

A team has three ways to win all but two of its games. It could win all but two games at home (probability $h^{((n/2)-2)}(1-h)^2$; there are $\frac{(n/2)!}{((n/2)-2)!2!}$ ways to do this (where $x!$ represents x factorial (or $1\cdot 2\cdot \ldots \cdot x-1\cdot x$)). The team could win all but one at home and all but one on the road; the probability is $(n/2)h^{((n/2)-1)}(1-h)\cdot(n/2)(1-h)^{((n/2)-1)}h$. Or, the team could win every game at home and all but two on the road; the probability is $h^{(n/2)}\cdot\frac{(n/2)!}{((n/2)-2)!2!}(1-h)^{((n/2)-2)}h^2$. In the standard-deviation calculation, these three terms are added and multiplied by $(((n-2)/n) - .5)^2$.

Note that in the league being considered, the probability of a team winning no games equals the probability that it wins every game, the probability of winning one game equals the probability of winning all but one, etc.

Considering all possible outcomes results in the following formulae for the home-advantage-corrected standard deviation (variance) of an evenly-balanced league:

$$\sigma^2 = 2\sum_{k=1}^{n/2}\left[\left\{\sum_{i=1}^{k}\binom{n/2}{k-i} h^{((n/2)-k+i)}(1-h)^{(k-i)} \times \binom{n/2}{i-1} h^{(i-1)}(1-h)^{((n/2)+1-i)}\right\}\left(\frac{n+1-k}{n}-.5\right)^2\right]$$

$$\sigma^2 = 2\sum_{k=1}^{n/2}\left[\left\{\sum_{i=1}^{k}\frac{(n/2)!}{((n/2)-k+i)!\,(k-i)!} h^{((n/2)-k+i)}(1-h)^{(k-i)} \times \frac{(n/2)!}{((n/2)+1-i)!\,(i-1)!} h^{(i-1)}(1-h)^{((n/2)+1-i)}\right\}\left(.5-\frac{k-1}{n}\right)^2\right]$$

$$\sigma = \sqrt{2\sum_{k=1}^{n/2}\left\{\sum_{i=1}^{k}\frac{((n/2)!)^2\, h^{((n/2)-k+2i-1)}\,(1-h)^{((n/2)+1+k-2i)}\left(.5-\frac{k-1}{n}\right)^2}{((n/2)-k+i)!\,(k-i)!\,((n/2)+1-i)!\,(i-1)!}\right\}}.$$

In the first formula, the notation for a binomial coefficient, such as $\binom{n/2}{k-i}$, represents $\frac{(n/2)!}{((n/2)-k+i)!(k-i)!}$, which is the number of ways of picking $k-i$ (unordered) outcomes from $n/2$ possibilities.

The above formulae can be easily computed using a mathematical computer program such as (the one used by the authors) Mathematica. Table 2 shows the home-advantage-corrected ideal standard deviations for various combinations of h and n.[10] The table also reports an approximate value for the average percentage bias created by implicitly assuming away home

[10] Note that when $h = .5$, so that a team playing at home is assumed to have no home advantage, the above formula simplifies to the traditional ideal standard deviation $\sigma = 0.5/\sqrt{n}$.

advantage. That bias depends, obviously, on the extent of the advantage. Calculations using the numbers in the table reveal, however, that the bias is relatively unaffected by the number of games.

As a frame of reference, consider how a change in the number of games in a season from 154 to 162 — as occurred in major league baseball — causes the (traditonally computed) ideal standard deviation to change; namely, from 0.04029 to 0.03928. Recalculating the traditional ISD to account for this change in n — which is common practice for researchers using this approach — alters its value by approximately 2.5%. Adjusting for home advantage using parameter values similar to some actually observed causes the HISD to differ from the traditional ISD by a comparable magnitude.

Home-Advantage-Corrected Ratio of Standard Deviations

In this section, 1990–2007 results from the four major North American sports leagues are used to produce home-advantage corrected versions of both the ideal standard deviation and the ratio of standard deviations. In so doing, the league-average historical home-team winning percentages over those years are used as a measure of the theoretical parameter h.[11] Remember from above that those empirical home winning percentages are: MLB — 53.7%, NHL — 55.6%, NFL — 58.4%, and NBA — 60.8%. Assuming for now that each league plays its current official number of games, the home-advantage corrected ideal standard deviations (HISD) based on these empirical results are: NFL — .123221; NBA — .053920; NHL — .054872; MLB — .039174.

Using the seasons in the 1990-2007 period, the average standard deviations of the season-end standings in the major North American sports have been: NFL — .19075; NBA — .15856; NHL — .10187; MLB — .06996.

[11]Note, though, that the empirical winning percentages don't perfectly capture the theoretical h, which is defined for a league of perfectly-balanced teams. The use of home-team winning percentage to measure home advantage is common, but there are other ways to measure the size of the advantage. Fair and Oster (2007), to cite one example, use the results of college football games to estimate that playing at home is, on average, worth the equivalent of 4.3 points.

Dividing ASD by traditionally-measured ISD (given above) for each year, incorporating the fact that leagues sometimes do not play their normal number of games, and then averaging the results over the period, produces the following values for the traditionally-measured ratio of standard deviations: NFL — 1.5260; NBA — 2.8365; MLB — 1.7597; NHL — 1.8177.[12]

Dividing yearly ASD by the HISD given above, incorporating shortened seasons, and averaging produces the following values for the home-advantage-corrected ratio of standard deviations (HRSD): NFL — 1.5485; NBA — 2.9046; MLB — 1.7646; NHL — 1.8291. Values for both traditional RSD and HRSD are shown in Table 3.

Accounting for home advantage has a greater impact on a league's RSD the larger is the home advantage in that league. The adjustment, therefore, makes the NBA (relative to the other three leagues) look even more competitively imbalanced.

Table 4 shows the significance of the bias in cross-league comparisons that results from failing to consider home advantage. The table shows how much of the difference in RSD between the NFL (the league with the smallest RSD (i.e., with the most competitive balance)) and the other leagues is eliminated — or magnified, in the case of the NBA — when HRSD values are used. For example, since the NFL displays a stronger home advantage than does MLB, adjusting for home advantage makes the difference in the ratio of standard deviations between MLB and the NFL — one way of comparing the degree of competitive imbalance in the two leagues — fall by 8%.

Conclusion

One method that researchers have used to measure the competitive balance of a sports league involves dividing the standard deviation of team winning percentages by the standard deviation that would be expected if each game was equally likely to be won by either team.

[12]Because of labor disputes, NHL teams played a 48-game season in 1994–95, NBA teams played 50 games in 1998–99, and MLB teams played a 144-game schedule in 1995, and averaged 114 games in 1994. In addition, the NHL regular season twice consisted of 80 games and twice of 84 games over the four seasons spanning 1990–95. Finally, the NHL did not play at all during what would have been its 2004–05 season.

Dividing by the so-called "ideal standard deviation" adjusts for differences in season length across leagues.

In no major team sport, however, are games between equally-skilled teams actually 50/50 propositions. Rather, teams playing in their regular locations win (on average) more than fifty percent of games. The extent of this home advantage differs across sports.

Ignoring home advantage means that the typical calculation of the ideal standard deviation is biased: it is larger than it would be if the advantage was taken into account. As a result, the ratio of standard deviations is inappropriately small. In other words, the typical procedure overestimates a league's degree of competitive balance. Because a larger home advantage produces a greater bias, comparisons of competitive balance across leagues are also affected.

This paper describes a formula that can be used to calculate a home-advantage-corrected ideal standard deviation, and therefore a corrected measure of competitive balance.

Since the NBA has the largest home advantage among the major North American sports leagues, correcting for home advantage increases the extent to which the NBA is shown to be competitively imbalanced. The home-advantage adjustment also narrows the gap in measured competitive imbalance between MLB and the NFL (as well as between the NHL and the NFL).

Table 1: Percentage of Games Won By Home Team

Year	MLB	NFL	NHL	NBA
1990	.537	.585	.589	.659
1991	.538	.589	.605	.631
1992	.552	.607	.557	.611
1993	.538	.549	.540	.612
1994	.517	.571	.583	.597
1995	.532	.600	.561	.604
1996	.541	.621	.550	.575
1997	.535	.608	.536	.595
1998	.538	.629	.543	.623
1999	.521	.597	.551	.611
2000	.540	.556	.551	.598
2001	.524	.548	.553	.591
2002	.542	.580	.549	.628
2003	.550	.613	.549	.614
2004	.535	.566	n/a	.605
2005	.537	.590	.574	.603
2006	.546	.531	.550	.591
2007	.543	.574	.537	.601
Overall	.537	.584	.556	.608
Stnd Dev	.009	.027	.019	.019

Table 2: Home-Advantage-Corrected Ideal Standard Deviation of Winning Percentage

number of games (n)	home-team winning probability (h) .50	.55	.60	.65
10	.158114	.157321	.154919	.150831
20	.111803	.111243	.109545	.106654
40	.0790569	.0786607	.0774597	.0754155
80	.0559017	.0556215	.0547723	.0533268
160	.0395285	.0393303	.0387298	.0377078
average bias from using $h = .5$	—	0.5%	2.1%	4.8%

Table 3: Home-Advantage-Corrected versus Traditional Ratio of Standard Deviations

League	HRSD	RSD	Difference
NBA	2.9046	2.8365	2.4%
NFL	1.5485	1.5260	1.5%
NHL	1.8291	1.8177	0.6%
MLB	1.7646	1.7597	0.3%

Table 4: Bias From Not Adjusting For Home Advantage on Ratio-of-Standard-Devation Comparisons Between Leagues

League Comparison	Bias
NBA to NFL	-3.4%
NHL to NFL	4.0%
MLB to NFL	8.1%

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