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Home Advantage in the NBA as a Game-Long Process

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Abstract

In papers on basketball, it is standard practice to treat the home-court advantage in terms of percentages or point differences at the end of the game. This practice leaves out of account how the advantage develops during the game, when it accumulates most strongly, its course and the in-course dynamics. This study analyzes all games played in two seasons of the NBA by quarters and overtime periods. The main result is that home advantage in the NBA is strongly front-loaded. In both years studied the home team accumulated two thirds of the home advantage it had at the end of the game in the first quarter. It accumulated less of an advantage in the second and third quarters, and still less in the fourth quarter. Further, the home team does not on average lengthen its lead in quarters which it enters ahead, but gains strongly in any quarter which it enters behind. The paper concludes with a discussion of theoretical issues raised by these results and next steps in research.

KEYWORDS: home advantage, game-long process, course, frontloaded, basketball

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Introduction

Prior to the pioneering paper by Schwartz and Barsky (1977), little was known and nothing published about the home advantage beyond its existence. Schwartz and Barsky reported results for four major team sports (major league baseball, college and professional football, professional ice hockey, and college basketball). They showed that the home advantage exists in all four sports and is often as important a determinant of outcome as team quality. They showed that the effect varies from one sport to another. It is largest in basketball and hockey and smallest in baseball. They gave many indications of how robust the effect is. It holds at college and professional levels, over periods of time as long as 40 years in the same sport, in regular season and championship play, in both the first and second halves of regular season play, for strong teams and for weak teams.

Schwartz and Barsky also discussed several commonly held opinions as to the causes of the home advantage. One such opinion was that the home team is more familiar with the field of play, its peculiarities, and is better able to take advantage of them. Another was that home advantage was due to the fatigue and disruption of family life occasioned by playing away from home. Schwartz and Barsky argued against both of these opinions. Their own opinion attributed the home advantage to social support by the home town crowd. They cited the enthusiasm of the fans, the cheering and jeering, and the energy it is said to elicit from the players.

In the years since 1977 study of the home advantage has burgeoned (Courneya and Carron, 1992; Nevill and Holder, 1999; Balmer, Nevill, and Wolfson, 2005). Some of Schwartz and Barsky's conclusions have been extended and others have been corrected. English football (soccer) was added to the list of major team sports in which the home team enjoys a substantial advantage (Clarke and Norman, 1995; Pollard, 1986), as were rugby (Jones et al., 2005) and Australian football (Clarke, 2005). The home advantage has also been shown to exist in women's basketball and field hockey but not in women's baseball (Gayton et al., 1987). The relationship to crowd size has become more complicated. Some studies have found no relationship between home advantage and crowd size, while others have found such a relationship, and still others have found a relationship but only up to a critical size (Agnew and Carron, 1994; Nevill et al., 1996; Pollard, 1986).

Several claims have been advanced for the home advantage in individual sports: high school wrestling and high school cross-country (Gayton and Langevin, 1992; McAndrew, 1993; McCutcheon, 1984), alpine skiing (Bray and Carron, 1993), speed skating (Koning, 2005), boxing (Balmer, Nevill, and Lane, 2005), and international golf and tennis (Nevill et al., 1997). In all of these cases, however, the advantages were small, roughly on the order of baseball in team

sports. In short, it now appears that home advantage in individual sports is either small, limited to the lower end of what it is in team sports, or nonexistent.

Schwartz and Barsky (1977) did not mention crowd effects on the officials as a possible factor in the home advantage. In the years since, however, it has received more attention, especially in subjectively judged individual sports (Courneya and Carron, 1992; Lehman and Reifman, 1987; Nevill et al., 1999, 2002; Mohr and Larsen, 1998; Balmer, Nevill, and Lane, 2005).

In his recent book on rules and tools for performance analysis in basketball Oliver (2004) discusses home advantage in terms of percentages and point differences at the end of a game. In this respect he follows the common practice. That practice, however, leaves open to question when during the game the home advantage is accumulated. Is it mostly built up early in the game or late, or is it, perhaps accumulated at a roughly even rate throughout the game? Widely held theories of the home advantage (for example, Koppett, 1973; Schwartz and Barsky, 1977; Pollard and Pollard, 2005) are silent about when during the game the home advantage primarily develops.[1] However, what they do hypothesize seems to point toward the 4th quarter, when the hometown crowd is usually most intense and vociferous in its support and the away team, possibly, more fatigued. It might be expected, therefore, that the home advantage would be mostly accumulated late in the game.

Methods

The home court advantage in the NBA is exceptionally well suited to analysis. The effect is large. The difference in points between home and away teams typically averages about 3.5 points and the percentage of games won by the home team about 60%. The regular-season NBA database is also large. The season lasts from the last few days in October to mid-April and involves a total of 1230 games (1189 in the years used for this study). No study on team functioning in experimental psychology, for example, Cannon-Bowers and Salas (1998), rests on so large a database and, among sports in North America, only hockey and major league baseball are comparable.

Box scores which give points scored by quarter and in overtime for all NBA games are available on the internet for the 2002-03 through the 2006-07 seasons (ESPN, 2007). The database for the present study consisted of the first two of

[1] The citation for Koppett is a book, *The Essence of the Game is Deception*, published in 1973, four years before the first academic publication on home advantage (Schwartz and Barsky, 1977) and more than two decades before a flurry of academic papers emphasizing the role of official bias in the home advantage, for example, Nevill, Balmer, and Williams (1999, 2002). Nevertheless, Koppett's is not only the first but also one of the baldest statements of the official-bias hypothesis, (p.86): "The primary cause [of the home advantage] is the effect of the home crowd on the referees." Further, home advantage will remain "until someone invents robot referees."

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these seasons, 2002-03 and 2003-04. In 7 games in 2002-03 and 12 in 2003-04 the scores for at least one quarter were missing. The missing scores were obtained by looking them up individually in the *Philadelphia Inquirer*, which publishes box scores for all NBA games.

Like any *post hoc* study of game outcomes, the present effort is basically observational. However, it does include one important element of experimental design. Each team in the league plays a balanced home-and-away schedule. The same two teams play each other as many times with the one team at home as the other. This balance allows us to obtain results regarding home advantage which are not confounded with team quality.

In 2002-03 and 2003-04 there were 15 teams in the Eastern Conference and 14 in the Western Conference. Each team in the West played two games at home and two away with every other team in the West, and one game at home and one away with every Eastern team, for a total of 41 games at home and 41 away. The schedule was more complicated in the Eastern Conference because of the odd number of teams. Further, some games had to be unmatched, that is, not paired with a game between the same two opponents but with the away team at home. Unmatched games in the NBA are arranged in cycles, for example, $A \rightarrow B \rightarrow C \rightarrow A$, where the arrowhead indicates the home team. In this example, all three teams play one game at home and one away and all three games are unmatched. The NBA schedule included 17 such games in both the 2002-03 and 2003-04 seasons; each team still played 41 games at home and 41 games away. These 17 games constitute a very small percentage (1.4%) of the 1189 games played each season. Thus, though not completely balanced, the schedule is sufficiently balanced that home court advantage may be safely analyzed as independent of team quality.[2]

The central purpose of this paper is to compare home advantage in each quarter with home advantage in other quarters and at the end of the game. There is, however, a technical question. Home advantage at the end of the game includes all 1189 games, that is, every game is either won or lost by the home team, but within a quarter a small percentage of games are neither won nor lost; the two teams score the same number of points. The question is, how are these tied games to be handled? The procedure adopted in this paper is to ignore the tied games. Home advantage within a quarter equals the number of games in which the home team scores more points than the away team divided by the number of games in

[2] In the 2005-06 season the NBA expanded from 29 to 30 teams, with the addition of the Charlotte Bobcats. Each team still plays 41 home and 41 away games, but with one more team the total number of games played increases from 1189 to 1230. The schedule, of course, can no longer be quite the same as it would have been with only 29 teams. The principles, however, for drawing up the schedule are the same. The main aim is still to specify a schedule in which home advantage and team quality are as orthogonal to each other as possible.

which either team scores more points than the other. The main advantage of this procedure is that it involves no special features not shared with home advantage at the end of the game.

There are other possibilities, however. One might, for example, score tied games half to the home team and half to the away team. Note first that this alternate procedure would make very little difference in the results. In the 1st quarter of 2002-03 the reported home advantage is 58.8% (Table 2). If the alternate procedure were adopted, the figure would drop to 58.3%.

Further, the alternate procedure suggests that if the tied games were resolved by additional play the home and away teams would be equally likely to win. That is definitely not the case. The home team would win more often. For example, in the two years together 129 games were tied at the end of the 1st quarter. In the next quarter home advantage by the adopted procedure in these 129 games was 58.1% (Table 4), only a little less than the home advantage for not-tied games in the first quarter, 58.8%. In short, the adopted procedure not only parallels in its terms home advantage at the end of the game it also yields a result much like what would be expected if the ties were resolved by additional play.

Finally, a word of clarification is in order about "home advantage." The term applies to both the point difference between the home and away teams (home minus away) and to home wins as a percentage of all wins. The latter is the preferred sense and, when not otherwise specified, is intended. When applied to home advantage within a quarter, the word "wins" should be replaced by "leads." However, even the phrase "home wins as a percentage of all wins" needs clarification. In general, the whole percentage of wins or leads will be used but, strictly speaking, the term refers to the difference between the percentage of home wins and 50%. Therefore, home advantage can be negative, for example, 46% or -4%.

Results

In 2002-03 the home team scored 3.89 more points on average than the away team and won 62.9% of the games. In 2003-04 the home minus away difference was 3.59 points and the home advantage 61.3%. These are the figures usually reported in studies of the home advantage. The present study focuses on when during the game these results accumulate (course) and how point differences accumulated in different periods of the game relate to one another (dynamics).

Course

Table 1 presents the average number of points scored by the home and away teams in the four quarters of regulation play and in overtime in 2002-03 and 2003-04. The average difference in points scored by the home team minus the number

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scored by the away team ($\bar{\Delta}$) consistently favors the home team. In both years $\bar{\Delta}$ is largest in the first quarter and decreases isotonically in the second, third, and fourth quarters. In 2002-03 $\bar{\Delta}$ in overtime is larger than in the fourth quarter but less than in the third quarter. In 2003-04 $\bar{\Delta}$ in overtime is smaller than in any quarter.

Table 1. Average number of points scored by the home and away teams by quarter or overtime, 2002-03 and 2003-04.

	2002-03				2003-04				Both Years			
Qtr	Home	Away	$\bar{\Delta}$	S_Δ	Home	Away	$\bar{\Delta}$	S_Δ	Home	Away	$\bar{\Delta}$	S_Δ
1st	24.8	23.3	1.47	7.2	24.1	23.0	1.09	7.4	24.4	23.1	1.28	7.3
2nd	24.1	22.9	1.14	7.3	23.7	22.7	1.00	7.2	23.9	22.8	1.07	7.2
3rd	23.8	22.9	0.88	7.7	23.5	22.6	0.91	7.2	23.7	22.8	0.89	7.4
4th	23.6	23.2	0.35	7.2	23.2	22.7	0.56	6.9	23.4	22.9	0.45	7.0
OT	11.0	10.3	0.71	4.9	10.9	10.6	0.29	4.9	11.0	10.4	0.52	4.9

Note. The number of games that went to overtime was 86 in 2002-03 and 71 in 2003-04. The number of games played in all other periods was 1189.

It should be noted, however, that overtime periods in the NBA last 5 minutes whereas the quarters last 12 minutes. It should also be noted that "Overtime" in Tables 1 and 2 includes all overtime periods, not just the 1st. In 2002-03 there were 86 overtime games of which 6 were double overtimes. In 2003-04 there were 62 single overtime games, 8 double overtime games, and 1 triple overtime game. Taking both the short duration of overtime periods and their multiplicity into account, $\bar{\Delta}$ in points per minute is almost as large in overtime as in the 1st quarter. Prorating to a hypothetical 12-minute overtime period, $\bar{\Delta}$ for the two study years together equals 1.14.[3] The comparable figure for the 1st quarter is 1.28 (Table 1). Of course, if the overtime period were actually extended to 12 minutes, the high per-minute rate in overtime would not necessarily be maintained.

Paired *t*-tests were used to evaluate the significance of the decrease in $\bar{\Delta}$ from the first to the fourth quarter. The unit of analysis is a game; hence, the tests have 1188 degrees of freedom. In 2003-04 the decrease did not reach significance at

[3] Home advantage in percentage of home wins is not subject to a similar calculation. The reason is that points cumulate with time played but who wins or leads, whether the home or the away team, does not.

the .05 level (t=1.78). However, in 2002-03 and in the two years together the decreases were significant beyond the .001 level (t=3.62 and 3.83).

As discussed earlier, home advantage in each quarter was determined by ignoring games in which the two teams scored the same number of points in the quarter and counting only those games in which one team or the other had at least a 1-point lead. Home advantage was the percentage of games in which the home team had the lead. The results are presented in Table 2. They follow the same pattern as $\bar{\Delta}$ followed in Table 1. In the two years taken together home advantage is smaller in the second and third quarters than in the first, and smaller yet in the fourth quarter and overtime.[4] In both years individually, slightly more than two thirds of the home advantage at the end of the game is accumulated in the first period. Home advantage in the 1st quarter is (58.8-50.0 =) 8.8% in 2002-03 and, by a similar calculation, 8.3% in 2003-04. The corresponding figures for home advantage at the end of the game are 12.9% and 11.3% respectively.

Significance levels, using McNemar's test for the difference between correlated proportions (Siegel, 1956), were also similar to what they were in Table 1. In 2003-04 χ^2 equaled 3.41 and did not reach significance at the .05 level. In

Table 2. Home advantage by period, 2002-03 and 2003-04.

	2002-03		2003-04		Both Years	
Period	N*	Home Adv.**	N	Home Adv.	N	Home Adv.
1st Qtr	1122	58.8	1127	57.9	2249	58.3
2nd Qtr	1135	57.7	1137	53.6	2272	55.7
3rd Qtr	1118	55.5	1121	56.4	2239	56.0
4th Qtr	1126	51.1	1116	54.0	2242	52.6
Overtime	86	57.0	71	47.9	157	52.9

* N is the number of games in the period in which the home and away teams scored an unequal number of points.

** Number of games in which the home team scored more points than the away team, divided by N and multiplied by 100.

[4] Note that the high per-minute rate of home-minus-away differences did not translate to a large home advantage in terms of home-win percentage. It seems likely that the standard deviation of Δ does not keep pace with the increasing mean as play is extended (see Table 3). If so, then a constant per-minute rate would give rise to an increasing home advantage in terms of home-win percentage. Conversely, if play is cut short, then the home advantage in percent will be held low, even though the per-minute rate remains constant.

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2003-04, however, χ^2 equaled 9.91, $p<.002$, and for the two years together it equaled 12.80, $p<.001$. The difference between the first quarter and overtime, though about the same size as that with the fourth quarter when both years were taken into account, was not significant. McNemar's test has one degree of freedom regardless of the number of cases on which the proportions are based, but the test statistic itself depends heavily on sample size.

Table 3 presents cumulative results for both differences in points and home advantage. $\overline{D}$ represents the average difference in points scored by the home and away teams from the beginning of the game to the end of each quarter and at the end of the game if it goes into overtime. S_D is the standard deviation of the differences used to compute $\overline{D}$. So understood, D is a sum of quarterly differences (Δ), and S_D increases regularly as more and more of the game is included in D. $\overline{D}$, however, increases a bit more rapidly, with the result that $\overline{D} \div S_D$ creeps gradually upward. As it does, home advantage gradually creeps upward too. The only exception is overtime. In both years $\overline{D} \div S_D$ remains the same but home advantage falls off a bit.

Table 3. Cumulative results by period, 2002-03 and 2003-04.

Year	Period	$\overline{D}$	S_D	$\overline{D} \div S_D$	Home Adv.
2002-03	1	1.47	7.20	0.20	58.8
	1,2	2.62	9.82	0.27	61.7
	1-3	3.48	12.21	0.28	63.0
	1-4	3.83	12.66	0.30	63.4
	1-4,OT	3.89	12.71	0.31	62.9
2003-04	1	1.09	7.44	0.15	57.9
	1,2	2.09	9.68	0.22	60.1
	1-3	3.00	11.11	0.27	60.8
	1-4	3.56	12.00	0.30	62.2
	1-4,OT	3.59	12.06	0.30	61.3

Note. The data for this table are the cumulative home-minus-away differences from the beginning of the game up to and including the periods indicated in the second column. The next column to the right is the mean of these differences over all 1189 games in the regular season, and the column after that is the standard deviation of the 1189 differences.

Altogether, Table 3 pictures the home effect as registering primarily on points scored and the difference in points scored gradually dragging home advantage in percentages from the large value it has at the end of the first quarter to the even larger value it attains by the end of the game. This interpretation is consistent with Sagarin's treatment of similar materials in his NBA ratings, for example, Sagarin (2007).

Dynamics

Basketball players know where their team stands in the game, whether it is ahead or behind and, roughly at least, by how much. Therefore, they may react to their own earlier performance. Table 4 presents home-team performance in the second, third, and fourth quarters as a function of where it stood in the game when the quarter began, whether it was ahead of, even with, or behind the away team. Performance in the third quarter, for example, is studied as a function of where the home team stood at halftime.

The results are clear. If the home team is ahead (D>0) when it starts a quarter, then on average it scores no more points in that quarter than its opponents. The average of the six "ahead" $\bar{\Delta}$ values is slightly negative. Similarly, four of the six home-advantage percentages are below 50%. Their average is slightly below 50%.

However, if the home team is behind (D<0) when it starts a quarter, then on average the home-team advantage in that quarter is large. The six "behind" values of $\bar{\Delta}$ in Table 4 are all larger than 1 point; and in each one of the six instances the mean difference between points scored by the home and away teams, $\bar{\Delta}$, is significant at the .001 level by paired *t*-test.

When the home team starts a quarter even with its opponent (D=0), $\bar{\Delta}$ is positive and home advantage is greater than 50% in all six cases, though smaller than when D<0. The increases in home advantage after the first quarter are accumulated mainly in quarters which the home team starts behind the away team. They are accumulated entirely in quarters which the home team starts behind or even with the away team.

The home team tends to come back when it is down. This tendency is general. Table 5 presents the correlations between Δ in different quarters. The correlations are small but pervasively negative. Their averages equal -.085 in 2002-03 and −.100 in 2003-04. Despite their small size these averages are strongly significant. The standard error of an average correlation over the same units of investigation, in the present case, games, decreases as the number of correlations averaged increases. If the population correlation equals zero and the sample correlations are first z-transformed, the standard error

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$$\sigma_{\bar{r}} = \frac{1}{(k(N-3))^{1/2}},$$

where k is the number of correlations being averaged and N is the number of games (1189) on which the correlations are based (Dunlap et al., 1983). Application to Table 5 yields normal deviates, $\bar{r} \div \sigma_{\bar{r}}$, of 7.32 in 2002-03 and 8.38 in 2003-4, $p<.0001$ in both cases.

Table 4. Mean Δ and home advantage in the 2nd, 3rd, and 4th quarters as a function of whether the home team was ahead of, even with, or behind the away team when the quarter started.

	Completed	Home	Next Quarter		
Year	Quarters	Team	N	$\bar{\Delta}$	Home Adv.
2002-03	1	ahead	660	-0.32	46.9
		even	67	0.48	50.8
		behind	462	1.63*	58.9
	1,2	ahead	709	0.53	53.1
		even	40	0.40	59.5
		behind	440	1.28*	58.5
	1-3	ahead	721	-0.65	45.0
		even	45	1.33	55.0
		behind	423	1.95*	61.1
2003-04	1	ahead	652	0.43	52.2
		even	62	0.92	66.1
		behind	475	1.80*	54.0
	1,2	ahead	693	0.01	48.8
		even	36	1.17	64.5
		behind	460	2.26*	67.3
	1-3	ahead	703	-0.22	49.4
		even	33	1.27	55.2
		behind	453	1.73*	61.3

* Significant at the .001 level

Table 5. Correlations among the home-minus-away differences in different quarters, 2002-03 and 2003-04.

Quarter	1st	2nd	3rd	4th
1st	—	-.127	-.107	-.035
2nd	-.079	—	-.101	-.137
3rd	-.035	-.026	—	-.094
4th	-.094	-.163	-.128	—

Note. The correlations below and to the left of the main diagonal are for 2002-03 and the correlations above and to the right of the main diagonal are for 2003-04.

Discussion

The results of this study were unexpected. Home advantage in the NBA appears to be strongly frontloaded, just the reverse of what had been expected. Two thirds of the home advantage at the end of the game is accumulated in the first quarter, and the remaining third is accumulated in small increments over the rest of the game, three quarters and possibly an overtime period or periods. Further, the gains in home advantage after the first period are confined largely to quarters which start with the home team behind. If the home team is ahead when a quarter starts, then on average the home team does not extend its lead in that quarter. Thus, home advantage is not only largely accomplished in the first quarter but the fact of its accomplishment does much to shape the size and context of any additional increments in the rest of the game.

The expectation that home advantage would be backloaded was based on current theories of the home advantage. The present study, however, should not be understood as a "critical experiment." NBA basketball is not played to test theories about the home advantage. Nevertheless, the results of the study do raise issues for current theories. In general, the home crowd is most involved and vociferous late in the game, when the outcome frequently hangs on every basket. Why, then, if home advantage is fueled by the clamorous support of the hometown crowd, is the home advantage frontloaded? Officials, it is said, respond to the pressure of the hometown crowd by favoring the home team in close calls. But, again, that pressure is greatest late in the game, precisely when home advantage is least in evidence. As for fatigue, wouldn't the away team, already disconcerted by its travels and perhaps short of sleep, be most tired relative to the home team late in the game?

An attempt to take frontloadedness better into account by modifying existing theories or formulating new ones is premature. There are too many questions re-

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maining to be answered. Some teams, for example, show little or no home effect. In 2002-03 Philadelphia won only 2 more games at home than on the road, 25 versus 23. Portland and Dallas also registered relatively small home effects, 27 versus 23 and 33 versus 27. Cleveland and Chicago, on the other hand, both won 27 games at home and only 3 on the road. All teams, of course, played the same number of games at home and away. These differences are probably statistically reliable, but the point should be checked by split-half reliability or some other test of internal consistency. If they are reliable, how does frontloadedness vary as a function of these differences? Is it exaggerated in teams like Cleveland and Chicago and absent or greatly reduced in teams like Philadelphia, Portland, and Dallas? It could even be reversed. Portland and Dallas, for example, might play less well at home than away early in the game but then somewhat better later on. The result would be a small or modest home advantage in the win column, with backloading.

The home advantage in major league baseball is small, typically around 53%. Is frontloadedness reduced in baseball or, possibly reversed? And what about other team sports? How general is frontloadedness? Does it characterize football, soccer, ice hockey, all sports which show a sizeable home advantage? Is it found, for that matter, in NBA basketball in other eras, in the 1950s, 60s, 70s, or 80s?

These and similar questions should be answered before an attempt is made to construct a theory of the home advantage that takes frontloadedness into account. In the meantime, however, even the present results have some relevance for actual play. An NBA team playing at home should be leading at the end of the first quarter. If it is behind, it has lost much of the advantage it had when the game started. Before the game starts the home team can expect to win the game roughly 62.0% of the time. If the home team is behind at the end of the first quarter, that percentage drops to 44.2% in 2002-03 and 43.8% in 2003-04. The home advantage is not something that the home team retains regardless of how it performs during the game. If the home team lets itself be outscored in the first quarter, then the advantage it had when the game started is lost.

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