Calling Foul on Fair Play: Home-Team Bias in NBA Referees

Parker Hara, Eytan Gilady, Noah Perelmuter, Ronit Kirumaki, Kalvin Alrez
https://github.com/np2446/Foul-Project

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Management Summary

There is a long-held belief among NBA fans that officials often favor stars and home teams by making unfair calls throughout a game to appeal to a home crowd. Notwithstanding rule-defining plays like James Harden's egregious stepback or Stephen Curry's foul drawing technique, refs come under fire year after year for giving preferential treatment to some players while coming down hard on players like Draymond Green and Desmond Bane. We decided to examine if this was simply a misunderstanding among fans or if there was really a systematic bias underlying the officiating process in the NBA. This study aims to investigate the possibility of referee bias in NBA games, focusing on the period from 2000 onwards.

The primary objective of this research is to analyze game-by-game foul data to identify patterns that might suggest bias towards home teams. To achieve this, we will calculate each team's average fouls per game and the standard deviation of fouls per game across multiple seasons. Our analysis will then focus on deviations from these averages in individual games, comparing the foul rates for home and away teams.

Our approach is grounded in statistical hypothesis testing. The null hypothesis (H0) posits that there is no significant difference in the number of fouls against home and away teams, suggesting unbiased officiating. The alternative hypothesis (H1) suggests that there is a significant difference, indicating potential bias. These hypotheses will be tested using standard deviation measures from the mean foul rates of teams in individual games.

The methodology involves a comprehensive analysis of NBA game statistics. By examining deviations from the mean fouls per game, this study aims to reveal whether certain teams are consistently subjected to more fouls, especially when playing away games. The significance of this study lies in its potential to contribute to the ongoing discussion about fairness in NBA officiating. By providing a data-driven analysis of fouls per game, this research aims to offer insights that could inform future policies and practices in professional basketball officiating.

Our results draw the conclusion that there are some inconsistencies in referee foul calling throughout the 20-year period we examined. However, these results are highly irregular and do not indicate any widespread bias toward home teams in the long run. We did notice a striking bias in the home team's foul preference for the Boston Celtics. This indicates that the environment in the T.D. Garden, earning it the reputation of one of the most challenging arenas to play in, has some statistical significance.

Problem Statement

Home-court advantage is a widely discussed topic across all sports in general, with the main question being "Why does this occur?". In basketball, there is no "mechanical" advantage given to the home team, dissimilar to baseball where the home team gets to bat in the bottom half of the inning. However, we see that throughout the NBA's existence, home teams tend to perform better. Observers of this trend have brought up the idea that referees may favor home teams on a general, long-term basis. This favoritism may not even be a conscious choice, rather, we can entertain the notion that the crowd's noise muddles

split-second decision-making of these referees in favor of the home team, or rather that group dissent, as the game progresses, may lead to a certain bias in favor of the home team yet again. Nevertheless, though the conclusion of our studies may not indicate a bias in fouls given for the home team that translates to wins, given the clear advantage that home teams have we decided it was an area worth looking into.

Objectives of the Study

The objective of this study is to use game-by-game foul data to determine if there is a pattern of bias that favors the home team. Before starting our research, we generated an important assumption that provides the foundation for what our research will be based on. This assumption is that a team given an above-average number of fouls will have a higher-than-average probability of winning. Intuitively this makes sense, as fouls either directly lead to an easier offensive possession and get the team closer to the "bonus", but as fouls against the offending team increase players may tend to play more passively on defense as a means to avoid going into the bonus and fouling out of the game.

To achieve this objective, we will calculate the average fouls given to each team on a per-game basis, and use the standard deviation of this data to determine if there is a significant deviation from the mean when these teams play at home. We chose to analyze this data from a broad perspective rather than at the granular/game level, as on any given night we could have a significant deviation, but the conclusions we would draw from this would not be useful in determining if there is an overall bias towards the home team. Simply put, referees are human as well and we are not analyzing their "bad nights" too closely, we are analyzing if there is a general implicit bias.

Methodology Overview

Steps for Testing the Null Hypothesis:
For each game we observed, we determined the deviation from the mean for both the home and away teams. This involves calculating how many fouls in a specific game were above or below that team's average. To compare this to a normalized average, we performed a t-test to compare the mean foul deviation for home and away teams. This assesses whether the observed differences are statistically significant or could have occurred by random chance. Next, we aggregated these deviations over multiple games to identify any consistent patterns. For instance, if a particular team consistently has fewer fouls called when playing at home compared to when they are the visiting team indicating a potential bias.

Interpreting the Test Results:
- If your statistical test shows a significant difference in foul calls between home and away games (p-value < 0.05, typically), you may reject the null hypothesis, suggesting potential officiating bias.
- If the test indicates no significant difference (p-value > 0.05), you fail to reject the null hypothesis, implying no substantial evidence of bias in the data.

Consider External Factors:

- Account for potentially confounding variables such as changes in team composition, playing style, or rule changes over the years. These factors might influence foul rates independently of officiating bias.

Robustness Checks:
- Perform additional tests to check the robustness of your results. This might include analyzing subsets of the data (e.g., playoff games vs. regular season) or applying different statistical models
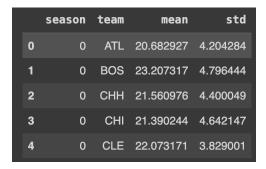
Important Considerations:
- Ensure that the data set is large enough to provide statistically meaningful results.
- Verify that the data meet the assumptions of the chosen statistical tests (e.g., normal distribution for a t-test).
- Be aware of the issue of multiple comparisons if conducting numerous statistical tests, as this can increase the likelihood of a Type I error (falsely rejecting the null hypothesis).

We started by collecting the home fouls and away fouls for each game from 2000 and calculating the basic stats for the entire compilation of data.

	game_id	season	away_team	home_team	away_fouls	home_fouls
0	20001062	0	VAN	UTA	19	21
1	20000685	0	TOR	BOS	18	21
2	20000562	0	LAC	BOS	23	14
3	20000224	0	PHI	CHH	25	22
4	20000081	0	TOR	CLE	18	17

	away_fouls	home_fouls
count	24024.00	24024.00
mean	21.00	21.02
std	4.53	4.44
min	5.00	7.00
25%	18.00	18.00
50%	21.00	21.00
75%	24.00	24.00
max	42.00	42.00

Initially, there doesn't seem to be any difference between the basic statistics of fouls called on away teams and on home teams. Next, we calculated each team's average and standard deviations per season. Then we tested each game's foul count to calculate its degree of deviation from the mean.

	season	team	mean	std
0	0	ATL	20.682927	4.204284
1	0	BOS	23.207317	4.796444
2	0	CHH	21.560976	4.400049
3	0	CHI	21.390244	4.642147
4	0	CLE	22.073171	3.829001

	game_id	season	away_team	home_team	away_fouls	home_fouls	away_fouls_num_devs_from_mean	home_fouls_num_devs_from_mean
0	20001062	0	VAN	UTA	19	21	-0.575466	-0.724433
1	20000685	0	TOR	BOS	18	21	-0.723780	-0.460199
2	20000562	0	LAC	BOS	23	14	0.282045	-1.919613
3	20000224	0	PHI	CHH	25	22	0.286651	0.099777
4	20000081	0	TOR	CLE	18	17	-0.723780	-1.324933

Next, we performed a paired sample t-test to assess whether there is a significant difference in the standard deviations of fouls called against away teams compared to home teams. The t-test is particularly suitable for this analysis because it compares the means of two related groups (in this case, the standard deviations of fouls for home and away teams within the same games) to see if they are statistically different from each other. By calculating the t-statistic and the associated p-value, we can infer whether the differences observed in our data can be attributed to chance. A low p-value (<0.05) would indicate that the differences in foul calls are statistically significant, suggesting a potential bias in officiating. This method provides a rigorous statistical approach to investigate patterns that might otherwise be hidden in the complexities of sports data.

To start this, we performed a t-test on each team individually to see if a significant difference in the standard deviations of fouls called for the home teams exists. Then we performed a t-test on the entire dataset to see if there is a significant difference in the standard deviations of fouls called against home teams versus away teams in general. The first part was done by season, and the global test was done on the entire dataset. The results of these two tests are analyzed in our main findings.

In simpler terminology, the t-test compares the standard deviation of fouls called against an away team is equal to the standard deviation of the fouls called against the home team. The standard deviation compares the fouls called against the team to their mean fouls (home and away) for the entire season. The purpose of this test is to compare whether the mean of the standard deviations is greater for specific teams playing at home. For example, Boston has a lower mean standard deviation of fouls called against relative to their season mean while playing at home compared to the team they are playing against. Thus, in our t-test graph, teams with higher t-scores like Boston demonstrate that these teams consistently had fewer fouls called against them at home over the 20-year period.

Main Findings

As stated, the per-season and global t-test results will indicate how significant the deviation in home-team vs. away-team fouls is.

Season	Home Team		
0	UTA	2.031367	0.097940
	BOS	2.510829	0.014141
	CHH	-1.268583	0.208620
	CLE	1.375628	0.173588
	MIL	2.447643	0.019111

	t_statistic	p_value
0	3.014583	0.002628
1	1.883139	0.059926
2	3.345822	0.000846
3	0.623578	0.533024
4	1.433551	0.151955

The image on the left shows the beginning of our per-season data set, each team's deviation from the average is shown as well as its significance. The right image depicts the global test, in which the season's deviation as a whole was compared with the average with the p-value calculated. We then filtered the data to count the amount of significant deviations in each table and created a script that would output this data. We also graphed out the p-values of both tests, the first one showing how each team's t-test and p-value compared within a given season, and the second set of graphs showing the overall results for each team. These graphs will be attached as supplemental findings to our study. The results are as follows:

Number of seasons with a statistically significant difference in fouls called on away teams vs. home teams: 10

Number of teams with a statistically significant difference in fouls called on away teams vs. home teams: 16

Number of times a team had a season with a statistically significant difference in fouls called on away teams vs. home teams: 160

We see from the global test that half the seasons and half of the teams in the league had a significant deviation from the mean of fouls called when they were at home. Concurrently, we see that there were 160 instances in which a team enjoyed a significant foul advantage at home throughout an entire season. While the results suggest that there is a noticeable difference in officiating based on where the team is playing, we cannot conclude that in any given game the home team can count on a significant officiating advantage.

Significance and Other Findings

Prior investigations into the fairness of NBA officiating have considered the impact of "make-up calls" where a referee will make a second compensatory foul call in order to offset a prior questionable ruling[1]. We did not consider the effect of this in our study given that the scope of our investigation examines 2 decades worth of games and we believe that the effects of these situations would not be impactful over this large of a time frame. However, it is important to note that the study found some weak indications that a referee is more likely to give a "make-up call" to an opposing team after a foul call. This evidence is highly dependent on the initial call and can be affected by a wide range of factors like team strategy and player aggression.

Another study set out to examine 3 types of referee bias: home vs. away, team or individual player, and race. This study focused on a much more specific situation set, focusing only on the final 2 minutes of a game where the score was within 5 points since 2015. These moments are what would be referred to as "clutch" situations for players, and are objectively more high-pressure for referees. This is the only study

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[1] Gift, Paul. "Do Two Wrongs Make a Right in NBA Officiating? An Analysis of Referee Bias in Make-Up Call Situations." MIT Sloan Sports Analytics Conference, 2-3 March 2012, Boston, MA, USA.

to date that has found convincing evidence of home-team bias, noted especially in the playoffs.[2] Even earlier, a study found that players were more likely to have fouls called against them when being officiated by opposite-race crews. This study was reexamined after the findings were published and found that the data was no longer significant in a 3 year period following the release of the statistics.[3] This study is an example of the immediate impact that studies like ours can make in officiating at the highest levels of basketball.

While there was a racial bias found in the Pope, Price and Wolfers study, not all studies on NBA officiating have found statistically significant results. A 2015 study aimed to determine if referees make the correct calls at the end of close games found no evidence in the literature[4]. Aimed at determining whether the calls were correct, rather than simply examining the made calls adds an extra layer of scrutiny on the officials. However, this ex-post data was not conclusive of any bias, proving that even in high-intensity situations, referees consistently make fair calls. This begs a different question, posing not whether the calls are biased, but whether the calls are accurate.

It is safe to say that the data on this subject is at best mixed. While home-court advantage was found to be most pronounced in the last 2 minutes of a close game, the effect essentially washes out over the course of a season. However, from the perspective of everyday fans, these are the moments where we feel a blown call the most. The close calls that impose the biggest impact on the game leave opposing fans with a real distaste for referees and create the narrative that officials give preferential treatment. Our findings demonstrate that even if bad calls are repeatedly made in big moments, referees on average are unbiased and just.

[2] Pelechrinis, K. "Quantifying implicit biases in refereeing using NBA referees as a testbed." *Sci Rep* 13, 4664 (2023). https://doi.org/10.1038/s41598-023-31799-y

[3] Pope, D. G., Price, J. & Wolfers, J. Awareness reduces racial bias. *Manag. Sci.* 64, 4988–4995 (2018).

[4] Deutscher, Christian. "No Referee Bias in the NBA: New Evidence with Leagues' Assessment Data". 1 Jan. 2015 : 91 – 96.