Sub-Perfect Game:

Profitable Biases of NBA Referees

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Abstract

This paper empirically investigates three hypotheses regarding biases of National Basketball Association (NBA) referees. Using a sample of 28,388 quarter-level observations from six seasons, we find that referees make calls that favor home teams, teams losing during games, and teams losing in playoff series. All three biases are likely to increase league revenues. In order to distinguish between referee and player behavior we use play-by-play data, which allow us to analyze turnovers referees have relatively high and low discretion over separately.

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1 Introduction

All firms face rules, such as tax laws, health regulations, and ethical codes, that constrain the actions they may take to maximize profits. How firms respond to these rules is theoretically ambiguous, as there exists a tradeoff between compliance and actions that violate the rules but directly enhance profits. In light of this tradeoff, we examine the behavior of National Basketball Association (NBA) referees. There are a number of ways in which the NBA may benefit from its referees favoring certain teams or players; yet, fans value the integrity of the sport and would lose interest if they perceived the officiating to be systematically skewed. In this paper, we empirically test for the existence of referee biases that are likely profitable to the league. The results shed light on the general question of whether firms "bend the rules," despite being observed closely by consumers and the media.

The main challenge to the empirical analysis is disentangling referee and player behavior. The basketball statistics most directly affected by referees, fouls and turnovers, are simultaneously influenced by the style and quality of the players' actions, which makes identification of bias difficult. To account for this issue, we use play-by-play data; these include more detailed description of plays than game-level data, and allow us to exploit the fact that referees have varying degrees of discretion over different types of turnovers. We use the detail of the play-by-play data to classify turnovers into two groups: "discretionary" (mainly traveling violations and offensive fouls) and "non-discretionary" (mainly bad passes and lost balls).[1] There is a clear dichotomy between these two groups, as discretionary turnovers are always caused by referees blowing the whistle while the ball is in play, while non-discretionary turnovers are either determined directly by the players and without a referee whistle, or by the ball going out of bounds. In other words, only discretionary turnovers involve active referee behavior while the ball is in bounds.

Generally speaking, to test for the presence of referee bias we compare how discretionary turnovers are impacted by variables pertinent to possible bias, relative to

[1] A turnover occurs when the offensive team loses possession of the ball without taking a shot at the basket.

how non-discretionary turnovers are affected. While the analysis is not a clean "treatment and control" comparison–both types of turnovers are affected by both player and referee behavior–identification of bias only rests on the assumption that, on average, referees have a *relatively* greater effect on discretionary turnovers, as compared to non-discretionary turnovers. A formal model and detail on this argument are provided in Section 3. As the discretionary/non-discretionary distinction can be drawn for turnovers but not fouls, the paper's discussion is focused on the estimates regarding bias effects on turnovers, and we caution that the results on fouls are only suggestive, though still important.

We find evidence of three biases: favoritism of home teams, teams losing during games, and teams that are losing by at least two games in a multi-game playoff series. All three biases are plausibly profit-enhancing for the following reasons. Home favoritism increases the home court advantage, which likely increases ticket demand, as most fans who attend games root for the home team. Biasing calls in favor of teams losing during games keeps games close and more competitive, which likely improves television ratings and consequently television contract values. Favoring teams losing in multi-game playoff series increases the likelihood of additional games being played in the series, which leads to higher ticket sales and, most likely, television revenues.

Each type of favoritism results in approximately a 5-10% advantage in discretionary turnovers, and a 2-5% advantage in shooting fouls (for the first two types of bias). The playoff bias results are only marginally significant, but come from a much smaller sample. The discretionary turnover home bias is also estimated to increase by 1% for every additional 1,000 fans in attendance. Our statistical tests are designed to identify the existence of the biases and thus we do not estimate the effects of the biases on game outcomes. While we suspect the impact on game outcomes of any particular turnover bias would likely be small, we note that the foul effects may be more substantive; Price and Wolfers (2007) find that a small effect (4%) on total fouls can have a significant influence on win/loss outcomes. Furthermore, the effects of two or three of the bias types combined together may be substantial, and even if the biases do not often alter game win/loss outcomes, the biases affect the entertainment value of games, and thereby fans' utility.

In Section 5 we discuss possible causes of the biases. Both our priors and a number of auxiliary empirical results lead us to believe that the biases are mainly psychosocial and cognitive in nature. Regardless, among major professional sports, the NBA has been particularly outspoken about the degree to which its referees are monitored. NBA commissioner David Stern said in 2008, "We decided five years ago that we would track literally every call in order to help develop our officials and make them better, and they really effectively are the most measured and metricized group of employees in the world."[2] This suggests that league management has in place the type of system needed to detect these biases. The fact that they persist suggests the league allows them to continue in order to realize their benefits or because the costs of eliminating the biases are too high. Moreover, despite the league's statements that they have made efforts to improve the consistency of officiating starting in 2003, we find that the biases have not decreased over time following that year, indicating the league is not focusing on minimizing these biases in particular.[3] It is also possible that league management is unaware of the biases. If that is the case, then our paper provides an empirical strategy that they (and similar organizations) might use to monitor these type of biases.

1.1 Related Literature

There is a growing literature on rule compliance and the detection of corruption, especially in sports. For example, Duggan and Levitt (2002) uncover evidence that non-linear payoffs in sumo wrestling lead to match fixing and Zitzewitz (2006) finds that Olympic judges favor athletes from their own country. Our findings on difficult to detect biases also relate to a larger class of rule-based goods and services beyond sports. For example, the television quiz shows in the 1950s used biased rule enforcement to make their shows more entertaining, by giving the most charismatic contestants answers in advance Van Doren (2008). This type of blatant violation of the rules is likely a thing of the past. However, our results suggest that even today it is possible that game

[2] Source: nba.com/news/stern_transcript_080612.html.

[3] Our data are only available from the 2002-03 season onward, therefore, to test for improvement in officiating consistency, the magnitude of the biases in the first and second half of the sample are compared.

show firms favor some contestants in a more subtle manner, perhaps by feeding them questions on subjects they are known to be strong on or giving them weaker opponents.

Our paper also relates to research on the home advantage in sports, such as Sutter and Kocher (2004), Garicano et al. (2005), Pettersson-Lidbom and Priks (2007), and Dohmen (2008). Our paper expands upon these studies in a number of ways. First, these previous studies all use soccer data. It is important to confirm the home bias in another sport, since the home bias may be especially strong in soccer as fans at soccer games are in general louder, more active and more violent, sometimes even towards referees, than fans of other sports. Second, these papers all focus on the home bias, while we analyze other biases. Some of the existing findings do indicate bias towards keeping games close; e.g., Dohmen (2008) shows the home bias is stronger when the home team is losing and the score is close, but these previous studies do not explicitly addresses this issue. Third, the literature focuses on social pressure as the explanation for the bias. We expand upon this interpretation and discuss another explanation for this bias: information-based persuasion.[4] Nevill et al. (2002) indicates social pressure cannot fully account for referee bias, as the authors conduct experiments showing that soccer referees watching game footage on videotape are influenced by crowd reactions in isolated, laboratory settings. This implies referees actually draw inferences about what the correct calls are from the crowd reactions–that is, referees are persuaded by, or learn from, the crowd. This phenomenon may partly explain the other biases we analyze.

Finally, our paper relates to other research on sports officiating bias. For example, Price and Wolfers (2007), Parsons et al. (2007), and Larsen et al. (2008) all find evidence of racial bias on the part of sports officials. Rodenberg and Winston (2009) investigate whether NBA referees favor particular teams, and find little supporting evidence. Anderson and Pierce (2009) and Zimmer and Kuethe (2009) also both study biases of basketball referees. The former find evidence that college basketball referees call more fouls against the visiting team and teams losing during games, and the latter find evidence that NBA referees have biases that extend playoff series and favor teams from larger television markets in the playoffs. The key difference between their

[4] See DellaVigna and Gentzkow (2009) for a survey of the empirical literature on persuasion.

papers and ours is our use of the discretionary/non-discretionary turnover distinction for identification of referee bias separate from player behavior.

2 Hypotheses

The NBA's revenues in the 2006-07 season were \$3.6 billion, \$1.2 billion of which were from ticket sales and \$1 billion from national television sales (Badenhausen et al. (2007)). One obstacle to continued revenue growth for the league is that the integrity of the officiating seems to frequently be under fire. The widespread criticism of refereeing caused the league itself to commission the "Pedowitz Report" in 2008 – a comprehensive review of the officiating program, with a focus on the influence of gamblers and bookies. The report states, "NBA management sends a clear and consistent message to referees that they are to make accurate and consistent calls and favor no team or player. We have found no evidence that the League has ever deviated from this message." The report also documents the league's extensive system for monitoring the performance of its officials. The study states that since the 2003-04 season the league has employed 30 "observers," one for each team, who attend every home game of their assigned team. From the report: "After each game, the observer reviews the game on video, rates every call, enters correct and incorrect non-calls, and includes some qualitative assessments of performance."

The report, however, does not discuss empirical analysis of referee biases that potentially enhance league profits. This section discusses hypotheses regarding three such biases.[5] While none of these biases are explicitly illegal, they undermine the credibility of an industry that is based on a well-defined set of rules that ensure fair treatment of all teams.

Hypothesis 1: Referees favor home teams (*home bias*).

The first hypothesis follows a line of research on the source of the home team advantage in sports. The conventional wisdom bought into by most fans and commentators

[5]There are numerous other biases that NBA referees are alleged to have, perhaps the most well known of which is favoritism of "superstar" players. This favoritism could also be consistent with profit-maximization, as the league may benefit from having a small set of players thought by fans to be significantly better than others. We do not examine this hypothesis in this paper, as we limit our scope to team-related biases.

is that this advantage is due to teams simply playing better at home; they are motivated by the crowd's support, more comfortable playing in a familiar environment, and more rested while not traveling. This theory has been supported by research from other disciplines, for example, Neave and Wolfson (2003) found higher levels of testosterone in athletes while playing at home versus away, and suggest the desire to defend one's "territory" as an explanation.

However, as discussed earlier, recent research indicates the home advantage is, at least partly, due to referee bias. Favoring the home team may increase profits in at least two ways. First, if the home team is more likely to win then attending games becomes more enjoyable for most fans, thereby increasing their willingness to pay for tickets. Second, if fans care about their home teams' game outcomes, and think their attendance positively affects the team's probability of winning, then a bias that reinforces this belief may also increase fans' willingness to pay.

Hypothesis 2: Referees favor teams losing during games to keep games close (*close bias*).

Hypothesis 2 is motivated by the idea that close games are more entertaining to watch, both in person and on television. Thus, a bias that keeps games artificially close would increase demand for television viewership, and possibly game tickets as well. The Pedowitz Report discusses allegations of this bias, but again, does not test for it empirically.[6]

Hypothesis 3: Referees favor teams down in playoff series in order to extend the series (*playoff bias*).

The third hypothesis, referees favor teams in order to extend playoff series, concerns the type of bias with the most direct impact on the NBA's bottom line. Playoff series are best-of-seven; i.e., the first team to win four games wins the series. Thus, if the team leading in the series has won three games, the series only continues if the trailing team wins the subsequent game. Consequently, the league benefits through ticket sales and television revenues from longer playoff series.[7] In fact, games "produced" by extending

[6]From Pedowitz (2008) (p.62), "A few ex-referees, including those who have held or hold supervisory positions with the NBA describe Bavetta's [a current NBA referee] calls as reflecting an effort to keep games close or to ingratiate himself with a team."

[7]We were unable to determine whether league television revenues are directly tied to the number of playoff games.

series would be particularly lucrative, since both ticket and television viewer demand is higher for games that occur late in playoff series.[8] The Pedowitz Report also discusses allegations of this bias, but mainly how it may have affected just a few particular games.

3 Data and Empirical Strategy

3.1 Data

We use play-by-play data obtained from ESPN.com for all NBA regular season and playoff games from the 2002-03 through 2007-08 seasons. The play-by-play data provide more detailed description of game events than game-level box-score data, allowing us to disaggregate turnovers, which is the key to our empirical strategy.[9] The play-by-play data also include the exact time at which each game event occurred, allowing us to analyze the effects of score changes within games. The downside to using play-by-play data is that they are not official league statistics, and may have more measurement error than box score data (we drop observations in which less than five or greater than 40 points were scored by one team in a quarter due to likely error). This is not too concerning, however, as the play-by-play data aggregated to the game-level are very similar to the official box score data, and the error should not bias our results towards referee favoritism regardless.

The primary challenge to our analysis is that nearly all basketball statistics are simultaneously affected by both referee and player behavior. Furthermore, it is likely that player behavior does change in the situations in which we are testing for referee bias. For example, players may play more confidently at home, or with more effort when their team is losing during a game. We address this problem by exploiting the detail in the play-by-play data to classify turnovers into two categories: "discretionary" and "non-discretionary." Traveling violations, offensive fouls, three second violations,

However, even if they are not, there is a strong indirect relationship, as the value of televising the playoffs depends on the expected number of games.

[8]It is worth noting that the league changed the format of the first round of the playoffs from best-of-five to best-of-seven starting in the 2003 playoffs. This change was ostensibly made to prevent flukish, or undeserved, upsets, but had the side effect of increasing the total number of playoff games. The change has affected a small percentage of series outcomes; since then, 45 of the 48 teams to first win three games in first round series have proceeded to win a fourth game.

[9]Pertinent basketball terms related to turnovers are defined in Table 1.

and offensive goal tending are classified as discretionary. These are all turnovers that are called by a referee blowing his or her whistle while the ball is in play, and hence would not have occurred without referee action. Both traveling violations and offensive fouls, which comprise the vast majority of the discretionary turnovers, are notoriously subjective and inconsistently called in the NBA, which also suggests they are statistics relatively susceptible to bias.[10] Three seconds and offensive goal-tending violations are also categorized as discretionary, as they are called by a referee whistle with the ball in play, but occur infrequently and bear little weight on the results.

Bad passes, lost balls, and shot clock violations are the turnover types classified as non-discretionary. These turnovers are determined either directly by player behavior, such as when a defensive player "steals" the ball from the offense, or when referees are forced to make a call either because the ball has gone out of bounds or the shot clock has expired; in either case refs have little discretion in making the call. Thus, there is a clear distinction between the two types of turnovers: discretionary turnovers are called by referees when the ball is in play and non-discretionary turnovers are not. We describe formally how this distinction is used to test for bias in the following subsection.[11]

In addition to the turnover analysis, we also examine fouls, which are the more frequently used measure of referee behavior. Unlike turnovers, it is more difficult to classify foul types by the degree of discretion referees have to judge them. Fouls are still split into two categories for the analysis, shooting and non-shooting, since this is also a natural distinction; however, it is not clear, *a priori*, which type is affected more by player or referee behavior.

Table 1 presents summary statistics for the turnover and foul types, aggregated to the team-game-quarter level, used in the subsequent empirical work. The table also reports tests of unconditional home-away and winning-losing, at start of quarter, differences in

[10] After the 2008-2009 season, Joe Borgia, the NBA's vice president of referee operations, claimed "the current [turnover] rule is so confusing that it's impossible to tell if it allows one step or two," (sports.espn.go.com/nba/news/story?id=3951002) and league management did in fact clarify the rule prior to the 2009-2010 season, which is outside of our sample. The offensive foul is prone to manipulation due to players "flopping" (pretending to fall down due to contact from offensive players), and there were reports that league management said that it would begin punishing floppers in May of 2008 after receiving pressure from fans and analysts (stoptheflop.net/) but the policy was not actually implemented (nba.fanhouse.com/2008/12/29/so-much-for-the-nbas-flop-crackdown/).

[11] The names of the types of turnovers ("bad passes", "lost balls", etc.) are those used in the ESPN.com play-by-play data. One type of turnover, double dribble violations, are dropped from the analysis. Although, according to the definition above, they are discretionary, they are arguably less subjective than the other discretionary turnover types. However, these violations occur infrequently, and results are robust to including them in either turnover group.

the various statistics. The table provides a preview of the econometric results, as both home and losing teams have significant advantages in most discretionary turnover and foul statistics, but not in non-discretionary turnovers.[12]

3.2 Formal Model

The following is a formal presentation of our identification strategy. We show how referee bias can be cleanly detected using the discretionary/non-discretionary turnover distinction with a few weak assumptions. For some fixed unit of game-time such as a quarter, let T_D be discretionary turnovers, T_N be non-discretionary turnovers, X_R be a measure of referee favoritism (referee favoritism is increasing in X_R), and X_P be a measure of player behavior (an increase in X_P corresponds to a change in player behavior that causes turnovers to decrease). Let Z be a variable that takes higher values in situations in which favorable bias is hypothesized to occur; for example, Z could be a dummy equal to one when the team is at home, losing during the game, or trailing in the playoff series. As both X_R and X_P may be affected by Z, assume:

$$X_R = \gamma_0^R + \gamma_1^R Z + \epsilon_1 \tag{1}$$

$$X_P = \gamma_0^P + \gamma_1^P Z + \epsilon_2. \tag{2}$$

Z is assumed to be independent of ϵ_1 and ϵ_2. The hypothesis of interest is that $\gamma_1^R > 0$; the causal effect of Z on referee bias is positive.

The problem is that neither X_R nor X_P are observable and, consequently, equation (1) cannot be directly estimated. Therefore, to test the hypothesis, additional assumptions are required. Suppose T_D and T_N are affected by both referee and player behavior as follows:

$$lnT_D = \beta_0^D + \beta_1^D X_R + \beta_2^D X_P + u_1 \tag{3}$$

[12] Offensive fouls are indeed turnovers, despite their name, both by definition and in practice. By definition, offensive fouls cause offensive teams to turn the ball over to the defensive team without taking a shot, and offensive fouls are officially recorded as turnovers and not recorded as personal fouls. In practice, the style of play which makes other turnovers more likely (aggressive, risky play on offense) also makes offensive fouls more likely. Regardless, the estimated biases are actually stronger when offensive fouls are dropped from the analysis.

$$lnT_N = \beta_0^N + \beta_1^N X_R + \beta_2^N X_P + u_2. \tag{4}$$

In both equations, the X's are assumed to be independent of the u's. Equations (3) and (4) are specified as log-linear so that the coefficients can be interpreted as percentage effects. To identify referee bias, two additional assumptions are made.

Assumption 3.1. $\beta_1^D < \beta_1^N \leq 0$.

Assumption 3.2. $\beta_2^N \leq \beta_2^D \leq 0$.

These assumptions seem highly plausible. Assumption 3.1 implies that, on average, referee behavior has a greater percentage effect on the turnovers directly called by referees (discretionary turnovers) than those not called by referees (non-discretionary). Assumption 3.2 states that when player behavior changes in a way affecting turnovers in general, the discretionary turnover percentage change is not greater (in magnitude) than the non-discretionary change.

Then, by substituting (1) and (2) into (3) and (4) we obtain:

$$lnT_D = \tilde{\beta}_0^D + (\beta_1^D \gamma_1^R + \beta_2^D \gamma_1^P) Z + \tilde{u}_1 \tag{5}$$

$$lnT_N = \tilde{\beta}_0^N + (\beta_1^N \gamma_1^R + \beta_2^N \gamma_1^P) Z + \tilde{u}_2. \tag{6}$$

Here, $\tilde{\beta}_0^D = \beta_0^D + \beta_1^D \gamma_0^R + \beta_2^P \gamma_0^N$ and $\tilde{u}_1 = \beta_1^D \epsilon_1 + \beta_2^D \epsilon_2 + u_1$ and $\tilde{\beta}_0^N$, and $\tilde{u}_2$ are defined analogously. Equations (5) and (6) can be estimated directly, as Z, T_D and T_N are observable and the single RHS variable in each equation is independent of the error term.

To test for the presence of referee bias, we first test whether Z is associated with an advantage in discretionary turnovers. That is, we test whether the coefficient on Z in (5) is negative:

$$\begin{aligned} \beta_1^D \gamma_1^R + \beta_2^D \gamma_1^P &< 0 \leftrightarrow \\ \gamma_1^R &> -\frac{\beta_2^D}{\beta_1^D} \gamma_1^P. \end{aligned} \tag{7}$$

Evidence of this inequality holding would be evidence of referee bias if $\gamma_1^P \leq 0$. This is because $\frac{\beta_2^D}{\beta_1^D} \geq 0$ by Assumptions 3.1 and 3.2, so if $\gamma_1^P \leq 0$, then $\gamma_1^R > -\frac{\beta_2^D}{\beta_1^D}\gamma_1^P$ implies $\gamma_1^R > 0$, which is equivalent to the existence of referee bias.

This test will not be sufficient, however, if $\gamma_1^P > 0$. To account for this case, the coefficients on Z from equations (5) and (6) can be employed to test the following:

$$\begin{aligned} \beta_1^D\gamma_1^R + \beta_2^D\gamma_1^P &< \beta_1^N\gamma_1^R + \beta_2^N\gamma_1^P \leftrightarrow \\ \frac{\beta_2^D - \beta_2^N}{\beta_1^N - \beta_1^D}\gamma_1^P &< \gamma_1^R. \end{aligned} \tag{8}$$

By Assumptions 3.1 and 3.2 $\frac{\beta_2^D-\beta_2^N}{\beta_1^N-\beta_1^D} \geq 0$, therefore, if $\gamma_1^P > 0$ then $\frac{\beta_2^D-\beta_2^N}{\beta_1^N-\beta_1^D}\gamma_1^P < \gamma_1^R$ implies $\gamma_1^R > 0$. Thus, for all γ_1^P, testing (7) and (8) is sufficient for testing $\gamma_1^R > 0$ and, thereby, identifying the existence of referee bias.

Practically speaking, to perform the hypothesis tests, equations (5) and (6) must first be separately estimated. Then, the coefficient on Z from (5), $\beta_1^D\gamma_1^R + \beta_2^D\gamma_1^P$, must be significantly greater than zero *and* greater than the coefficient on Z from (6), $\beta_1^N\gamma_1^R + \beta_2^N\gamma_1^P$. It important to note that this test does not require that player behavior affects both types of turnovers in the same way (i.e. it is not assumed that $\beta_2^D = \beta_2^N$). However, in order to isolate the magnitude of the bias, $\beta_1^D\gamma_1^R$, additional assumptions are required. By assuming $\beta_2^D = \beta_2^N$ and $\beta_1^N = 0$, we can difference the estimates of $\beta_1^D\gamma_1^R + \beta_2^D\gamma_1^P$ and $\beta_1^N\gamma_1^R + \beta_2^N\gamma_1^P$ to obtain $\beta_1^D\gamma_1^R$. Yet, these assumptions are fairly strong and, therefore, we only refer to conservative approximations of estimates that rely upon them.

4 Analysis

The analysis is based almost entirely on quarter-level data-sets. These allow us to control for within-game dynamics in a simple, transparent way. Using quarter rather than game-level data is necessary to avoid the hypothesized biases possibly interacting with each other, which would confound the estimation results. For example, if referees indeed favor both home teams and teams losing during games, failing to control for within-game scores could cause the varying biases to nullify each other. In this case, home teams would be favored at the beginning of games when neither team is losing, then home teams would be disfavored after taking the lead; therefore, in game-level data home bias would be under-estimated. The downside of using quarter-level data is that within-quarter dynamics are not as tightly controlled for. Consequently, as score margins can change substantially within quarters, the magnitude of the close bias may be underestimated.

The analysis of each hypothesis is performed using four unique dependent variables: shooting fouls, non-shooting fouls, discretionary turnovers, and non-discretionary turnovers. As they are all count variable–each only takes non-negative integer values–Poisson regression is the most appropriate estimation technique. The Poisson model is estimated via maximum likelihood, under the assumption that the dependent variable takes a Poisson distribution with log-mean equal to a linear function of the regressors.[13] Log-linearity allows for estimates to be interpreted as percentage changes. However, a disadvantage of using this model is that we are unable to obtain estimates of covariances of the coefficients across equations. For this reason, results of across-equation tests are not reported. However, we are often able to show coefficients are significantly different across equations for all feasible covariances (those with absolute value less than the product of the standard errors). In the following subsections, unless otherwise specified, any discussion of across-equation differences refers to significance levels for all feasible covariances.

For each dependent variable two specifications are examined; one with controls for the team's performance in the quarter, and the other without any performance controls. The controls are dummy variables representing score margin categories for the quarter ("Score Margin Dummies").[14] The benefit of including these variables is they directly control for changes in player behavior. The cost is that they are determined simultaneously with the dependent variables and, in fact, are caused in part by the

[13]The Poisson distribution assumption for a variable requires that its mean and variance are equal; Table 1 shows that this is not problematic for our data. Results are very similar when we use other model specifications.

[14]The categories are: lose quarter by more than five points, lose by one to five points, win by zero to five points. Winning by more than five points is the omitted category.

dependent variables. This misspecification is likely not problematic, as the coefficients on the score margin dummies are not of interest; if anything, since score margins are also affected by referee behavior, including these variables weakens the estimates of referee bias. Finally, quarter fixed effects and "match-up" (team-opponent-season) fixed effects are included in all models. Thus, our estimated effects are solely a result of the variation in a team's performance from their mean performance against the same opponent, in the same season. Including these fixed effects allows us to tightly control for variation in team quality and the composition of game pairings.[15]

All analysis is conducted at the team-game-quarter level, using a sample with two observations for each quarter of each game (one for each team). The final three minutes of the fourth quarters are dropped, as game play often changes dramatically in those situations. For example, losing teams sometimes intentionally commit more fouls in those minutes for strategic reasons. Standard errors are clustered by game to account for the repetition of game-quarters in the sample.

4.1 Home Bias

Table 2 provides the results from the Poisson regressions for the full sample. The home team has approximately 8% to 11% fewer discretionary turnovers on average, but only a 2% to -2% advantage in non-discretionary turnovers. The discretionary turnover coefficients are significantly greater than both zero and the non-discretionary turnover coefficients at the 1% level whether or not within-quarter performance is controlled for, which, according to the argument detailed in Section 3.2, implies the existence of referee bias. The home team also has a 5%-6% advantage in shooting fouls and a 1% advantage in non-shooting fouls, significantly different from zero at the 1% and 5% levels, respectively.

The home advantage in discretionary turnovers also increases by more than 1% for every 1,000 fans in attendance, which is significantly different from zero and the non-discretionary estimate at the 5% level. The estimated attendance effects are much smaller for all of the other dependent variables, but also significantly different from

[15] Results are similar when we simply use team-season/opponent-season fixed effects.

zero at 5% for non-shooting fouls. The match-up fixed effects specification controls for the possibility that player behavior and game attendance are both correlated with the quality and type of game opponent. Consequently, the significant attendance result is not simply caused by teams playing differently against, say, better opponents, which also attract larger crowds.

Additionally, in results not reported, we find the home bias is not affected by whether the game is televised or occurs in the playoffs, though bias is estimated to increase by 4% for discretionary turnovers in the playoffs. The home bias is also unaffected by whether the game took place in the 2005-06 season or later; however, home teams do enjoy a greater in advantage in non-shooting fouls in later seasons. These findings suggest that the home bias has not been reduced over the last several years, despite the NBA's implementation of more intense referee monitoring.[16]

4.2 Close Bias

Estimation results reported in Table 2 also support the close bias hypothesis, as teams trailing at the start of a quarter are systematically favored throughout the subsequent period. Using a set of dummy variables that account for start of quarter score difference,[17] we find that as the score margin grows the losing team receives increasingly favorable treatment, in terms of discretionary turnovers, from the referees. When a team trails by more than 10 points at the start of a quarter it has 10% fewer discretionary turnovers in the subsequent quarter, relative to teams who start a quarter trailing or winning by no more than three points; however, teams losing by a wide margin actually commit more non-discretionary than teams winning or losing by a slim margin. The estimates for the two types of turnovers are different at the 1% level, so there is strong evidence of bias in favor of teams down by large margins. Furthermore, teams down by moderate margins appear to be favored, as teams losing by 4-10 points

[16]We also tested for whether the home bias is stronger in the fourth quarter, and found that it was not. Since the crowd is generally strongest in those situations, this result is, at face-value, surprising. It can be explained, however, by the referee convention of making fewer calls at the end of games, so as to "let the players decide the games." This convention may exist partly because those calls are more highly scrutinized.

[17]The categories are "home team down more than 10 points", "home team down by 10 to 4 points", "home team winning by 4 to 10 points", and "home team winning by more than 10 points." Dummy variables are used in place of a linear measure of start quarter score difference to allow for the possibility that score difference has a non-linear effect on referee bias. Results are similar when we use a simple linear score difference variable.

have over 5% fewer discretionary turnovers than baseline teams, which is significantly different from zero at the 1% level, and significantly different from the non-discretionary turnover estimate at the 5% level. Results are robust to whether or not controls are included for within-quarter performance. The differences between estimates of discretionary and non-discretionary turnover effects for teams up by 4-10 points and greater than 10 points are small. Losing teams commit 2-4% fewer shooting fouls, and winning teams commit more shooting and non-shooting fouls than teams in close games, but again, it is less clear how to interpret these estimates with respect to bias. We do not find any differences in the close bias based on whether the game is nationally televised or a playoff game, nor do we find that this bias has decreased over time.

4.3 Playoff Bias

Our third hypothesis is that the league attempts to extend multi-game playoff series by favoring the team that is close to elimination.[18] Although this theory is especially well known and easy to link to direct revenue increases, investigating it is relatively difficult due to the limited number of playoff series in the data sample. We start by looking at mean game-level turnover differences, categorized by playoff series score, which are graphed in Figure 1. The data are grouped by the win-loss record of the home team for the series coming into the game, and ordered by the approximate degree to which the home team winning would affect the length of the series.[19] Points on the left part of the figure represent games in which home team wins are more likely to extend the series, and points on the right represent games in which away team wins are more likely to extend the series. The sample sizes are especially small for games in which the home team is up 2-0 and 3-0 (four and two, respectively), as the visiting team rarely wins the first two games of a series.[20]

[18] We have also tested for another alleged playoff bias: that the league favors large market teams in all playoffs games, not just those that would extend the series, to increase television ratings of the later playoff rounds. We find no evidence that large market teams have an advantage in discretionary turnovers and, therefore, do not report results.

[19] There are 16 playoff teams and four playoff rounds. Each round consists of paired match-ups between the teams, each of which consists of a best-of-seven series. Thus, there are 16 possible series scores (home wins-away wins) at the start of each playoff game.

[20] The team with the better regular season record is the home team for the first two games of each playoff series. Thus, in cases when the home team is leading 2-0 or 3-0, the team with the worse regular season record has won the first two games of the series despite being on the road, which happens very rarely.

The figure indicates two patterns. First, most of the points for discretionary fouls lie below zero (the horizontal axis), which is consistent with the home bias discussed earlier. Second, the home team's advantage is larger in games in which the home team winning would be more likely to extend the series. Both of these patterns are weaker for non-discretionary turnovers. As a rough statistical check, two linear predictions are fitted to the data, one for each type of turnover. The discretionary turnover line is positively sloped and steeper than that of non-discretionary turnovers, which supports the playoff bias hypothesis.

To formally test the hypothesis, we use Poisson regression models similar to those described above, with two main differences. First, the sample is restricted to only include playoff games, and second, two new binary variables, "Bias For" and "Bias Against" are added to the models. Bias For is equal to one when the team is down in the series by at least two games or facing elimination (down 0-2, 0-3, 1-3 or 2-3) at the start of the game, as these are situations in which teams are most likely to be favored. Bias Against is defined analogously. The series score 0-2 is included in Bias For situations because a win by the trailing team in this situation is likely to extend the series length; a loss by the trailing team would render the series effectively over, as no team has ever won a series after falling behind 0-3.

When we estimate a Poisson regression of discretionary turnovers on just the Bias For and Bias Against variables, we obtain coefficients of -0.065 and 0.097, respectively, indicating teams facing elimination in the series or down 0-2 receive a 16.2% discretionary turnover advantage, significant at the 1% level. When the same regression is estimated using non-discretionary turnovers as the dependent variable, the coefficients are equal to -0.007 and -0.018 and are not significantly different. These results confirm the patterns displayed in Figure 1; discretionary turnovers are called less frequently for teams whose wins likely lengthen the series, while non-discretionary turnovers appear independent of series status. The estimates do not, however, account for confounding variables, such as home status, attendance, team quality, etc. Simply controlling for home game reduces the discretionary turnover advantage to 11.0%.

Table 3 presents estimation results from models that incorporate the full set of control variables, including match-up controls.[21] While the bias variable coefficient estimates are generally not significant, teams down 0-2, 0-3, 1-3 or 2-3 do have an 11.7% advantage over their opponents in discretionary turnovers (which is significant at the 5% level) in the specification controlling for current quarter performance.[22] The advantage is not significant, however, for any other statistical category – including non-discretionary turnovers. The advantage is 2.9% for shooting fouls, but is -1.6% for non-shooting fouls. Due to the relatively small sample and large standard errors, the discretionary turnover estimates are not significantly different from those for non-discretionary turnovers for all feasible covariances. Still, the results provide strong suggestive evidence that teams are favored in ways consistent with our hypothesis.

Since the playoff bias has greater (potential) direct effects on revenues than the other biases, we also examine whether the bias changes in more pivotal game situations. To do this we construct a new, minute-level data set, and define a dummy variable equal to one in minutes that occur in the fourth quarter with a score margin at the start of the minute of five or fewer points. This definition of the dummy variable is admittedly *ad hoc*, but the results are robust to defining it in different ways. The dummy variable is interacted with the Bias For and Bias Against variables, and the estimation results are reported in Table 5. The interaction terms are largely insignificant, and the signs for the discretionary turnover estimates are not consistent with explicit bias. The results imply the discretionary turnover playoff bias disappears in these critical game minutes, perhaps as a consequence of improved referee performance in more important game situations. It is also of note that the non-interacted newly constructed dummy variable estimate is substantial and significant only for non-discretionary turnovers, indicating that this is the only one of the four dependent variables highly affected by changes in style of play in more consequential game situations. Finally, we test whether the bias is larger in series between large television market teams, and if the bias has changed over time. In general, these results are neither statistically nor economically significant.[23]

[21] The match-up controls are quarter-level means from the regular season games between the two teams. For simplicity and due to Table 2 indicating only minor non-linear effects, a linear term is used to control for start of quarter score difference.

[22] The 11.7% advantage is calculated by subtracting the Bias Against estimate, .068, from the Bias For estimate, -.049. In the other specification, the estimated advantage has a (two-sided) p-value of 0.1057.

[23] To examine the connection between television market size and playoff bias, we test whether the advantage of teams

5 Discussion

We have presented strong evidence that home teams, teams losing during games, and teams losing in playoff series, have a relatively large advantage in discretionary turnovers, and almost no advantage in non-discretionary turnovers. We consider this indicative of referee bias, since the first type of turnover is determined directly by referee actions, and the second directly by player actions. While we cannot completely rule out the possibility that both turnover types are caused entirely by player actions (and referees are on average completely neutral), we think it is extremely unlikely that this is the case, especially since the pattern is so consistent for the three different types of game situations.

We have not yet addressed possible causes of the biases. Our prior is that they are caused by psychosocial factors and cognitive error. Home bias may be caused by social pressure from fans at the arena (as discussed by previous literature) or information transmission, or persuasion, from fans. Close bias could be caused by referees favoring trailing teams out of sympathy for the losing players and coach, to make up for previous calls that favored the winning team, or because losing teams plead for favorable calls relatively often (persuasion). The playoff bias could be due to referees unconsciously favoring the losing team to support the "underdog," or teams losing in playoff series pleading for calls more strongly than the teams up in the series. It is also plausible that the home crowd is stronger in playoff games in which the home team is near elimination. Alternatively, the biases may be done intentionally to promote league revenue.

Our auxiliary empirical results appear to mainly support our prior. The estimated positive effect of attendance on home bias is consistent with the bias being caused by social pressure and/or persuasion from the crowd. The insignificant effects of national television and playoff status of games on the home and close biases indicate unconscious bias, since these variables are likely independent of psychological factors but correlated with the revenue effects of bias.[24] The findings that the playoff bias does not increase

hypothesized to be favored increases as the total Nielsen television market size of the two teams increases. We do not report these results in the interest of brevity, but they are available upon request.

[24]For example, if the magnitude of the close bias increased during nationally televised games, in which the returns to close games are higher, it would indicate the bias is an intentional means to increase profits, since television status should have less effect on the psychological factors that could cause close bias.

in critical minutes of games or in series between large television market teams are also consistent with bias not being an intentional means of increasing profits.

Another question we address is, given that the playoff bias is not done intentionally to increase profits, is it caused mainly by increased home bias (since the home crowd is likely more active in playoff games in which the home team is near elimination). We analyze this issue by recoding the Bias For (Bias Against) variables discussed in Section 4.3 to equal one for home (away) teams in games in which the series score is 3-3. The home crowd should be strongest in those double-elimination games. We find both the magnitude and significance of the playoff bias decrease, and interpret this to mean the increased home bias is not the entire source of the playoff bias.

It is also worth noting that the estimated effects of variables representing possible bias on discretionary turnovers are generally substantially larger than the estimated effects on both types of fouls. We do not draw formal conclusions from these results due to the identification problem for fouls, but speculate it is unlikely that player behavior systematically affects discretionary turnovers more than fouls. Thus, even if the foul effects were caused by bias, the bias affecting discretionary turnovers would seem to be more severe. It is unclear how to interpret these results with respect to the league's profit motive, however. It is possible the league allows greater bias for discretionary turnovers since they are not reported in box scores and, thus, less observable to fans and analysts. On the other hand, it is possible discretionary turnovers are more difficult to judge and inherently more subjective than fouls, and consequently it is more costly for the league to eliminate bias affecting discretionary turnovers.

We conclude by discussing bias mitigation. We assume it is in the interests of both league management and fans to reduce the biases, since their suspicious nature may cause fan enjoyment of the sport to decrease, independent of the biases' source. The biases may be reduced by league management more carefully monitoring referee behavior, especially regarding discretionary turnovers, in the situations the analysis was focused on. We should note it is possible to excessively monitor the referees, and the NBA should be careful not to become overzealous in its supervision officials. This could create a host of new problems, as, for example, referees might feel compelled to make calls in one game to make up for perceived disparities in previous games. Hopefully, simply calling attention to and raising awareness of the biases will help to alleviate them. We also think the league's clarifying the traveling rule in 2009 may be beneficial. Similarly, clarifying rules regarding offensive fouls (increasing the penalties for flopping) could help in the future. Finally, it might be helpful to report traveling and offensive foul violations separately from other turnovers in box scores and for the league to make public its internal reports on officiating. In general, being sure rules are defined clearly and appropriately, and making data on rule compliance public may be the ideal (i.e., lowest cost) way for both the NBA and organizations in general to improve compliance and reduce suspicion about lack of compliance.

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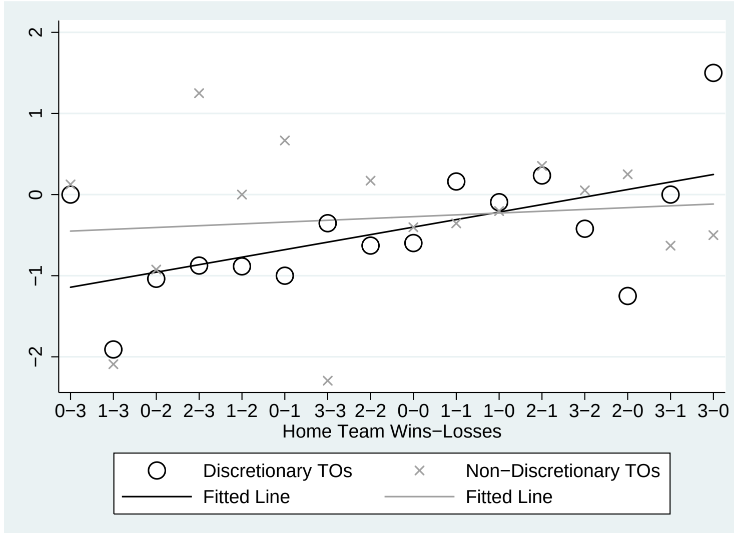

Figure 1: Mean Game-Level Turnover Differences (Home Minus Away) by Playoff Series Score (Home Wins-Losses)

Table 1: Definitions of Turnover-Related Basketball Terms

Term	Definition
Turnover	The offensive team loses possession of the ball without making a shot attempt.
Travel*	Progressing in any direction while in possession of the ball [without dribbling], which is in excess of prescribed limits as noted in Rule 10-Section XIV.
Three seconds	An offensive player remains in the painted lane in front of the basket for more than three consecutive seconds.
Offensive Goal-Tend	A player interferes with the ball when it is on a downward trajectory or is in an extended cylinder-shaped region above the rim.
Offensive foul*	Illegal contact committed by the offensive player.
Shot clock	The offensive team fails to take a shot that hits the rim within 24 seconds of possession.

Notes: Definitions for terms with * from: http://www.basketball.com/nba/rules/rule4.shtml#IV (definitions for other terms unavailable).

Table 2: Quarter-Level Summary Statistics

	Home Mean (SD)	Away Mean (SD)	Difference	Winning Mean (SD)	Losing/Tied Mean (SD)	Difference
Discretionary Turnovers						
Travel	0.227 (0.486)	0.272 (0.530)	-0.0444 ***	0.254 (0.514)	0.247 (0.506)	0.0070
Three seconds	0.082 (0.288)	0.074 (0.274)	-0.0080 ***	0.091 (0.301)	0.071 (0.269)	0.0196 ***
Offensive foul	0.469 (0.693)	0.508 (0.727)	-0.0382 ***	0.525 (0.734)	0.468 (0.696)	0.0574 ***
Offensive goal-tend	0.012 (0.111)	0.013 (0.115)	-0.0009	0.012 (0.111)	0.013 (0.114)	-0.0010
Non-Discretionary Turnovers						
Bad pass	1.445 (1.225)	1.419 (1.230)	-0.0264 **	1.425 (1.232)	1.436 (1.225)	-0.0108
Lost ball	0.679 (0.847)	0.715 (0.873)	-0.0358 ***	0.698 (0.856)	0.697 (0.862)	0.0019
Shot clock	0.058 (0.246)	0.064 (0.260)	-0.0060 ***	0.069 (0.270)	0.056 (0.243)	0.0123 ***
Non-Shooting Fouls						
Personal	1.751 (1.309)	1.750 (1.312)	-0.0006	1.850 (1.352)	1.695 (1.283)	0.1552 ***
Loose ball	0.309 (0.558)	0.318 (0.567)	-0.0097 **	0.340 (0.582)	0.299 (0.551)	0.0418 ***
Inbounds	0.002 (0.050)	0.003 (0.054)	-0.0004	0.003 (0.056)	0.002 (0.050)	0.0005
Clearing	0.006 (0.077)	0.007 (0.086)	-0.0013 *	0.008 (0.089)	0.006 (0.077)	0.0019 **
Away from ball	0.005 (0.068)	0.004 (0.065)	-0.0002	0.005 (0.070)	0.004 (0.064)	0.0008
Shooting Fouls						
Non-flagrant	2.310 (1.427)	2.430 (1.476)	-0.1203 ***	2.521 (1.496)	2.285 (1.422)	0.2359 ***
Flagrant	0.010 (0.099)	0.012 (0.109)	-0.0020 **	0.010 (0.102)	0.011 (0.105)	-0.0003

Notes: Sample includes all regular season and playoff quarters from 2002-2003 - 2007-2008 seasons with play-by-play data available on ESPN.com; overtime periods, last three minutes from fourth quarters and quarters in which one team scored five or fewer or greater than 40 points dropped. “Winning” = winning by one or more points at start of quarter; “Losing/Tied” = losing or tied at quarter start. In total there are 28,338 quarters in the sample. *, **, *** denote 10%, 5% and 1% significance, respectively (for differences; two-tailed tests, unequal variances).

Table 3: Home and Close Bias Estimation Results

	Discretionary Turnovers		Shooting Fouls		Non-Shooting Fouls		Non-Discretionary Turnovers	
Home Game	-0.1119***	-0.0857***	-0.0666***	-0.0471***	-0.0099**	-0.0117**	-0.0187***	0.0159***
	(0.0082)	(0.0082)	(0.0045)	(0.0044)	(0.0050)	(0.0051)	(0.0053)	(0.0051)
Attendance × Home	-0.0130***	-0.0104***	-0.0006	0.0013	-0.0039**	-0.0040**	-0.0029	0.0005
	(0.0029)	(0.0029)	(0.0016)	(0.0016)	(0.0018)	(0.0018)	(0.0019)	(0.0018)
Quarter Start Score Diff < - 10	-0.1487***	-0.1296***	-0.0425***	-0.0281***	-0.0043	-0.0056	0.0117	0.0363***
	(0.0186)	(0.0186)	(0.0097)	(0.0097)	(0.0110)	(0.0110)	(0.0111)	(0.0109)
-10 $\leq$ Score Diff ≤ -4	-0.0633***	-0.0526***	-0.0258***	-0.0184**	0.0038	0.0030	-0.0103	0.0025
	(0.0156)	(0.0155)	(0.0084)	(0.0083)	(0.0091)	(0.0091)	(0.0095)	(0.0094)
4 $\leq$ Score Diff $\leq$ 10	0.0655***	0.0556***	0.0508***	0.0435***	0.0306***	0.0313** *	0.0442***	0.0314***
	(0.0152)	(0.0151)	(0.0082)	(0.0082)	(0.0090)	(0.0089)	(0.0095)	(0.0093)
10 < Score Diff	0.0928***	0.0749***	0.1100***	0.0958***	0.0359***	0.0371** *	0.1311***	0.1068***
	(0.0175)	(0.0174)	(0.0093)	(0.0092)	(0.0107)	(0.0107)	(0.0109)	(0.0108)
Score Margin Dummies		✓		✓		✓		✓

Notes: N = 56,776. Poisson models with match-up (team-opponent-season) fixed effects, quarter fixed effects, and de-meaned attendance (in thousands) included in all specifications. "Score Diff" = start of quarter own score minus opponent score (dummy variables for difference being less than -10, greater than -11 and less than -3, etc.). "Score Margin Dummies" are dummy variables equal to one if lose quarter by more than five points, lose by one to five points, win by zero to five points (winning by more than five points is omitted category). Robust standard errors clustered by game. *, **, *** denote 10%, 5% and 1% significance.

Table 4: Playoff Bias Estimation Results

	Discretionary Turnovers		Shooting Fouls		Non-Shooting Fouls		Non-Discretionary Turnovers	
Bias For	-0.039	-0.049	-0.034	-0.041	0.050*	0.051*	-0.012	-0.027
	(0.053)	(0.054)	(0.027)	(0.027)	(0.029)	(0.029)	(0.034)	(0.033)
Bias Against	0.057	0.068	-0.020	-0.012	0.036	0.035	-0.032	-0.016
	(0.045)	(0.045)	(0.028)	(0.028)	(0.031)	(0.031)	(0.034)	(0.032)
Home Game	-0.028	0.011	-0.107***	-0.085***	0.004	0.002	-0.037	0.013
	(0.057)	(0.058)	(0.028)	(0.029)	(0.029)	(0.029)	(0.038)	(0.035)
Attendance × Home	-0.072***	-0.066***	0.005	0.010	-0.021**	-0.022**	-0.009	0.001
	(0.022)	(0.022)	(0.011)	(0.011)	(0.011)	(0.011)	(0.015)	(0.014)
Quarter Start Score Diff	0.007***	0.005**	0.006***	0.005***	0.001	0.001	0.005***	0.002
(Own - Opponent Score)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Score Margin Dummies		✓		✓		✓		✓
p-value for H_0:								
Bias For = Bias Away	0.1057	0.0474	0.6562	0.3688	0.6444	0.6124	0.6627	0.8028

Notes: N = 3,792 (playoff game team-quarters only). Bias For = 1 if team down in series 0-2, 0-3, 1-3, 2-3; 0 otherwise. Bias Against = 1 if team up in series 2-0, 3-0, 3-1, 3-2; 0 otherwise. Match-up (team-opponent-season) fixed effects (regular season means) and de-meaned attendance (in thousands) used in all models. "Score Margin Dummies" are dummy variables equal to one if lose quarter by more than five points, lose by one to five points, win by zero to five points (winning by more than five points is omitted category). Robust standard errors clustered by game. *, **, *** denote 10%, 5% and 1% significance.

Table 5: Playoffs Only, Minute-Level Sample

	Disc. TOs	Shoot. Fouls	Non-Shoot. Fouls	Non-Disc. TOs
Bias For	-0.051	-0.054*	0.048	-0.021
	(0.056)	(0.028)	(0.030)	(0.034)
Bias Against	0.074*	-0.019	0.033	-0.042
	(0.045)	(0.029)	(0.031)	(0.034)
Home Game	-0.126***	-0.056***	-0.031	-0.034
	(0.036)	(0.019)	(0.019)	(0.024)
Attendance × Home	-0.067***	0.008	-0.019*	-0.005
	(0.022)	(0.011)	(0.011)	(0.015)
Bias For × Critical	0.133	0.134	-0.026	0.131
	(0.179)	(0.101)	(0.102)	(0.119)
Bias Against × Critical	-0.286	0.002	-0.013	0.254*
	(0.185)	(0.107)	(0.100)	(0.134)
Home × Critical	-0.201	-0.101	-0.005	0.053
	(0.129)	(0.071)	(0.074)	(0.096)
Critical	0.055	0.082	0.115*	-0.271***
	(0.094)	(0.059)	(0.063)	(0.083)
p-value for H_0:				
Bias For = Bias Away	0.0403	0.2772	0.6533	0.6419
BF × Critical = BA × Critical	0.0617	0.2208	0.9059	0.4449
BF + (BF×Crit) = BA + (BA×Crit)	0.1784	0.3566	0.9848	0.5254

Notes: N = 44,532. Poisson models with match-up (team-opponent-season) fixed effects (regular season means), and de-meaned attendance included in all specifications. Bias For = 1 if team down in series 0-2, 0-3, 1-3, 2-3; 0 otherwise. Bias Against = 1 if team up in series 2-0, 3-0, 3-1, 3-2; 0 otherwise. Critical = 1 if minute occurs in 4th quarter and minute-start score margin less than 6. Robust standard errors clustered by game. *, **, *** denote 10%, 5% and 1% significance.

Referee Appendix (Not For Publication)

Table 6: Regular Season and Playoff, Quarter-Level Sample

	Discretionary Turnovers		Shooting Fouls		Non-Shooting Fouls		Non-Discretionary Turnovers	
Home Game	-0.1263***	-0.0958***	-0.0679***	-0.0450***	0.0055	0.0034	-0.0204**	0.0205***
	(0.0136)	(0.0135)	(0.0073)	(0.0071)	(0.0079)	(0.0079)	(0.0080)	(0.0077)
Attendance × Home	-0.0130***	-0.0104***	-0.0004	0.0016	-0.0031*	-0.0033*	-0.0027	0.0007
	(0.0030)	(0.0029)	(0.0016)	(0.0016)	(0.0019)	(0.0019)	(0.0019)	(0.0018)
Playoff × Home	-0.0475	-0.0364	-0.0310*	-0.0237	-0.0193	-0.0204	-0.0292	-0.0161
	(0.0381)	(0.0379)	(0.0188)	(0.0184)	(0.0194)	(0.0194)	(0.0254)	(0.0240)
Televised × Home	0.0259	0.0152	0.0249	0.0157	-0.0198	-0.0192	0.0059	-0.0103
	(0.0457)	(0.0457)	(0.0233)	(0.0231)	(0.0263)	(0.0263)	(0.0275)	(0.0258)
Post05 × Home	0.0212	0.0155	-0.0038	-0.0079	-0.0243**	-0.0239**	0.0020	-0.0054
	(0.0167)	(0.0164)	(0.0090)	(0.0088)	(0.0102)	(0.0102)	(0.0106)	(0.0101)
Fourth Quarter × Home	0.0143	0.0065	0.0131	0.0071	-0.0096	-0.0090	0.0077	-0.0033
	(0.0233)	(0.0232)	(0.0122)	(0.0120)	(0.0139)	(0.0139)	(0.0144)	(0.0139)
Quarter Start Score Diff	0.0068***	0.0056***	0.0043***	0.0035***	0.0019***	0.0020** *	0.0035***	0.0020***
(Own - Opponent Score)	(0.0009)	(0.0009)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0005)
Playoff × Score Diff	-0.0021	-0.0025	0.0015	0.0012	-0.0006	-0.0006	0.0011	0.0006
	(0.0022)	(0.0022)	(0.0011)	(0.0011)	(0.0012)	(0.0012)	(0.0014)	(0.0013)
Televised × Score Diff	-0.0046*	-0.0045*	0.0007	0.0008	0.0003	0.0003	0.0007	0.0008
	(0.0026)	(0.0026)	(0.0014)	(0.0014)	(0.0017)	(0.0017)	(0.0016)	(0.0015)
Post05 × Score Diff	-0.0002	-0.0000	-0.0001	0.0000	0.0002	0.0002	-0.0002	0.0001
	(0.0010)	(0.0010)	(0.0005)	(0.0005)	(0.0006)	(0.0006)	(0.0007)	(0.0006)
Fourth Quarter × Score Diff	0.0044***	0.0039***	0.0016***	0.0013**	-0.0008	-0.0007	0.0009	0.0002
	(0.0011)	(0.0011)	(0.0006)	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
Score Margin Dummies		✓		✓		✓		✓

Notes: N = 56,776. Poisson models with matchup (team-opponent-season) fixed effects, quarter fixed effects, and de-meaned attendance included in all specifications. “Score Margin Dummies” are dummy variables equal to one if lose quarter by more than five points, lose by one to five points, win by zero to five points (winning by more than five points is omitted category). “Playoff,” “Televised,” “Fourth Quarter,” “Post05” = dummies for playoff game, nationally televised, fourth quarter, season >= 2005-06, respectively, included in all specifications. Robust standard errors clustered by game. *, **, *** denote 10%, 5% and 1% significance.

Referee Appendix (Not For Publication)

Table 7: Playoffs Only, Quarter-Level Sample

	Discretionary Turnovers		Shooting Fouls		Non-Shooting Fouls		Non-Discretionary Turnovers	
Bias For	-0.040	-0.055	-0.045	-0.055	0.099	0.104	-0.197**	-0.215**
	(0.148)	(0.148)	(0.072)	(0.070)	(0.083)	(0.084)	(0.093)	(0.091)
Bias Against	0.018	0.024	-0.179**	-0.175**	0.064	0.067	-0.009	0.008
	(0.137)	(0.134)	(0.077)	(0.076)	(0.087)	(0.087)	(0.082)	(0.080)
Home Game	-0.030	0.009	-0.111***	-0.089***	0.005	0.002	-0.031	0.019
	(0.058)	(0.058)	(0.028)	(0.028)	(0.029)	(0.029)	(0.038)	(0.035)
Attendance × Home	-0.071***	-0.065***	0.008	0.012	-0.021**	-0.022**	-0.012	-0.002
	(0.022)	(0.022)	(0.011)	(0.011)	(0.011)	(0.011)	(0.015)	(0.014)
Quarter Start Score Diff	0.007***	0.005**	0.006***	0.005***	0.001	0.001	0.005***	0.002
(Own - Opponent Score)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Bias For × TV Market Size	-0.006	-0.006	0.008	0.008	-0.010	-0.010	0.043**	0.043**
	(0.029)	(0.029)	(0.014)	(0.014)	(0.016)	(0.017)	(0.017)	(0.017)
Bias Against × TV Market Size	-0.007	-0.006	0.024*	0.025*	-0.009	-0.010	-0.003	-0.002
	(0.027)	(0.026)	(0.015)	(0.014)	(0.018)	(0.018)	(0.017)	(0.017)
Bias For × Post05	0.058	0.065	-0.047	-0.042	-0.010	-0.014	0.003	0.008
	(0.107)	(0.107)	(0.053)	(0.053)	(0.058)	(0.058)	(0.065)	(0.065)
Bias Against × Post05	0.131	0.131	0.095*	0.096*	0.027	0.024	-0.019	-0.023
	(0.090)	(0.088)	(0.057)	(0.056)	(0.062)	(0.062)	(0.067)	(0.064)
Score Margin Dummies		✓		✓		✓		✓

Notes: Poisson models with matchup (team-opponent-season) fixed effects (regular season means), quarter fixed effects, de-meaned attendance, "TV Market Size" = Nielsen TV homes as of 9-27-2008 (sum of TV homes for both teams) and "Post05" (dummy for 05-06 season or later) included in all specifications. "Score Margin Dummies" are dummy variables equal to one if lose quarter by more than five points, lose by one to five points, win by zero to five points (winning by more than five points is omitted category). Robust standard errors clustered by game. *, **, *** denote 10%, 5% and 1% significance.