

Online Appendix to “Racial Discrimination Among NBA Referees”
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This appendix shows results from five sets of robustness tests that are referenced verbally in the main text of our paper.

First, the regressions reported in Table A-1 address the possibility that our results reflect the interaction of different refereeing styles with different playing styles. Table 4 reported the top-line results from regressions controlling for measures of playing style, interacted with *%white referees*. Table A-1 expands on this, reporting the coefficients on each of these control variables. Each column reports the results from a different dependent variable: the foul rate, each player’s point-scoring rate, or minutes played. The results shown come from the most complete specification of equation 1 (corresponding with the final column of Table 4), which includes the control variables listed, plus player*year, home team*player race, and team*game fixed effects.

Table A-1: Exploring the Effects of Different Refereeing and Playing Styles

Independent variables	<u>Dependent Variable</u>		
	Personal Fouls per 48 min	Points per 48 min	Minutes played
<u>Coefficient of interest</u>			
Black player * % White refs	0.181** (0.080)	-0.403** (0.158)	-0.482** (0.226)
<u>Control variables</u>			
<i>%white referees interacted with...</i>			
Height	0.002 (0.017)	-0.033 (0.033)	0.048 (0.048)
Weight	-0.003 (0.002)	-0.003 (0.004)	-0.004 (0.005)
Forward	0.055 (0.092)	0.298 (0.183)	-0.172 (0.261)
Center	-0.208 (0.153)	0.803*** (0.304)	-0.123 (0.434)
All-star	0.008 (0.093)	0.239 (0.186)	-0.346 (0.265)
Starter	0.055 (0.057)	-0.018 (0.113)	-0.232 (0.161)
Age	-0.009 (0.020)	0.041 (0.041)	-0.122** (0.058)
Experience	0.002 (0.022)	-0.03 (0.044)	0.095 (0.062)

and %white referees is also interacted with career averages of the following statistics (measured per 48 minutes played, except minutes played which is per game)

Minutes	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Assists	-0.017 (0.022)	-0.026 (0.044)	0.048 (0.063)
Blocks	0.105** (0.044)	-0.084 (0.088)	0.01 (0.126)
Defensive Rebounds	0.015 (0.025)	0.02 (0.050)	-0.068 (0.072)
Offensive rebounds	-0.017 (0.044)	-0.032 (0.087)	0.175 (0.124)
Steals	0.043 (0.058)	0.131 (0.115)	-0.233 (0.163)
Turnovers	0.053 (0.061)	-0.005 (0.121)	0.018 (0.173)
Free throw attempts	-0.025 (0.021)	-0.023 (0.041)	-0.049 (0.058)
2 point attempts	-0.004 (0.011)	0.031 (0.021)	-0.02 (0.030)
3 point attempts	-0.002 (0.019)	0.056 (0.037)	-0.015 (0.052)
Fouls	0.012 (0.031)	-0.068 (0.063)	-0.025 (0.089)
2 point percentage	1.543* (0.906)	-2.024 (1.802)	1.568 (2.567)
3 point percentage	0.346 (0.324)	-1.194* (0.644)	0.53 (0.917)
Free throw percentage	0.199 (0.433)	-1.169 (0.862)	-1.451 (1.228)
I(Zero two point attempts)	49.159 (51.666)	12.172 (102.779)	-0.104 (146.439)
I(Zero three point attempts)	0.174 (0.210)	0.051 (0.417)	-0.398 (0.594)
I(Zero free throw attempts)	3.408 (3.019)	-3.017 (6.005)	2.84 (8.555)
Observations	266,984	266,984	266,984
R-squared	0.28	0.69	0.36
F-test of joint significance of all interactions with racial mix of referees.	F=1.19 (p=0.24)	F=0.94 (p=0.55)	F=0.98 (p=0.50)

Notes: Table shows full set of controls from key regressions in column 3 of Table 5. Not shown are player, referee, year, home-team*race, player-year and team-game fixed effects; player-level controls such as age, height, weight, position, all-star status are not identified in the presence of player*year fixed-effects.

Table A-2 explores the findings from Table 4 in greater depth, re-analyzing the relationship between individual fouls earned, and the racial composition of the refereeing crew. This table explores the robustness of these results to several different functional forms. We begin by showing the basic results from the first column of Table 4 (we use this as the baseline, because the more complete specifications are computationally expensive). The next three columns show the alternative specifications described in the text: the second column restricts the sample to starting players (who are rarely called upon to foul strategically); the third column controls for a quartic in minutes played; and the fourth column is a count (Poisson) model that allows the natural log of minutes played as a dependent variable. Care should be taken in interpreting this final model, as the coefficient of interest should be interpreted as (approximately) the percentage change in the foul rate.

Table A-2: Testing Alternative Functional Forms

Specification	Baseline (Table 4, col. 1)	Starters only	Control for a quartic in minutes played	Count Model
Dependent variable:	Fouls per 48 minutes	Fouls per 48 minutes	Fouls per 48 minutes	#Fouls earned
Sample:	All player-games	Starting five only	All player-games	All player-games
Estimation:	OLS	OLS	OLS	Poisson
Coefficient of interest:				
<i>%white referees</i> *	0.197*** (0.061)	0.158** (0.068)	0.148*** (0.059)	0.028*** (0.003)
Extra controls				
<i>Ln(Minutes)</i>				0.503*** (0.001)
<i>Minutes</i>			-0.158*** (0.017)	
<i>Minutes</i> ²			1.024*10 ⁻⁴ (10.982*10 ⁻⁴)	
<i>Minutes</i> ³			1.77*10 ⁻⁵ (2.82*10 ⁻⁵)	
<i>Minutes</i> ⁴			2.35*10 ⁻⁸ (25.3*10 ⁻⁸)	
Observations	266,984	133,225	266,984	266,984
R-squared	0.18	0.20	0.226	Pseudo-R ² =0.056

Notes: Each column reports the results of a separate regression; all estimates weight by minutes played. (Standard errors in parentheses). ***, **, and * denote statistically significant at 1%, 5% and 10%. All specifications control for the observable variables listed in equation 1 (age, all-star, starter, home team, attendance, out-of-contention and black coach), plus referee, year and player fixed effects, as in the first column of Table 4.

Table A-3 explores the differential impact of own-race bias on black versus white players. We begin by re-estimating the baseline specification shown in the first column of Table 4. The second column is the same specification, but we omit the referee fixed effects, which allows us to separately estimate coefficients on both *black player*%white referees* and *white player*%white referees*. The difference in these coefficients is equal to that obtained if we simply drop referee fixed effects from our baseline specification. The third and fourth columns estimate this same equation, but estimate it separately for white and black players, respectively. In these regressions the coefficient of interest is *%white referees*, which describes how the propensity of each group of players to earn fouls varies with the racial composition of the refereeing pool (and again, this coefficient is only identified when we omit referee fixed effects).

Table A-3 Isolating Impacts on Black versus White Players
Dependent variable: Fouls earned, per 48 minutes played

Specification:	Baseline (Table 4, col. 1)	Drop referee fixed effects	White players	Black players
Sample:	All players	All players	White players	Black players
Referee fixed effects?	Yes	No	No	No
<u>Coefficient of interest:</u>				
<i>%white referees</i>	n.a.		-0.259*** (0.061)	-0.059** (0.025)
<i>%white referees * black player (β_{wb})</i>	0.197*** (0.061)	-0.059** (0.025)		
<i>%white referees * white player (β_{ww})</i>		-0.259*** (0.056)		
<i>Difference ($\beta_{wb}-\beta_{ww}$)</i>		0.199*** (0.061)		
Observations	266,984	266,984	52,693	214,291
R-squared	0.18	0.18	0.18	0.17

Notes: Each column reports the results of a separate regression; all estimates weight by minutes played. (Standard errors in parentheses). ***, **, and * denote statistically significant at 1%, 5% and 10%. All specifications control for the observable variables listed in equation 1 (age, all-star, starter, home team, attendance, out-of-contention and black coach), plus year and player fixed effects, as in the first column of Table 4.

Table A-4 explores how our findings change when they are based only on comparisons between all black and all white refereeing crews. The first column shows our baseline specification, reported in the first column of Table 4. The second column runs the same regression, but restricts the sample to games refereed by all black or all white crews. Instead of completely discarding all the information in games involving mixed-race crews, the third column tries an alternative approach, including all games, but adding a dummy variable for games refereed by mixed-race refereeing crews (and an interaction of this variable with a dummy variable describing player race). This specification allows games refereed by mixed-race crews to help sharpen the estimates on the control variables, but not the coefficient of interest. Similarly, the fourth column adds specific variables describing the exact racial composition of the refereeing crew (interacted with variables describing player race). In this specification games with all black refereeing crews are the omitted category, and hence the coefficient on all white crews * player race (β_3) highlights the all-white versus all-black contrast.

Table A-4: Examining the Racial Composition of Refereeing Crews
Dependent variable: Fouls per 48 minutes played

Specification:	Baseline (Table 4, col. 1)	All black or All- White Crews	Dummy out mixed-race crews	Exact racial composition of crew
Sample:	All player- games	All black or all white referee crews	All player-games	All player- games
Coefficient of interest:				
<i>%white referees</i> *	0.197*** (0.061)	0.315*** (0.100)	0.212*** (0.078)	
<i>I(Mixed race crew)</i> *			0.014 (0.043)	
<i>0 white referees</i> *				0 (omitted group)
<i>black player</i> (β_0)				0.024 (0.046)
<i>1 white referee</i> *				0.103* (0.055)
<i>black player</i> (β_1)				0.164** (0.069)
<i>2 white referees</i> *				
<i>black player</i> (β_2)				
<i>3 white referees</i> *				
<i>black player</i> (β_3)				
<i>F-test for linearity</i>				$F_{2,256,670}=0.63$ ($p=0.53$)
<i>H₀: $\beta_1-\beta_0=\beta_2-\beta_1$ and $\beta_2-\beta_1=\beta_3-\beta_2$</i>				
Observations	266,984	86,130	266,984	266,984
R-squared	0.18	0.19	0.18	0.18

Notes: Each column reports the results of a separate OLS regression; all estimates weight by minutes played. (Standard errors in parentheses). ***, **, and * denote statistically significant at 1%, 5% and 10%. All specifications control for the observable variables listed in equation 1 (age, all-star, starter, home team, attendance, out-of-contention and black coach), plus referee, year and player fixed effects, as in the first column of Table 4. The referee fixed effects render the direct terms *%white referees* and *I(mixed race crew)* unidentified.

Table A-5 analyzes the role played by other referee characteristics beyond their race, focusing on experience, age, and whether they were born in the South. We include the same set of controls as the first column of Table 4 but with additional interactions between the player's race and the characteristics of the referee crew (and the appropriate main effects). League experience is available for most of the referees but information on age and whether they attended high school in the South was only available for referees who were officiating in 2007 (from a website maintained by the National Basketball Referees Association).

Table A-5: Exploring the Effects of Other Referee Crew Characteristics

Independent variables	<u>Dependent Variable</u>		
	Personal Fouls per 48 min	Points per 48 min	Minutes played
<u>Coefficient of interest</u>			
Black player * % White refs	0.200*** (0.070)	-0.337* (0.202)	-0.495*** (0.157)
<u>Control variables</u>			
<i>Black player interacted with...</i>			
Average ref experience	0.001 (0.005)	-0.025* (0.014)	0.011 (0.011)
Observations	206,411	206,411	206,411
R-squared	0.184	0.259	0.558

Independent variables	<u>Dependent Variable</u>		
	Personal Fouls per 48 min	Points per 48 min	Minutes played
<u>Coefficient of interest</u>			
Black player * % White refs	0.204 (0.127)	-0.457 (0.362)	-0.802*** (0.285)
<u>Control variables</u>			
<i>Black player interacted with...</i>			
Average ref experience	0.004 (0.014)	-0.023 (0.040)	0.058* (0.031)
Average ref age	-0.000 (0.010)	-0.011 (0.028)	0.005 (0.022)
Fraction of crew from the South	0.014 (0.124)	-0.135 (0.352)	0.028 (0.277)
Observations	62,478	62,478	62,478
R-squared	0.191	0.273	0.568
F-test of joint significance of interactions.	F=0.03 (p=0.911)	F=0.35 (p=0.787)	F=1.76 (p=0.153)

Notes: Each column reports the results of a separate OLS regression; all estimates weight by minutes played. (Standard errors in parentheses). ***, **, and * denote statistically significant at 1%, 5% and 10%.

All specifications control for the observable variables listed in equation 1 (age, all-star, starter, home team, attendance, out-of-contention and black coach), plus referee, year and player fixed effects, as in the first column of Table 4.