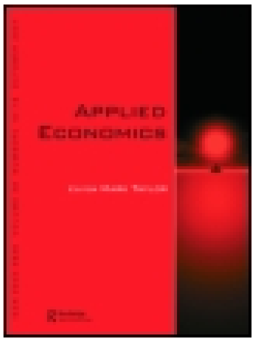

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Are professional basketball players reference-dependent?

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ABSTRACT

Models with reference-dependent preferences suggest that agents exert considerable effort to avoid falling below a reference point and 'losing'. We provide visual and statistical evidence that player performances in the National Basketball Association (NBA) bunch at salient, normatively extraneous round numbers. Using data on nearly three million shot attempts with precise (*x*, *y*) coordinates, we find that players improve free throw accuracy and attempt shots closer to the hoop when shooting for a round number. The results are strongest for players on home teams, suggesting that the reference-dependent enters preferences through an external, social evaluation channel.

KEYWORDS
Reference-dependent preferences; round numbers; loss aversion; NBA

JEL CLASSIFICATION
D03; D81; L83

I. Introduction

A rich literature has documented systematic ways in which decision makers violate standard economic assumptions (Camerer, Loewenstein, and Rabin 2004). One of the most prominently discussed behavioural biases is reference dependence, where agents exert considerable effort to avoid falling below a reference point and 'losing' (Kahneman and Tversky 1979; Abeler et al. 2011). While the bulk of prior studies utilized lab experiments, a growing literature has documented reference-dependent preferences in field settings, including gambling (Lien and Zheng 2015), game shows (Post et al. 2008), marathons (Allen et al. 2014), and professional golf (Pope and Schweitzer 2011).

This article examines how reference-dependent preferences shape behaviour in the National Basketball Association (NBA). The NBA is widely considered to be the pre-eminent men's professional basketball league in the world, with players who are the world's highest paid athletes. Studying reference-dependent preferences in the NBA is particularly interesting for several reasons. First, it is difficult to identify exactly what reference points exist and are important for agents in field settings (see Barberis 2013, for a discussion). For example, a series of articles with conflicting findings investigate the presence of reference-dependent preferences for taxi drivers, where agents may have a downward-sloping labour supply curve due to daily income targets (Camerer et al. 1997; Farber 2008; Crawford and Meng 2011). The primary challenge for field studies is that reference points are often unobserved, heterogeneous and non-stationary. We propose that in the NBA, salient and stable reference points exist, which themselves have arisen from psychological and social factors, and not from direct monetary rewards. The prevalence of salient reference points in the NBA provides us with clean and direct tests of reference-dependent preferences.

Investigating the NBA is also interesting since the stakes are high (the average player salary in 2013–2014 was $4.9 million) and the agents are experienced (players specialize in basketball the majority of their lifetime). Many researchers remain cautious about the persistence of behavioural biases in market settings, positing that biases are likely to be quashed by competition, high stakes and experience (e.g. Levitt and List 2008). The NBA presents an ideal setting to investigate persistent reference-dependent preferences in the face of professional experience and stakes. Though NBA players should only care about their team's overall performance in a game, players may be influenced by normatively extraneous reference points.

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'We definitely should have lost, and it was all my fault. I was chasing a triple-double.'
-Draymond Green of the NBA's Golden State Warriors, who finished with 10 points, 13 rebounds, and 9 assists on 30 January 2016

Utilizing over 700,000 player game observations from the 1986 to 2015 seasons, we provide visual and statistical evidence of round number reference-dependent preferences in the NBA. Significant bunching of performances occurs at or slightly above round numbers. For instance, players are significantly more likely to score 50–51 and 60–61 points versus 48–49 and 58–59 points, respectively. These results are strongest for home-team players, suggesting that the reference-dependent enters preferences through a social channel, where others judge the player with respect to a reference point. Reference dependence also expands to triple-doubles, where a player is significantly more likely to collect 10 versus 9 rebounds if the player also records 10 or more points and assists.[1]

To understand how the bunching of player performances occurs, we construct a sample of nearly three million shot attempts using play-by-play data from the 2004–2015 seasons. For each shot, we observe precise (x,y) coordinates of shot location on the court. First, estimating models with player, game and quarter fixed effects, we find that players experience a significant increase in free throw accuracy when shooting for a round number.[2] For instance, the probability a player makes a free throw increases from 80.9% when shooting with 40 points to 86.2% when shooting with 39 points. We find no evidence of a discontinuous shift in the frequency of shots attempted by the number of points the player had. Instead, we find evidence of discontinuous shifts in shot distance and in the probability of making a shot near round numbers. More specifically, when shooting for a round number, players take significantly closer shots to the hoop and are more likely to make these shots. Overall, these results suggest that players increase effort and focus when shooting for a round number.

The remainder of this article proceeds as follows. Section II briefly discusses the institutional features of the NBA. Section III introduces the data. Section IV presents evidence of reference-dependent preferences in the NBA. Section V concludes.

II. Institutional background

Our study focuses on the NBA, the pre-eminent men's professional basketball league in North America. The NBA has 30 franchised member clubs (29 in the United States and 1 in Canada), with each club comprised of 12 players. During the regular season, from late October to mid-April, these 30 clubs compete against each other, with each team playing a total of 82 games. The highest-performing 16 teams at the end of the regular season play a tournament against each other from late April to mid-June to determine which club is the champion of the league. For the 2015–2016 season, teams spent an average of over $78 million on player salary.

The basic rules of basketball are simple. Each team fields five players at one time, and each team tries to score by shooting a ball through a hoop elevated off the ground. Each team has a designated hoop placed at opposite ends of a rectangular court. A team moves the ball down the court towards their basket by passing or dribbling. The team without the ball gains possession by stealing it, forcing an offensive foul or turnover, collecting missed shots, or allowing a made shot. Made shots are worth two points, unless the shot was taken behind the three-point arc, in which case the shot is worth three points. Points may also be scored from free throws, which are worth one point. A free throw attempt is an uncontested shot attempt 15-feet from the hoop, and is awarded if the opposing team commits certain types of fouls. Each game is split into four quarters, and the team with the most points after the fourth quarter wins. In instances where the two teams have the same number of points after the fourth quarter, additional periods, called overtime, are played in order to break the tie.

III. Data

Our analysis utilizes two data sets. First, we use regular season and playoff NBA box score data from *www.basketball-reference.com* for the 1986–2015 seasons. This data set has a total of 718,536 player-game observations. Among other variables, the data contain the total number of rebounds (a collection of a missed shot), assists (a pass before a made shot) and points

[1] A triple-double is recorded when within a game, a player accumulates a double digit number total in three of five statistical categories: points, rebounds, assists, steals, and blocks. Conditional on recording 10 or more points and assists, a player is nearly twice as likely to record 10 rebounds versus 11 rebounds, while the median and mode number of rebounds is 4.

[2] A free throw is an uncontested attempt to score one point from a designated line. Free throws are awarded when the opposing team commits certain types of fouls.

recorded for each player at the end of each game. Secondly, we use play-by-play game logs from the NBA's website for the 2004–2015 regular seasons and playoffs. Each observation in this data set pertains to a single play (e.g. shot, free throw, foul, rebound, assist) made within a game. For each shot attempt, the NBA records precise (x,y) coordinates of where the shot was taken on the court.[3] We reduce this play-by-play data set into two subsets of interest: shot attempts (n=2,299,145 observations) and free throws (n = 694,062 observations).[4]

Table 1 presents summary statistics. Players play an average of 23.7 min per game, and record 9.9 points, 4.2 rebounds, and 2.2 assists on average per game. The total number of points scored between both teams per game is 199.5, with a total of 84.5 rebounds and 44.9 assists being recorded. Nearly 76% of free throws are made, while 45.4% of shots are made. The average distance of shot attempts is 12.5 ft.

There are many potential reference points that may motivate players. For instance, a player may want to be the highest scoring player on his team, giving him a reference point of his highest scoring teammate. In this article, we focus on the set of round numbers as potential reference points. We primarily test for reference dependence through round numbers in the most fundamental statistical category: points scored. The motivation to focus on round numbers is twofold. First, round numbers are clear, stable, and easily testable. While being the highest scoring player on the team may be an important reference point, these alternative reference points are fluid and difficult to test, as well as applicable to only a subset of players. Second, round numbers are frequently cited by NBA fans, pundits, and coaches, and thus are likely to serve as motivators for players. Round number reference points could motivate players through both a psychological, internal channel and through a social channel, where others judge a player with respect to a reference point.[5] Despite their prevalence in basketball, player salaries are not determined by round-number game statistics; instead, the performance-based incentives of players' salaries are often a function of games played, team wins, or ranking against other players in basic statistical categories and contests.

Table 1. Descriptive statistics from the National Basketball Association (NBA).

	Mean	SD	Observations
Panel A. Box score data, player-game level			718,536
Points	9.860	8.195	
Rebounds	4.162	3.648	
Assists	2.224	2.642	
Minutes played	23.678	12.002	
Panel B. Box score data, game level			35,320
Points	199.547	22.104	
Rebounds	84.466	9.744	
Assists	44.875	8.333	
Panel C. Play-by-play data, free throw attempts			694,062
Shot distance (in feet)	15.000	0.000	
Made shot	0.756	0.429	
Panel D. Play-by-play data, shot attempts			2,299,145
Shot distance (in feet)	12.474	9.925	
Made shot	0.454	0.498	

Points are awarded for made shots. Made shots are worth two points, unless the shot was taken behind the three-point arc, in which case the shot is worth three points. Free throws are worth one point. A rebound is a collection of a missed shot. An assist is awarded to a player if he made the pass before a made shot.

Figure 1 presents two descriptive figures. The first uses the play-by-play data (n = 694,062) to plot free throw percentages (the fraction of made to attempted free throws) by the number of points the player had at the time of the free throw to observe increases in free throw percentages when the player was shooting for a round number. Analyses in the next section will provide statistical tests, controlling for potential biasing factors, for whether these observed increases are significant. The second histogram presents the distribution of player-game rebounds, conditional on the player recording 10 or more points and assists in the game. If a player records 10 or more points, assists and rebounds within a game, then the player collects the oft-cited statistic of a triple-double. While the median and mode number of rebounds is 4, a player is significantly less likely to collect 9 versus 10 rebounds. Furthermore, a player is nearly twice as likely to record 10 rebounds versus 11 rebounds, suggesting the player is allocating just enough effort to achieve the triple-double. These histograms

[3]The play-by-play data also contain an identifier for whether the shot attempt was worth two or three points. When we cross-validate the point-identifier against the (x,y) coordinates, 4,640 observations (0.2% of observations) were awarded as a three-pointer even though the (x,y) coordinates suggest it was a two-pointer; this could perhaps be attributable to NBA referees incorrectly awarding a three-pointer even though the player's foot was on the three-point line. 87 observations were awarded two points but were supposed to be worth three points according to (x,y) coordinates.

[4]The play-by-play data do not include all passes made. Instead, the only passes recorded are assists (a pass before a made shot). Hence, we cannot directly test for changes in passing behaviour as a player's assist total approaches a round number.

[5]As Allen et al. (2014) discuss, it is inherently difficult to separately tease out these two channels in field settings. For instance, is a home seller worried about selling below his previous purchase price (the reference point) because he will feel a loss, or because he is worried about what others in his life will think if he lost money on the house? Regardless of whether the loss aversion is internalized or due to social factors, evaluations are still made with respect to a reference point.

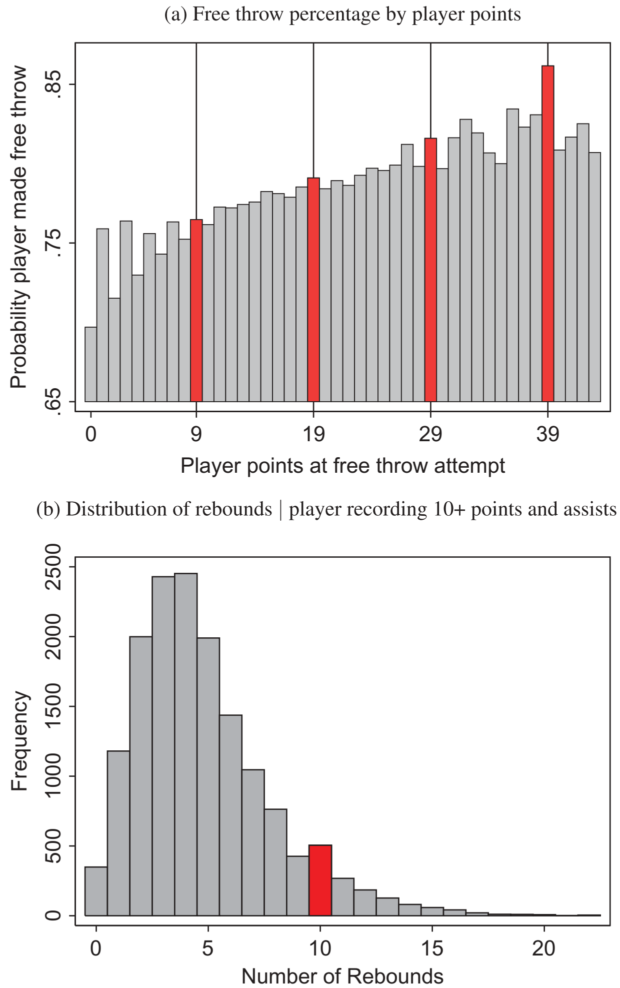

Figure 1. Descriptive figures from the National Basketball Association (NBA).

Figure (a) utilizes free throw attempts from the play-by-play data (n = 694,062) for the 2004–2015 regular seasons and playoffs. For (b), each observation is unique at the player-game level, with data pulled from www.basketball-reference.com for the 1986–2015 NBA regular seasons and playoffs.

provide some preliminary evidence of bunching at round numbers in the NBA.[6]

IV. Methods and results

Bunching at round numbers

To formally test whether an excess mass of observations occurs at each round number of player-game points in the distribution, we conduct a series of Mccrary (2008) tests on the box score data. The idea is to see whether the largest discontinuities in the density function occur at round number point bins, and if these discontinuities are statistically significant. Mccrary (2008) outlines a test, frequently used in regression discontinuity designs, to determine whether there is a discontinuous shift in the density function at a designated threshold. The test works by estimating density functions on the left and right sides of the threshold using a local linear approximation. Bootstrapped standard errors are calculated to determine whether the gap between the two local linear approximations is statistically significant.

In Figure 2, we conduct the McCrary test at each two-point bin between 8 and 47 and plot the t-ratio from each test. The figure shows large, statistically significant t-ratios at the round number points bins for 10, 20, 30 and 40. Furthermore, the t-ratios jump at these bins, making each of these t-ratios local maxima.[7] This suggests that the largest discontinuities in the density function occur at these round numbers. The pattern is similar when using one-point bins, but with more extreme t-ratios (Figure A1).[8]

How bunching occurs

Free-throw data

In order to understand how reference-dependent preferences influence player actions and efforts, we first look at free throw attempts from the NBA play-by-play data. A free throw attempt is an uncontested shot attempt to score one point from a designated line, 15-feet from the hoop. To start, we conduct a series of binomial tests to determine whether the probability of making a free throw is dependent on how many points the player had when shooting the free throw. To test for round number reference dependence, we will want to see whether a player is significantly more likely to make a free throw when shooting for a round number (shooting to avoid falling below a reference

[6]Table A1 presents results from a series of binomial tests to estimate differences in likelihood of players scoring a round number versus falling just below a round number by the end of the game. Unconditionally, players are more likely to score 50–51 and 60–61 points versus 48–49 and 58–59 points, respectively.

[7]The sum of McCrary t-ratios across the entire support of the density function should approximately equal zero. Hence, large t-ratios at the round number bins implies significantly negative t-ratios in neighbouring bins.

[8]As an alternative to the local linear approximation of Mccrary (2008), we also fit a 10-order polynomial to the density function from 2 to 63 player-game points scored. In Figure A2, we plot the residuals between the actual and fitted number of player-game point frequencies. Five of the largest residuals occur at round number bins.

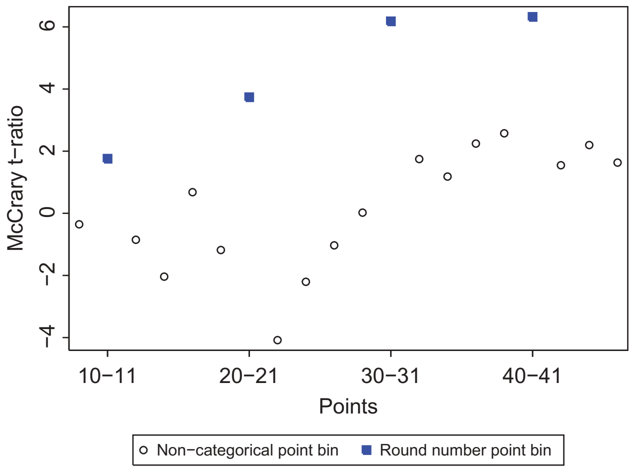

Figure 2. Running McCrary *t*-ratios for distribution of points scored.

The Mccrary (2008) test is conducted at each two-point bin to test whether a significant discontinuity in the density function exists at that point bin.

point and encoding a 'loss') versus shooting at a round number (shooting when already avoiding a 'loss').

Table 2 presents the results from this analysis. Focusing on the middle cells in the even columns, we find that players are more likely to make a free throw when shooting with 19, 29, and 39 points versus shooting with 20, 30, and 40, respectively (p-values of 0.109, 0.055 and 0.043, respectively). Free throw accuracy is also improved when a player is shooting with 19, 29 and 39 points versus shooting with 18, 28 and 38, respectively. The differences in free throw percentage become more pronounced for higher round numbers, culminating with a 5.3 percentage point increase in free throw accuracy when a player is shooting with 39 versus 40 points. Since all free throws are uncontested and equidistant from the hoop, these results suggest that players increase focus and effort put into the free throw when shooting just below a round number.[9]

An alternative explanation for this result could be that the composition of free throw shooters is unbalanced across the point distribution. If players who are accurate free throw shooters are more likely to get fouled and visit the free throw line when sitting just below a reference point, then the increase in free throw accuracy does not reflect an increase in focus when shooting for round numbers, but instead reflects an increase in better free throw shooters shooting for round numbers. Hence, differences in free throw accuracy would simply reflect changes in the distribution of free throw shooters. To account for this possibility, we estimate the following fixed effect specification:

$$y_{ispgq} = \alpha + \delta R_p + \lambda_i + \lambda_g + \lambda_q + \beta f(pts_p, pts_p^2, \ldots, pts_p^{10}) + \gamma X_s + \varepsilon_{ispgq} \quad (1)$$

where each observation is a free throw attempt s by player i when he had points p in game g during quarter q. The dependent variable y_{ispgq} is an indicator for whether the player made the free throw. R_p is an indicator for whether the free throw attempt was taken when the player was shooting with 19, 29, 39 or 49 points. The coefficient of interest is δ, which can be interpreted as the average change in free throw accuracy when the free throw will result in a round number of points for the player. λ_i are player

Table 2. Differences in probability of making free throws by how many points player had.

	Accuracy	Change in accuracy		Accuracy	Change in accuracy		Accuracy	Change in accuracy
	(1)	(2)		(3)	(4)		(5)	(6)
18	.7853		28	.7983		38	.8308	
	(.0036)	**−.0057**		(.0074)	**−.0176***		(.0188)	**−.0308**
19	.7910	**(.0052)**	29	.8159	**(.0109)**	39	.8616	**(.0270)**
	(.0038)	**.0068**		(.0079)	**.0191***		(.0194)	**.0530****
20	.7842	**(.0055)**	30	.7969			.8086	**(.0313)**
	(.0040)	−.0051		(.0090)	−.0194*		(.0245)	−.0081
21	.7893	(.0059)	31	.8163	(.0132)	41	.8168	(.0373)
	(.0043)			(.0096)			(.0280)	

Notes: The cells in columns 1, 3 and 5 report the probability of making a free throw (i.e. the ratio of free throws made to free throws attempted) by how many points the player had when attempting the free throw. The cells in columns 2, 4 and 6 report the differences in the probabilities of making a free throw by how many points the player had when attempting the free throw. For instance, from the middle cell of column 6, players were 5.3 percentage points more likely to make their free throw when shooting with 39 versus shooting with 40 points. Bold results compare free throws taken when the player was shooting for a round number versus not for a round number. Asterisks indicate rejection of the hypothesis that the difference in probabilities is equal to zero from a binomial test. Standard errors in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$.

[9]Moreover, as further depicted in Table A3, the majority of falsification comparisons of free throw percentage (e.g. shooting a free throw with 40 points versus 41 points) are small and insignificantly different than zero.

fixed effects, which control for all factors that vary at the player level and influence free throw accuracy. Importantly, these fixed effects control for the average free throw percentage for each individual player irrespective of when the free throw was taken. Consequently, we are estimating differences in free throw percentages across point bins *within* each individual player. λ_g and λ_q are game and quarter fixed effects, respectively, which control for any unobserved factors at the game and quarter level that may influence free throw accuracy. We fit a 10-order polynomial in player-game points at the time of the free throw. X_s is a vector of shot-level controls, including the number of minutes remaining in the quarter when the shot was taken and the point spread in the score when the shot was taken (i.e. player's team score minus opposing team score).

The results from this analysis are presented in Panel A of Table 3. In column 1, we run specification (1) without fixed effects and in column 2, we add player fixed effects. The remaining columns consider the sensitivity of the results to different combinations of player, game, and quarter fixed effects. Each cell reports the estimated δ. Heteroscedastic robust standard errors are clustered at the player level, and presented in parentheses. We again find statistically significant increases in free throw accuracy when players are shooting for a round number. This result is robust across all specifications. Furthermore, the estimated coefficient only slightly drops when including player fixed effects, suggesting that there is little concern about differential composition of free throw shooters across the point distribution.

In Panel B, we consider a slightly different classification for R_p. Given a player can reach multiple round number thresholds within a game, it could be that lower point thresholds carry relatively less significance for higher scoring players. To consider this possibility, we redefine R_p as an indicator for whether the free throw attempt was taken when the player was shooting for the ex post highest round numbers reached for that game. For instance, if a player finished with 39 points, R_p will switch on only for the player's free throw attempt at 29 and 39. The results for this alternative construction for R_p remain consistent with those from Panel A.

Shot attempt data

We now turn to the 2,299,145 shot attempts portion of the play-by-play data. We first show that the distribution of shots taken does not discontinuously shift by how many points the player had. Similar to Figure 2, in Figure 3, we plot the running t-ratios from a series of Mccrary (2008) tests to see if there is significant bunching of shot attempts by how many points the player had. In general, the distribution of shot attempts by player-game points is smooth, and we especially find no evidence of a significant jump in shot attempts just before a round number. This suggests that players are attaining their round numbers through means other than simply hoisting more shots.[10]

We utilize the (x,y) coordinates of all shot attempts to investigate whether the distance of the shots a player takes and the probability of making a shot shifts discontinuously when a player is shooting to attain a round number. We again consider specification (1), where for Panels C and D in Table 3, y_{ispgq} is the distance of the shot s taken by player i, and for Panels E and F, y_{ispgq} is an indicator for whether player i made the shot s. Similar to the free throw analysis, we consider two constructions for R_p: For Panels C and E, R_p is an indicator for whether the player took the shot with 18–19, 28–29, 38–39 or 48–49 points (i.e. an indicator for whether the shot resulted in any round number of points scored), while for Panels D and F, R_p is an indicator for whether the shot was attempted when the player was shooting for the ex post highest round numbers reached for that game. From Panels C and D, we find that players take significantly closer shots to the hoop when shooting for a round number. Results from Panels E and F are statistically insignificant, but we mostly find that these closer shots are associated with increases in the probability of making the shot.

Heterogeneities

In this section, we return to the box score data to identify several interesting subsamples for which the bunching are especially strong, each of which provides suggestive evidence about the mechanisms driving the results. First, under the hypothesis that the round number preferences are an inefficient behavioural bias that

[10]One notable shortcoming of the shot attempts portion of the play-by-play data is we cannot observe whether a player simply decided to shoot the ball when it was in his possession. This is because all the alternative actions to shooting the ball (e.g. passing the ball) are not recorded in the data. Hence, we are restricted to investigating the distribution of the frequency of shots taken by how many points the player had to back out likelihoods of taking a shot.

Table 3. Regressions with play-by-play data.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: made free throw								
Shot for any round number	0.007 **	0.006 *	0.007 **	0.007 **	0.006 *	0.007 **	0.006 *	0.006 *
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Observations	694,062	694,062	694,061	694,062	694,061	694,061	694,062	694,061
Panel B: made free throw								
Shot for largest round number	0.006 **	0.005 *	0.007 *	0.007 **	0.006 *	0.007 **	0.006 *	0.006 *
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Observations	694,062	694,062	694,061	694,062	694,061	694,061	694,062	694,061
Panel C: shot distance								
Shot for any round number	−0.111 ***	−0.070 *	−0.111 ***	−0.125 ***	−0.062	−0.112 ***	−0.070 *	−0.061
	(0.042)	(0.040)	(0.042)	(0.043)	(0.040)	(0.042)	(0.040)	(0.040)
Observations	2,299,142	2,299,142	2,299,142	2,299,142	2,299,142	2,299,142	2,299,142	2,299,142
Panel D: shot distance								
Shot for largest round number	−0.114 ***	−0.064	−0.113 ***	−0.134 ***	−0.060	−0.121 ***	−0.065	−0.060
	(0.043)	(0.040)	(0.043)	(0.043)	(0.039)	(0.043)	(0.040)	(0.039)
Observations	2,299,142	2,299,142	2,299,142	2,299,142	2,299,142	2,299,142	2,299,142	2,299,142
Panel E: made shot								
Shot for any round number	0.002	0.002	0.003	0.003	0.003	0.003	0.002	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	2,299,145	2,299,145	2,299,145	2,299,145	2,299,145	2,299,145	2,299,145	2,299,145
Panel F: made shot								
Shot for largest round number	−0.001	−0.001	0.000	−0.000	−0.000	0.000	−0.001	−0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	2,299,145	2,299,145	2,299,145	2,299,145	2,299,145	2,299,145	2,299,145	2,299,145
Player FE		X			X		X	X
Game FE			X		X	X		X
Quarter FE				X		X	X	X

Notes: Each cell presents the estimated coefficient on an indicator variable for whether the shot would result in a round number of player-game points. All regressions include controls for the number of minutes remaining in the quarter when the shot was taken and the point spread at the time the shot was taken (i.e. player's team score minus opposing team score). Heteroscedastic-robust standard errors are clustered by player and presented in parentheses * $p < .10$, ** $p < .05$,*** $p < .01$.

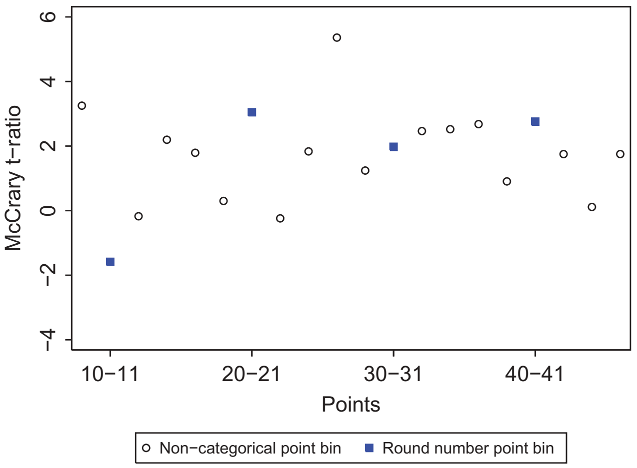

Figure 3. Running McCrary *t*-ratios for distribution of shots taken.

The Mccrary (2008) test is conducted at each two-point bin to test whether a significant discontinuity in the density function of number of shots taken exists at that point bin.

should dissipate in this market setting with high stakes, one would predict that the bunching at round numbers should disappear after a sufficient amount of time. In Figure 4, we plot running Mccrary (2008) *t*-ratios for games played in more recent seasons (2000–2015) versus games played from 1986–1999. Results from these graphs suggest a very different story from this hypothesis, where the bunching is driven almost entirely by player-games in more recent seasons. This directly implies that individuals' reference-dependent preferences are only getting stronger. Furthermore, the underlying reason for the stronger bunching in more recent seasons could be that the reference points enter player preferences through a social channel, where players feel that they are being judged and evaluated by others through comparisons to round numbers. Bunching would be more likely in more recent seasons, then, since the fan base of the NBA has become larger and more widespread over time.

To further consider the possibility of reference points entering player preferences through a social channel, we split the sample of observations by whether the player was on the home or away team. Each game in the NBA has a designated home team who hosts the matchup in their city, and thus, home teams in the NBA have a substantially larger fan base in attendance. If the reference-dependent influences players through a social channel, then a player playing at home would be especially motivated by a round number since that player's fans are directly watching and evaluating their results. In Figure 5, we plot the running Mccrary (2008) *t*-ratios by home versus away games. While bunching still exists

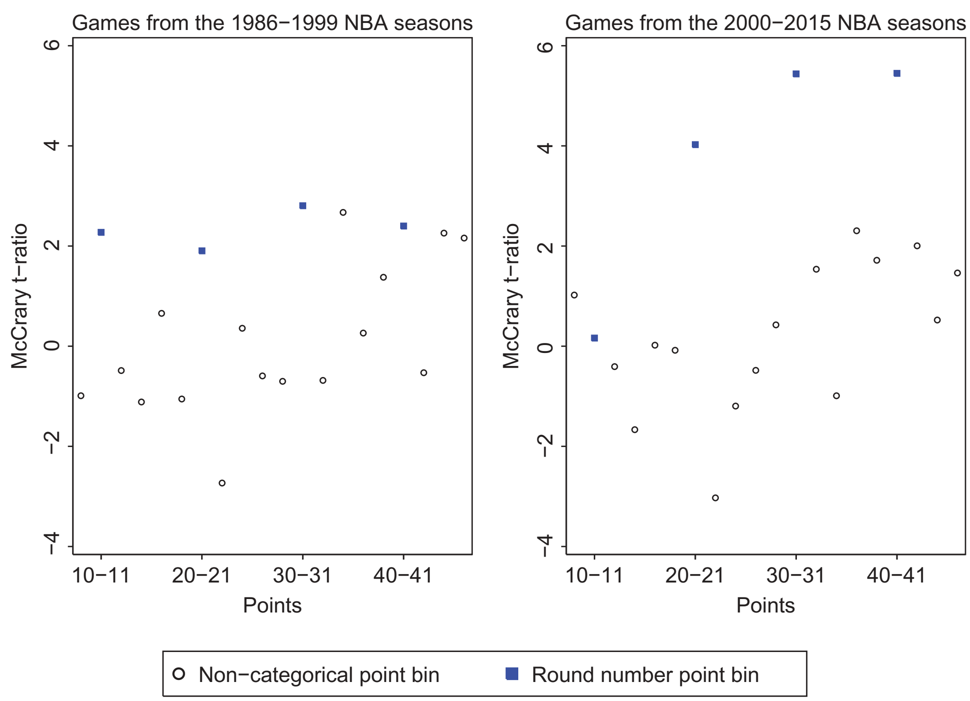

Figure 4. Running McCrary *t*-ratios for distribution of points scored: Season subsamples.

The Mccrary (2008) test is conducted at each two-point bin to test whether a significant discontinuity in the density function exists at that point bin. The left graph considers games played in the 1986–1999 NBA seasons, while the right graph considers games played in the 2000–2015 NBA seasons.

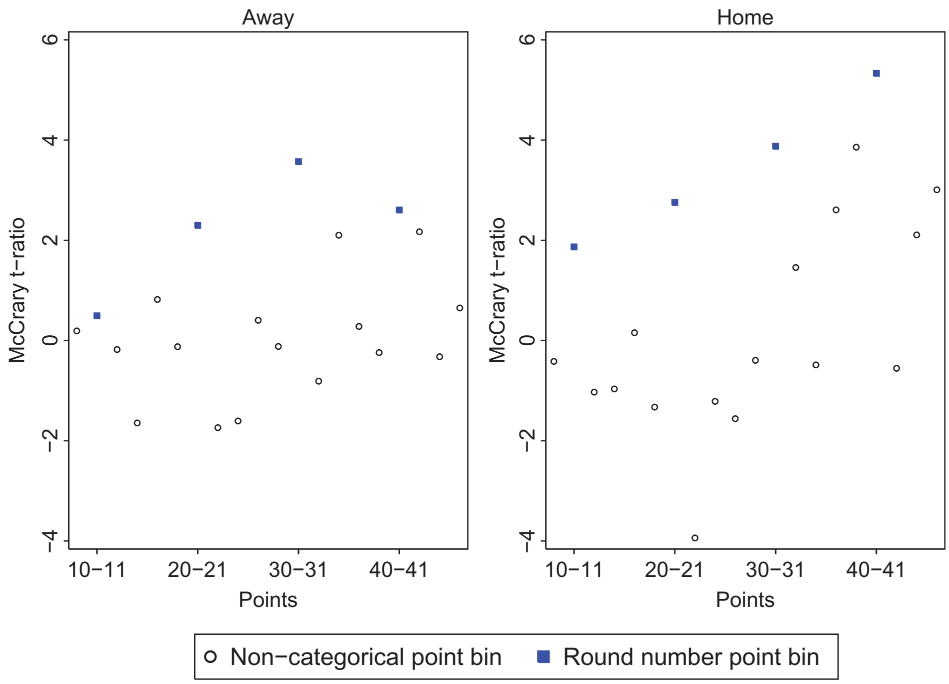

Figure 5. Running McCrary *t*-ratios for distribution of points scored: road versus home subsamples.

The Mccrary (2008) test is conducted at each two-point bin to test whether a significant discontinuity in the density function exists at that point bin. The left graph considers player-game observations where the player's team was the visiting team, while the right graph considers player-game observations where the player's team was hosting for that game.

in away games, the results are substantially stronger in home games, providing further evidence that the players believe their performances are being evaluated by others in reference to round numbers.[11]

In Figure 6, we split the sample by whether the two teams participated in a relatively competitive game or not. The first graph considers the sample of player-games where the final margin of victory was less than five points, while the second graph considers 'blow-outs' where the margin of victory was 15 points or higher. These graphs show that the bunching at round numbers is driven by blowout games. The likeliest explanation for this result is that the players' preferences for round numbers surface when the game is no longer on the line. In other words, in blowout games, players shift their focus from their team's outcomes to their own individual outcomes. Further supporting this explanation is Figure 7, which considers the sample of games played in the second half of the regular season, and splits by whether the player was on a team that lost less than a third of their games at the time of the game. By the second half of the regular season, teams generally have an idea of whether they will be able to compete for the NBA championship. We find that the bunching of round numbers is driven by players on teams that are not serious championship contenders, further suggesting that players start chasing the round numbers once their team-based outcomes are determined.

V. Conclusions

There has been a growing literature documenting reference-dependent preferences in field settings. This article examines how reference points influence player behaviour in the NBA. Unlike the majority of field settings, the NBA provides a backdrop where salient and stable reference points exist in the form of round numbers, thus allowing us to conduct clean, direct tests of reference-dependent preferences. Furthermore, the NBA allows us to investigate persistent reference dependence in the face of professional experience and stakes, where many researchers argue that welfare-reducing behavioural biases should dissipate under competition and high stakes.

[11]Goldman and Rao (2012) use a subset of the free throw data to find that free throw shooters experience significant decreases in home games during 'clutch' situations.

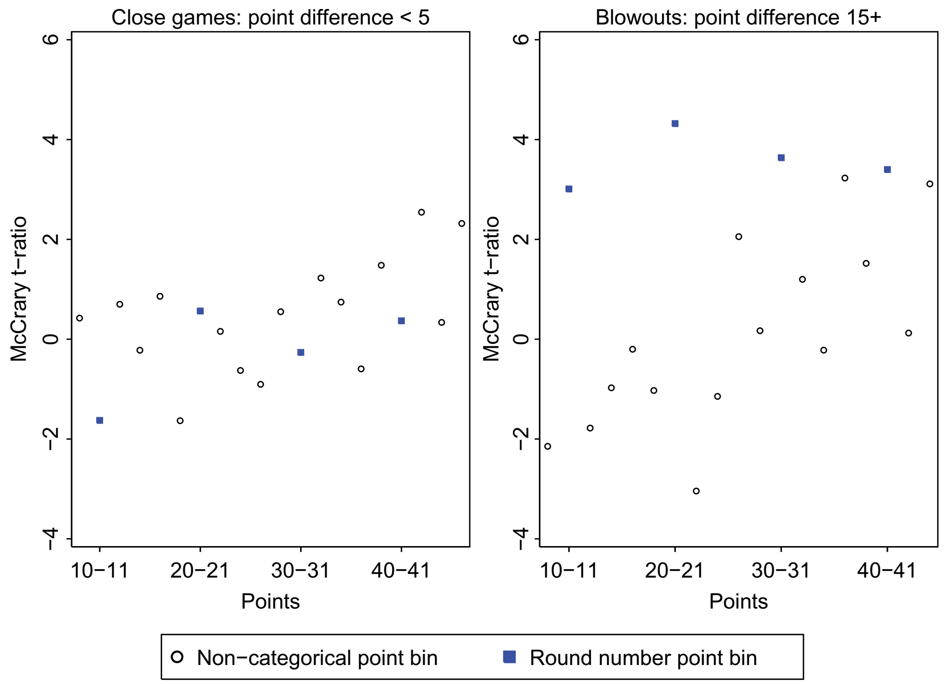

Figure 6. Running McCrary *t*-ratios for distribution of points scored: point differential subsamples.

The Mccrary (2008) test is conducted at each two-point bin to test whether a significant discontinuity in the density function exists at that point bin. The left graph considers player-game observations where the point difference between the two teams at the end of the game was less than 5 points (close games), while the right graph considers player-game observations where the point difference between the two teams at the end of the game was over 15 points (blowouts).

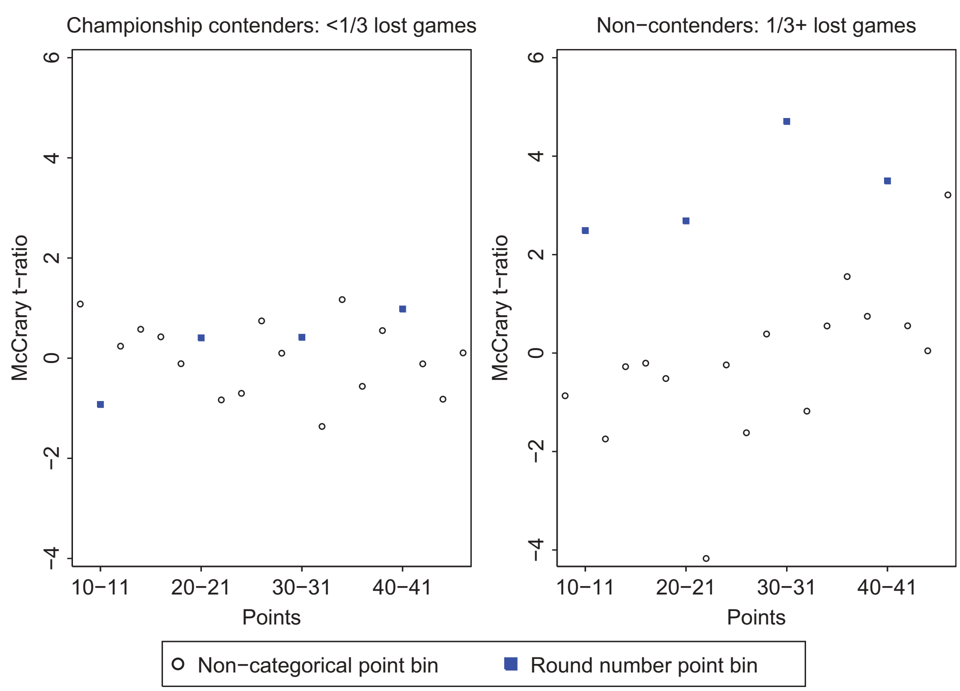

Figure 7. Running McCrary *t*-ratios for distribution of points scored: team winning percentage subsamples.

The Mccrary (2008) test is conducted at each two-point bin to test whether a significant discontinuity in the density function exists at that point bin. Each graph only considers games played in the second half of the regular season (February–June). The left graph considers player-game observations where the player's team had lost less than a third of their games (championship contenders), while the right graph considers player-game observations where the player's team had lost over a third of their games (non-contenders).

We find prevalent round number reference-dependent preferences in the NBA. Significant bunching of individual performances occurs at or slightly above round numbers. These results are stronger in more recent years, suggesting that reference-dependent preferences are only becoming more prevalent. Furthermore, the bunching is driven by players on home teams, suggesting that the reference points enter player preferences through an external, social-preference channel. Using play-by-play data with precise (x,y) coordinates, we find that players experience significant increases in free throw accuracy and decreases in shot distance when shooting for a round number with no change in shot frequency. Overall, our evidence suggests that players increase effort and focus to avoid falling below round numbers.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Abeler, J., A. Falk, L. Goette, and D. Huffman. 2011. "Reference Points and Effort Provision." *The American Economic Review* 101: 470–492.

Allen, E. J., P. M. Dechow, D. G. Pope, and G. Wu (2014): "Reference-Dependent Preferences: Evidence from Marathon Runners," Discussion paper, National Bureau of Economic Research.

Barberis, N. 2013. "The Psychology of Tail Events: Progress and Challenges." *The American Economic Review* 103 (3): 611–616.

Camerer, C., L. Babcock, G. Loewenstein, and R. Thaler. 1997. "Labor Supply of New York City Cabdrivers: One Day at a Time." *The Quarterly Journal of Economics* 112: 407–441.

Camerer, C. F., G. Loewenstein, and M. Rabin. 2004. "Prospect Theory in the Wild: Evidence from the Field." *Advances in Behavioral Economics* 148–161.

Crawford, V. P., and J. Meng. 2011. "New York City Cab Drivers' Labor Supply Revisited: Reference-Dependent Preferences with Rational Expectations Targets for Hours and Income." *The American Economic Review* 101 (5): 1912–1932.

Farber, H. S. 2008. "Reference-Dependent Preferences and Labor Supply: The Case of New York City Taxi Drivers." *The American Economic Review* 98 (3): 1069–1082.

Goldman, M., and J. M. Rao (2012): "Effort Vs. Concentration: The Asymmetric Impact of Pressure on NBA Performance," In *Proceedings MIT Sloan sports analytics conference*, pp. 1–10. Citeseer.

Kahneman, D., and A. Tversky. 1979. "Prospect Theory: An Analysis of Decision under Risk." *Econometrica: Journal of the Econometric Society* 47: 263–291.

Levitt, S., and J. List. 2008. "Economics. Homo Economicus Evolves." *Science (New York, NY)* 319 (5865): 909.

Lien, J. W., and J. Zheng. 2015. "Deciding When to Quit: Reference-Dependence over Slot Machine Outcomes." *American Economic Review* 105 (5): 366–370.

Mccrary, J. 2008. "Manipulation of the Running Variable in the Regression Discontinuity Design: A Density Test." *Journal of Econometrics* 142 (2): 698–714.

Pope, D. G., and M. E. Schweitzer. 2011. "Is Tiger Woods Loss Averse? Persistent Bias in the Face of Experience, Competition, and High Stakes." *The American Economic Review* 101 (1): 129–157.

Post, T., M. J. Van den Assem, G. Baltussen, and R. H. Thaler. 2008. "Deal or No Deal? Decision Making under Risk in a Large-Payoff Game Show." *The American Economic Review* 98: 38–71.

Appendix

Table A1. Relative likelihoods of game points scored by player

Panel A: relative likelihood of player-game points

	38	39	40	41		48	49	50	51		58	59	60	61
37	.45	.38	.38	.30	47	.44	.35	.47	.39	57	.30	.13	.36	.46
38	–	.43	**.42**	**.35**	48	–	.41	**.53**	**.45**	58	–	.25	**.57**	**.67**
39		–	**.50**	**.42**	49		–	**.63****	**.54**	59		–	**.80**	**.86***
40			–	.42	50			–	.41	60			–	.60

Panel B: relative likelihood of player-game points | 2000–2015 seasons

	38	39	40	41		48	49	50	51		58	59	60	61
37	.44	.38	.38	.30	47	.50	.25	.48	.47	57	.33	.00	.43	.43
38	–	.44	**.44**	**.36**	48	–	.25	**.48**	**.47**	58	–	.00	**.60**	**.60**
39		–	**.51**	**.42**	49		–	**.74*****	**.73*****	59		–	**1**	**1**
40			–	.41	50			–	.48	60			–	.50

Notes: Each cell reports the frequency of the column number of points being scored divided by the frequency of the column or row number of points being scored (i.e. Pr[column]/(Pr[column]+Pr[row])). If a player is more likely to record the column number than the row number, then Pr[column]/(Pr[column]+Pr[row]) > 0.50. Bold results compare round number points, or slightly above round number points, to points scored just below a round number. Asterisks indicate rejection of the hypothesis Pr[column] ≤ Pr[row] from a binomial test. * $p < .10$, ** $p < .05$, *** $p < .01$. This approach is relatively conservative (reduced likelihood of detecting statistical significance and committing type I error) so long as we test using 'far away' round numbers since under a log-normal distribution, observations further away from the central tendency of the distribution (from Table 1, $\bar{x} = 9.86$) are less likely to occur.

Table A2. Regressions with play-by-play data

	Make free throw		Shot distance		Make field goal	
	Away	Home	Away	Home	Away	Home
Shot for round number	0.005	0.008 *	−0.055	−0.068	0.004	0.000
	(0.005)	(0.004)	(0.058)	(0.060)	(0.003)	(0.003)
Observations	338,040	355,944	1,149,043	1,149,831	1,149,043	1,149,831
Player FE	X	X	X	X	X	X
Game FE	X	X	X	X	X	X
Period FE	X	X	X	X	X	X

Each cell presents the estimated coefficient on an indicator variable for whether the shot would result in a round number of player-game points. Heteroscedastic-robust standard errors are clustered by player and presented in parentheses * $p < .10$, ** $p < .05$, *** $p < .01$.

Table A3. Differences in probability of making free throws by how many points player had

	18	19	20		28	29	30		38	39	40
19	**−.0057**	–	–	29	**−.0176***	–	–	39	**−.0308**	–	–
	(.0052)				**(.0109)**				**(.0270)**		
20	.0011	**.0068**	–	30	.0014	**.0191***	–	40	.0222	**.0530****	–
	(.0054)	**(.0055)**			(.0117)	**(.0120)**			(.0301)	**(.0313)**	
21	−.0040	**.0017**	−-.0051	31	−.0181*	**−.0004**	−.0194*	41	.0141	**.0449***	−.0081
	(.0056)	**(.0058)**	(.0059)		(.0121)	**(.0124)**	(.0132)		(.0337)	**(.0340)**	(.0373)

Each cell reports the difference (column minus row) in probabilities of making a free throw by how many points the player had when attempting the free throw. For instance, from the middle cell of the right box, players were 5.3 percentage points more likely to make their free throw when shooting with 39 versus shooting with 40 points. Bold results compare free throws taken when the player was shooting for a round number versus not for a round number. Asterisks indicate rejection of the hypothesis that the difference is equal to zero from a binomial test. Standard errors in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$.

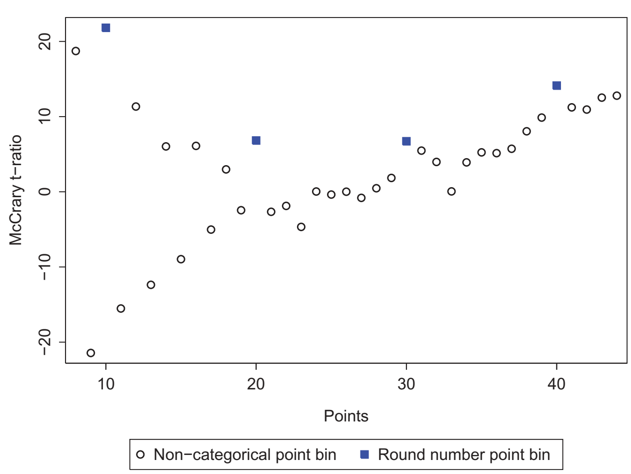

Figure A1. Running McCrary *t*-ratios for distribution of points scored.

The Mccrary (2008) test is conducted at each one-point bin to test whether a significant discontinuity in the density function exists at that point bin.

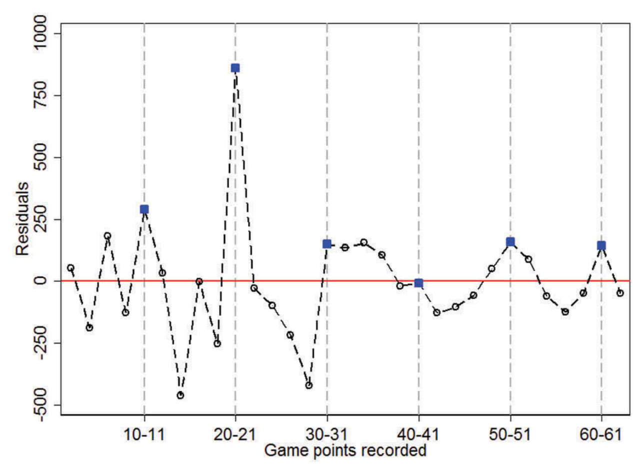

Figure A2. Residual frequency between observed and polynomial fit to player-game points.

A 10-order polynomial is fit to the density function of player-game points. Each bin contains two points. For instance, there were 861 more actual 20–21 player-game points scored than predicted by the polynomial fit.