Reference Dependence and Monetary Incentive

-Evidence from Major League Baseball-

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Abstract

- Using the data of Major League Baseball (MLB), we analyzed the relationship between observed reference dependent behavior and monetary incentives.
- MLB players evaluate their performance indexes as an outcome, with the reference dependent preference.
- They adjust their effort levels in order to achieve the reference points of the performance indexes, even though there are NOT observed any monetary incentives.

Contents

Research Question

- How observed reference dependence is related to the monetary incentives?
- Specify the factor that lead individuals to recognize the benchmarks and make efforts to achieve it.

Reference Dependence

- Individuals evaluate outcomes by the relative value to their internal benchmarks, or reference point, not by their absolute ones: reference dependence
- Reference dependence enabled us to interpret some inconsistent empirical decision making with the traditional microeconomic theory, by applying additional assumptions.
- There are a lot of following researches that shows the evidence for the reference dependence in field and laboratory settings, including about athletes' decision making.
  : Performance of sports is measured by nonmonetary outcomes.

Literature

- Pope and Schweizer (2011) pointed out that for the professional golf players regard "par" as the reference point, which results in the different probability of success in their putts.
- Allen et al. (2016) specified the existance of reference point dependence of marathon runners, using data about the finish time of enormous number of race in the United States.
  $\Rightarrow$ Runners try to goal before the round numbers, and it results in observed excess mass, or "bunching" around 4 hours.

Literature

Pope and Simonsohn (2011)

- picked up the case of Major League Baseball (MLB) players, about the observed attitude to their performance indexes.
- MLB position players manipulate their batting-average (AVG), in order to meet their internal goals: .300
- As a result, there is observed excess mass, or "bunching" around .300 of AVG.

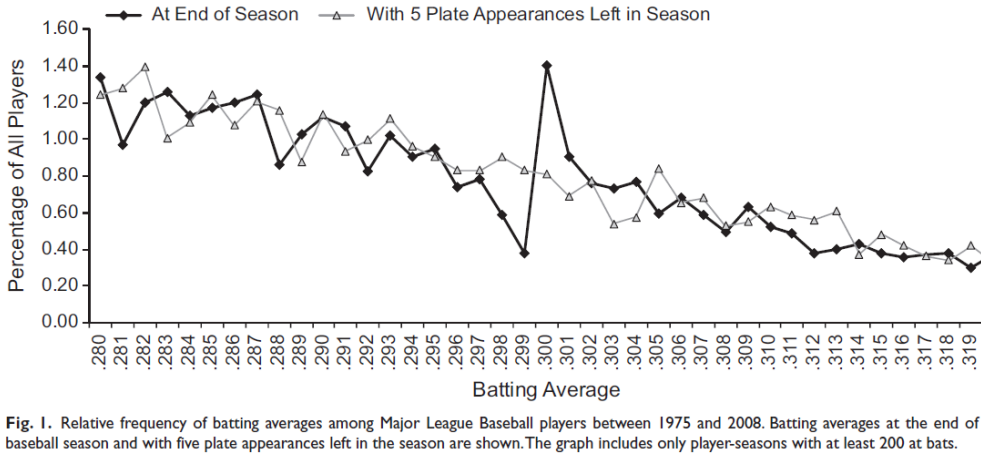

Fig. 1. Relative frequency of batting averages among Major League Baseball players between 1975 and 2008. Batting averages at the end of baseball season and with five plate appearances left in the season are shown. The graph includes only player-seasons with at least 200 at bats.

Figure: Excess Mass Around .300 (quated from Pope and Simonsohn (2011))

Extention and Contribution

- The case of MLB is different from that of marathon, in that players receive monetary rewards according to the contracts they signed.
- Their contracts might include some incentivesed parts, which pay them additional bonus when their AVG reaches a certain cutoff point.
- The contribution of our research is to examine this: examine if there exists any monetary incentives that make players make effort to the cutoff point.

Assumtion

- Reference dependence is specified by some additional assumption about the utility function
  : “kink” or “notch” at a certain cutoff point expresses the reference dependence, and as a result, we observe excess mass, or “bunching” around the possible reference point.
- In our research, we consider the possibility that the monetary reward to the players have the same functional features that lead the excess mass.
- When excess mass occurs, then at least one of the two: players utility function of the performance index X or the monetary reward function of X has the functional features above.

Assumptions

Functional Features that Cause Bunching

- function with notch, or jump at the reference points

$$\lim_{\epsilon \to 0} U_r(r+\epsilon) \neq \lim_{\epsilon \to 0} U_r(r-\epsilon)$$
$$\lim_{\epsilon \to 0} F_r(r+\epsilon) \neq \lim_{\epsilon \to 0} F_r(r-\epsilon)$$

- function with kink:

$$\lim_{\epsilon \to 0} U'_r(r+\epsilon) \neq \lim_{\epsilon \to 0} U'_r(r-\epsilon)$$
$$\lim_{\epsilon \to 0} F'_r(r+\epsilon) \neq \lim_{\epsilon \to 0} F'_r(r-\epsilon)$$

Theoretical Frameworks

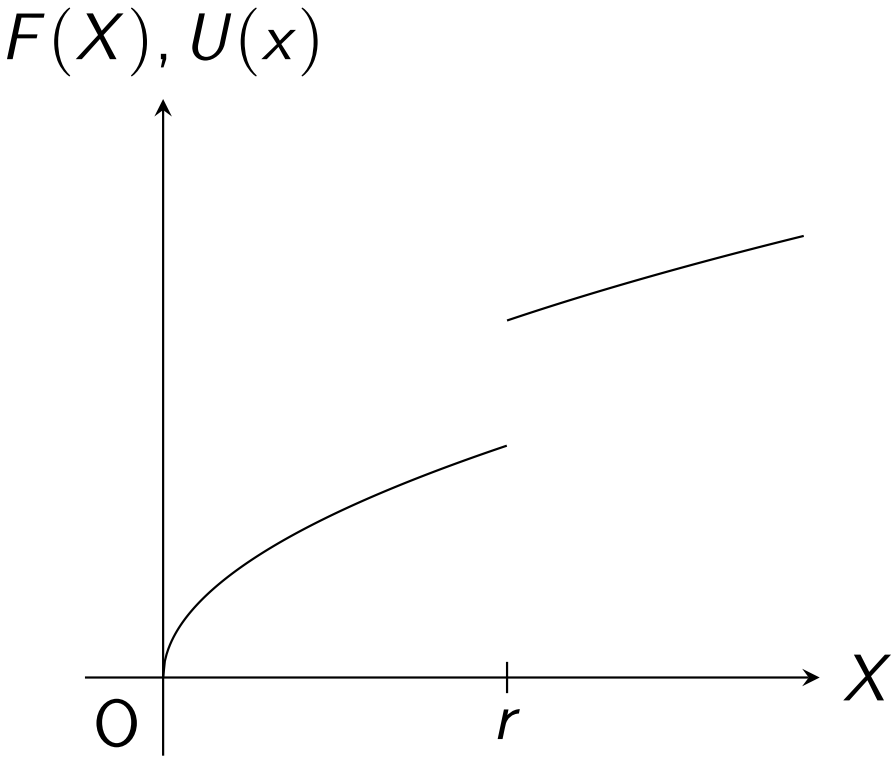

Figure: "Notch" at the reference point

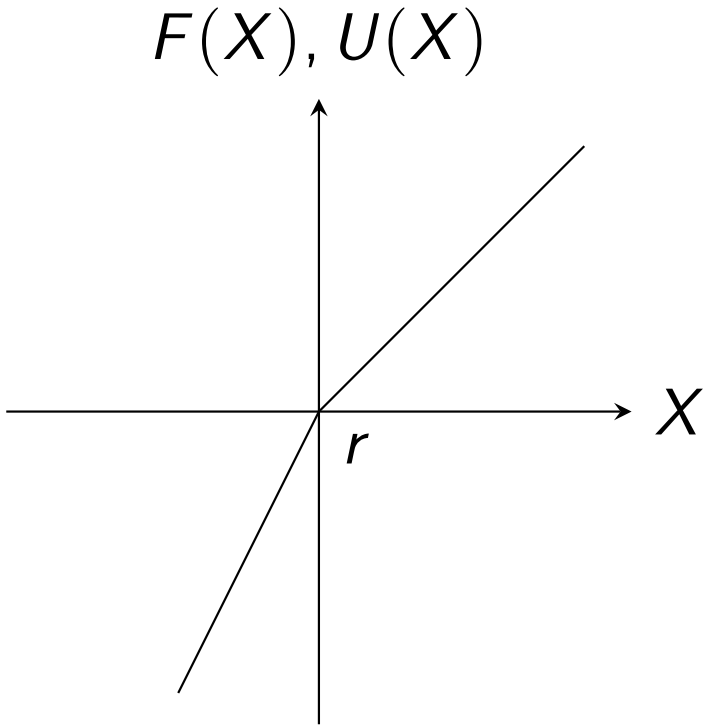

Figure: "Kink" at the reference point

Flow of Specification

1. First, confirm that there exists bunching in AVG, including other round-numbers such as .200 or .350:
   Also, we examine this about other performance indexes.
   – On-base percentage (OBP), homerun (HR), runs-batted-in (RBI), stolen-bases (SB), base-hit (H), and stolen-base (SB).
2. Second, for the possible reference points, test if there are any monetary incentives: discontinuous design of the contracts.

Specification: Bunching

- We exploit the McCrary (2007)'s manipulation test, which is used in regression discontinuity design.
- Make local approximation of the histgram of the variable of interest, and calculate the predicted values of $f(r)$ at the cutoff point, from both above and below there.

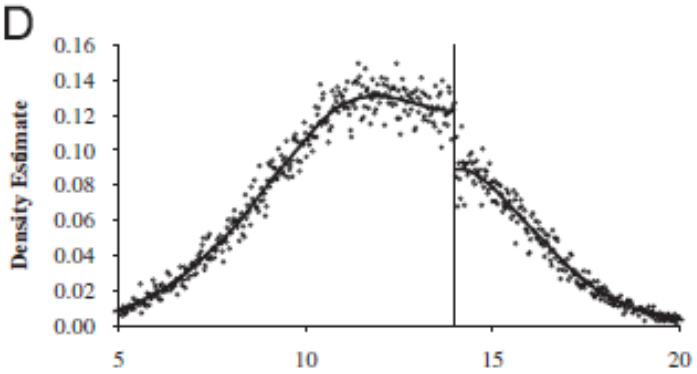

Figure: Discontinuous frequency (quated from McCrary(2007))

Specification: Contract Design

- Notch of the contract design is tested by local-linear regression:

$$w_{it} = \beta_0 + \beta_1 \text{PERF}_{it} + \beta_2 \text{ABOVE}_{it}$$

where

w_{it} : log salary of the next season

PERF_{it} : performance index

ABOVE_{it} : indicator for achievement

- Also, kink is examined by introducing the interaction term of PERF_{it} and ABOVE_{it}

$$w_{it} = \beta_0 + \beta_1 \text{PERF}_{it} + \beta_2 \text{ABOVE}_{it} + \beta_3 \text{PERF}_{it} \times \text{ABOVE}_{it}$$

We also conduct analysis including other performance and other player specific charactaristics.

Data

We obtain information about the players' stats (indexes) and annual salary.

- Stats Data
  - From *FanGraphs*
  - Play stats from 1957 to 2018
  - We restrict the sample to the players with at least 200 plate-appearances $N = 18143$ (62 seasons $\times$ players)
- Salary Data
  - From *USA TODAY* and *Baseball References*
  - Contract information from 1987 to 2017 $N = 8915$(31 seasons $\times$ players)
    - Fixed part of the salary of each player
    - In formation about possession of free agency, the right to negotiate any team in MLB.

Results: Bunching

Figure: Histgram of Batting-Average

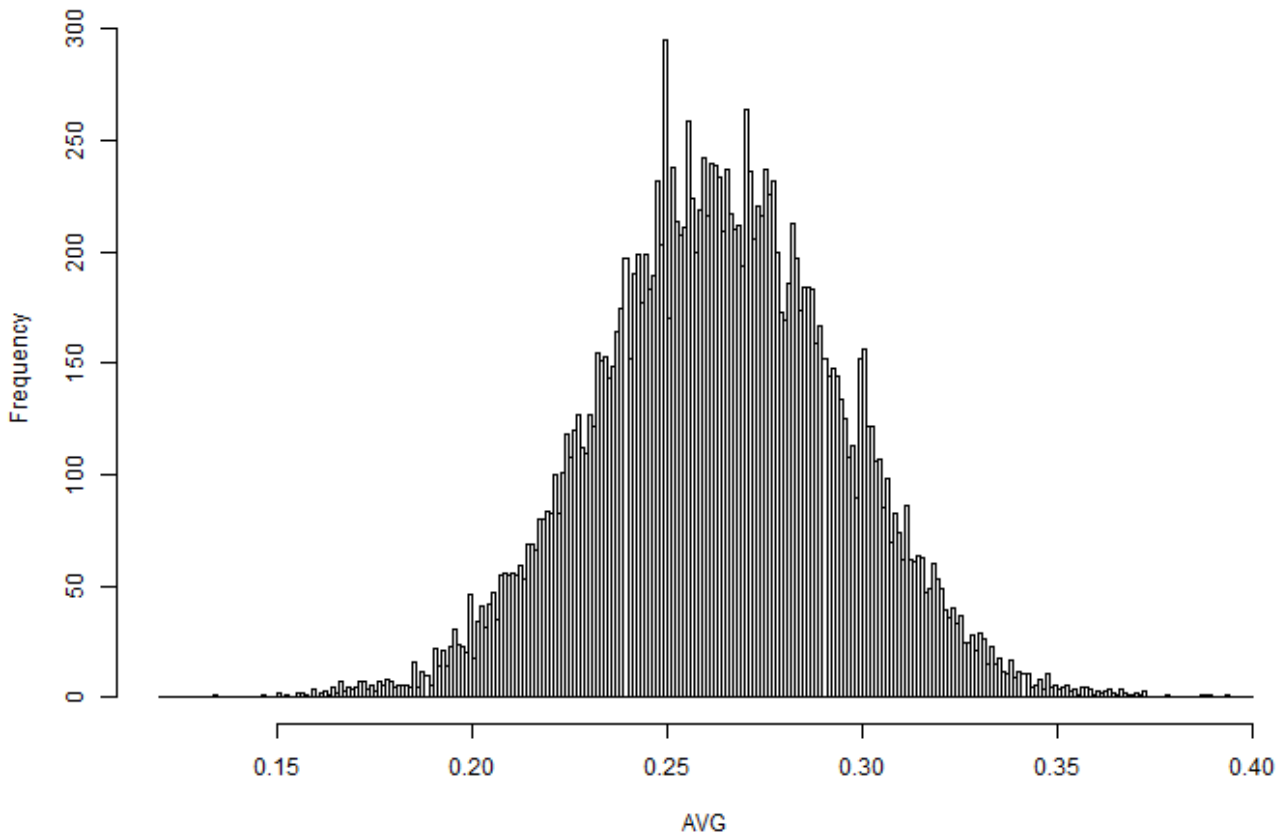

Figure: Discontinuity at .300 of AVG

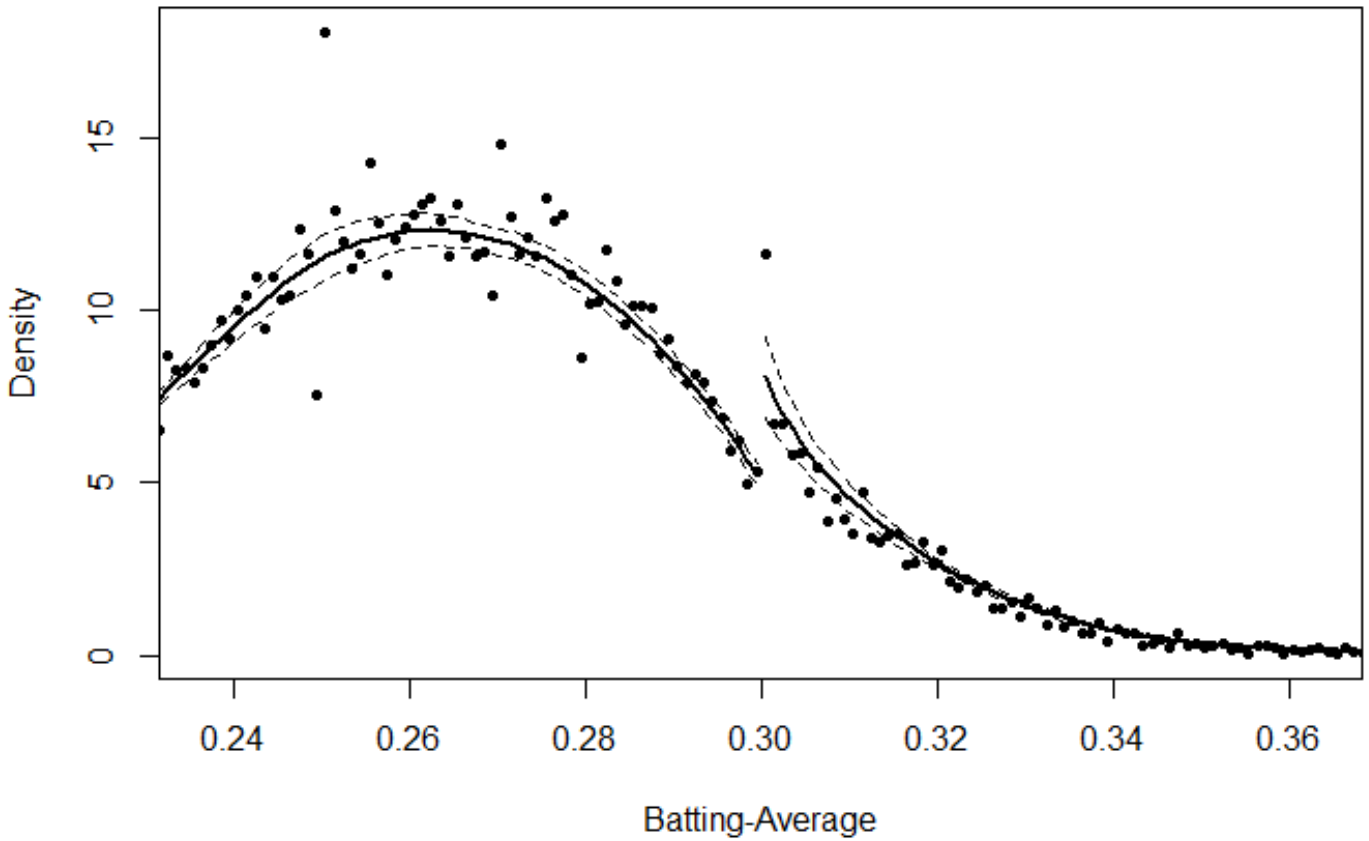

Table: Test for Bunching, leastPA = 200

index	type	cutpoint	binsize	bandwidth	θ	z
AVG	rate	.300	.001	.019	.499	7.442***
					(.067)	
		.250	.001	.024	.212	5.061***
					(.042)	
OBP	rate	.350	.001	.024	.139	2.854**
					(.049)	
HR	cumulative	20	1	5.309	.259	3.465***
					(.075)	
RBI	cumulative	100	4	15.423	.311	3.295***
					(.094)	
SB	cumulative	30	1	10.000	.529	4.274***
					(.124)	
		40	1	11.505	.481	2.764**
					(.174)	
PA	cumulative	500	1	.003	.160	2.515*
					(.063)	
H	cumulative	200	1	18.922	.453	2.547 *
					(.178)	

Note ***: $p < 0.1\%$, **: $p < 1\%$, *: $p < 5\%$.
Bandwidth is optimized following the method of McCrary(2008).

Results: Bunching

- In .300 of batting-average, there in fact exists excess mass by the players.
- Also in .250 of AVG and some of other round numbers of indexes, there were observed discontinuity:
  $\Rightarrow$ Players consider these numbers as reference points and adjust their aspiration levels.
- Bunching is not observed in all the round numbers.

Table: Local-Linear Regression for Monetary Incentives

index,cutpoint	Other Control	bw type	bandwidth	Observations	Estimate	Std. Error	z
AVG, .300	No	LATE	.084	8514	.047	.061	.773
		Half-BW	.042	5599	.088	.075	1.174
		Double-BW	.170	8915	.067	.056	1.184
	Yes	LATE	.045	5930	.034	.056	.615
		Half-BW	.023	3005	.061	.077	.788
		Double-BW	.090	8605	.016	.045	.354
AVG, .250	No	LATE	.036	6110	.019	.068	.286
		Half-BW	.018	3496	.015	.092	.161
		Double-BW	.072	8539	.034	.054	.636
	Yes	LATE	.048	7271	.070	.052	1.340
		Half-BW	.024	4402	.066	.069	.953
		Double-BW	.096	8810	.075	.044	1.713
HR, 20	No	LATE	3.32	1315	.071	.175	.406
		Half-BW	1.66	562	.073	.127	.576
		Double-BW	6.64	2582	-.004	.109	-.034
	Yes	LATE	3.30	1307	-.002	.141	-.015
		Half-BW	1.65	560	.030	.102	.299
		Double-BW	6.61	2558	-.032	.088	-.364
OBP, .350	No	LATE	.044	6440	-.038	.065	-.592
		Half-BW	.021	3542	-.076	.089	-.849
		Double-BW	.087	8656	-.029	.051	-.570
	Yes	LATE	.045	6525	-.013	.049	-.272
		Half-BW	.022	3673	-.055	.069	-.807
		Double-BW	.089	8637	.004	.039	.107

Note: ***: $p < 0.1\%$, **: $p < 1\%$, *: $p < 5\%$.
Bandwidth is optimized following the method of Imbens and Kalyanaraman (2009).
"Half" and "Double" stands for using a half and twice of bandiwidths, respectively.
"Yes" in "Other Control" shows including players' age (quadratic), FLD, BsR, FA dummy, Season and Position dummies.

Table: Regression on Log-Salary, Including Interaction Term: around .300

	Dependent variable:					
	Loggarithm of Salary Next Year					
	OLS				*felm*	
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	11.166***	−6.616***	−5.203***	−5.319***		
	(.423)	(.665)	(.671)	(.667)		
AVG	11.513***	11.620***	4.361***	4.221***	3.774**	3.808**
	(1.537)	(1.209)	(1.209)	(1.201)	(1.194)	(1.189)
AVG_300	−.169	−.413	−.191	−.142	−.287	−.069
	(1.050)	(.821)	(.785)	(.780)	(.775)	(.706)
FLD		.006***	.008***	.007***	.007***	.008***
		(.002)	(.002)	(.002)	(.002)	(.002)
BsR		.009*	.002	.003	.004	.020***
		(.005)	(.005)	(.005)	(.004)	(.005)
AVG:AVG_300	.663	1.428	.681	.540	.996	.160
	(3.429)	(2.681)	(2.566)	(2.549)	(2.532)	(2.312)
Season dummies		X	X	X	X	X
WPA			X	X	X	X
AGE (quadratic)		X	X	X	X	
FA dummy				X	X	X
Position dummies			X	X		
Fixed effects					Team	Individual
Observations	5,960	5,930	5,930	5,930	5,930	5,930
R^2	.035	.420	.470	.478	.488	.744
Adjusted R^2	.035	.416	.466	.473	.482	.660
Residual Std. Error	1.286 (df = 5956)	1.001 (df = 5892)	.957 (df = 5881)	.950 (df = 5880)	.943 (df = 5860)	.764 (df = 4459)
F Statistic	71.983*** (df = 3; 5956)	115.152*** (df = 37; 5892)	108.865*** (df = 48; 5881)	109.753*** (df = 49; 5880)		

Note: *p<0.05; **p<0.01; ***p<0.001

The bandwidth is same as RDD for .300 of AVG.

FLD and BsR stands for the contribution of the player to the team, expressed by the runs they earned.

WPA is "win-percentage added."

FA dummy indicates the possession of the free agency.

":" stands for the interaction term of the two elements.

Table: Local-Linear Regression for Monetary Incentives (Cont')

index,cutpoint	Other Control	bw type	bandwidth	Observations	Estimate	Std. Error	z
RBI, 100	No	LATE	4.08	393	.072	.289	.250
		Half-BW	2.04	228	.282	.400	.707
		Double-BW	8.16	714	.008	.185	.043
	Yes	LATE	4.04	390	.018	.209	.086
		Half-BW	2.02	227	-.042	.324	.130
		Double-BW	8.07	708	.056	.127	.435
H, 200	No	LATE	3.173	75	-.786	.396	-1.985*
		Half-BW	1.587	35	.386	.271	-1.421
		Double-BW	6.347	137	-.061	.309	-.199
	Yes	LATE	3.175	75	-.420	1.042	-.403
		Half-BW	1.587	35	-4.779	.576	-8.288**
		Double-BW	6.349	137	-.109	.413	-.265
SB, 30	No	LATE	3.39	282	.962	.372	2.585**
		Half-BW	1.70	134	.920	.263	3.492***
		Double-BW	8.16	714	.008	.185	2.941**
	Yes	LATE	3.40	282	.379	.297	1.271
		Half-BW	1.70	134	.290	.249	1.163
		Double-BW	6.79	533	.408	.180	2.260*
SB, 40	No	LATE	3.16	134	-1.276	.453	-2.818**
		Half-BW	1.58	56	-.736	.383	-1.924
		Double-BW	6.32	245	-.712	.313	-2.274*
	Yes	LATE	3.16	134	-.346	.396	-.875
		Half-BW	1.58	56	-.313	.429	-.730
		Double-BW	6.33	245	-.115	.244	-.472

Note: ***: $p < 0.1\%$, **: $p < 1\%$, *: $p < 5\%$.
Bandwidth is optimized following the method of Imbens and Kalyanaraman (2009).
"Half" and "Double" stands for using a half and twice of bandiwidths, respectively.
"Yes" in "Other Control" shows including players' age (quadratic), FLD, BsR, FA dummy, Season and Position dummies.

Table: Regression on Log-Salary: around .300, Including Only FA Players

	Dependent variable:					
	Loggarithm of Salary Next Year					
	OLS				*felm*	
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	7.033**	7.339*	7.114*	7.524*		
	(2.374)	(3.225)	(3.243)	(3.062)		
AVG	26.614**	26.230***	22.624**	14.443*	16.909*	13.286
	(8.308)	(7.245)	(7.355)	(6.851)	(6.961)	(10.076)
AVG_300	6.740	2.770	1.883	.969	1.636	2.727
	(4.231)	(3.707)	(3.749)	(3.453)	(3.468)	(4.444)
FLD		.005	.006	.007	.004	.001
		(.006)	(.006)	(.005)	(.005)	(.007)
BsR		.027	.025	.019	.016	−.013
		(.014)	(.015)	(.014)	(.014)	(.025)
AVG:AVG_300	−23.155	−10.065	−6.893	−4.015	−6.451	−9.953
	(14.071)	(12.333)	(12.474)	(11.489)	(11.540)	(14.911)
Season dummies		X	X	X	X	X
WPA				X	X	X
AGE (quadratic)		X	X	X	X	
Position dummies			X	X		
Fixed effects					Team	Individual
Observations	503	493	493	493	493	493
R^2	.028	.388	.406	.502	.529	.937
Adjusted R^2	.022	.339	.345	.448	.453	.735
Residual Std. Error	1.052 (df = 499)	.870 (df = 455)	.866 (df = 446)	.795 (df = 444)	.791 (df = 424)	.551 (df = 117)
F Statistic	4.824** (df = 3; 499)	7.808*** (df = 37; 455)	6.630*** (df = 46; 446)	9.328*** (df = 48; 444)		

Note: *p<0.05; **p<0.01; ***p<0.001

The bandwidth is same as RDD for .300 of AVG.

FLD and BsR stands for the contribution of the player to the team, expressed by the runs they earned.

WPA is "win-percentage added."

FA dummy indicates the possession of the free agency.

":" stands for the interaction term of the two elements.

Table: Without Players around the Cutoff

	Dependent variable:					
	Loggarithm of Salary Next Year					
	OLS				*felm*	
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	11.457***	−6.672***	−5.567***	−5.734***		
	(.465)	(.709)	(.716)	(.711)		
AVG	10.428***	11.419***	4.782***	4.643***	4.346***	4.393***
	(1.697)	(1.328)	(1.325)	(1.315)	(1.306)	(1.333)
AVG_300	−1.277	−.032	.274	.320	.136	.190
	(1.440)	(1.122)	(1.076)	(1.068)	(1.062)	(.968)
FLD		.007***	.008***	.008***	.008***	.009***
		(.002)	(.002)	(.002)	(.002)	(.002)
BsR		.006	−.0003	−.0003	.0004	.018**
		(.005)	(.005)	(.005)	(.005)	(.006)
AVG:AVG_300	4.263	.309	−.757	−.897	−.333	−.657
	(4.600)	(3.582)	(3.438)	(3.412)	(3.393)	(3.103)
Season dummies		X	X	X	X	X
WPA			X	X	X	X
AGE (quadratic)		X	X	X	X	
FA dummy				X	X	X
Position dummies			X	X		
Fixed effects					Team	Individual
Observations	5,259	5,232	5,232	5,232	5,232	5,232
R^2	.034	.425	.473	.481	.492	.752
Adjusted R^2	.034	.421	.468	.476	.485	.657
Residual Std. Error	1.286 (df = 5255)	.996 (df = 5194)	.955 (df = 5183)	.947 (df = 5182)	.939 (df = 5162)	.767 (df = 3787)
F Statistic	62.260*** (df = 3; 5255)	103.758*** (df = 37; 5194)	96.869*** (df = 48; 5183)	97.991*** (df = 49; 5182)		

Note: *p<0.05; **p<0.01; ***p<0.001

The bandwidth is same as RDD for .300 of AVG.

FLD and BsR stands for the contribution of the player to the team, expressed by the runs they earned.

WPA is "win-percentage added."

FA dummy indicates the possession of the free agency.

":" stands for the interaction term of the two elements.

Results: Monetary Incentives

- As a whole, there are not observed clear evidence of notch or kink at the round numbers in the monetary rewards.
  $\Rightarrow$ Players stick to reaching the benchmarks even though there are little or no monetary incentives to do so.
- For 30 stolen-bases, our analysis does not show determinant results, so we should further results.
- Robustness
  - Restricting the sample to the players with the right of free agency yields essentially the same results.
  - Removing the players just below and above the cutoffs (for batting-average, the range is .005) yields the same results.

Extention

- By-Time analysis
  - Replicate the same examination, but now we devide the sample by histrical terms:
    1. Before the system of free agency regulated (-1975)
    2. Before the Strike of Players Association (-1994)
    3. Before *Moneyball* (Lewis) was published (-2003)
    4. Afterward (2004-)

       * Note that because we obtain the sample of contract design only after '87, we cannot conduct the second analysis for before '86.
  - Hakes and Sauer (2006) aregued that after the publication of *Moneyball*, team managers regard on-base percentage as more important index to measure the players' contribution to the team they belong to.

Table: Bunching Test for the Grouped Sample by Time

index, cutpoint		'57-'75	'76-'94	'95-2003	2004-	full sample
AVG, .300	bw	.023	.020	.022	.019	.019
	θ	.573	.566	.310	.403	.499
		(.146)	(.120)	(.130)	(.120)	(.067)
	z	3.934***	4.732***	2.393*	3.376***	7.442***
AVG, .250	bw	.028	.028	.032	.027	.024
	θ	.250	.151	.306	.121	.212
		(.080)	(.069)	(.094)	(.076)	(.042)
	z	3.149**	2.188*	3.242**	1.595	5.061***
OBP, .350	bw	.031	.030	.036	.030	.024
	θ	.137	.149	-.035	.137	.139
		(.089)	(.081)	(.093)	(.082)	(.049)
	z	1.538	1.846	-.380	1.672	2.854**
HR, 20	bw	6.313	6.677	10.165	7.273	5.309
	θ	.222	.214	.145	.315	.259
		(.150)	(.123)	(.129)	(.112)	(.075)
	z	1.479	1.751	1.117	2.819**	3.465***

Note ***: $p < 0.1\%$, **: $p < 1\%$, *: $p < 5\%$.
Bandwidth is optimized following the method of McCrary(2008).

Table: Local-Linear Regression for the Grouped Sample by Time

index, cutpoint	bw, type		'87-'94	'95-2003	2004-	full sample
AVG, .300	LATE	bw	.024	.042	.030	.045
		Obs.	697	1806	1872	5930
		estimate	-.034	.064	.066	.034
			(.137)	(.092)	(.103)	(.056)
		z	-.250	.697	.637	.615
AVG, .250	LATE	bw	.036	.043	.075	.048
		Obs.	1482	1806	3991	7271
		estimate	.154	.064	.076	.070
			(.084)	(.092)	(.060)	(.052)
		z	1.825	.697	1.277	1.340
HR, 20	LATE	bw	4.183	3.685	2.46	3.30
		Obs.	341	371	475	1307
		estimate	-.255	-.348	.343	-.002
			(.228)	(.218)	(.264)	(.141)
		z	-1.122	-1.600	1.300	-.015
OBP, .350	LATE	bw	.031	.025	.027	.045
		Obs.	1098	1281	2042	6525
		estimate	.109	-.151	-.030	-.013
			(.106)	(.120)	(.093)	(.049)
		z	1.031	-1.262	-.323	-.272

Note: ***: $p < 0.1\%$, **: $p < 1\%$, *: $p < 5\%$.
Bandwidth is optimized following the method of Imbens-Kalyanaraman.

- Players' attitude to the indexes seems to be affected by the historical changes.
- However, .300 of batting-average has been a solid benchmarks for the players.
- On the other hand, team managers (since '87) does not propose any monetary incentives for the players.
  $\Rightarrow$ Again, we argure there does not exists no monetary incentive that leads them to bunching.
- Restricting the sample to the FA players also show the same.

Conclusion

Main Findings

1. Bunching is observed in their performance indexes, caused by the players' adjustment of their effort level to meet them with some round numbers.
2. There exist no monetary incentives in their contracts that makes players to do so.
3. Tendency of the bunching changes through the history of baseball.
   - Among them, especially, .300 of AVG shows consistent results, which shows it is solid benchmarks for the players.

Note that some indexes require following research, obatining information that makes limitation of our analysis.

Reference

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Contract Length

- Krautmann and Oppenheimer (2002) pointed out that the longer the contract duration extend, the lower return to their performance is obtained: Players show the risk-aversion.

$$\ln(SAL_{it}) = \beta_1 + \beta_2 PERF_{it} + \beta_3(PERF_{it} * LENGTH_{it}) + \beta_4 LENGTH_{it}$$

* The model is quoted from Krautmann and Oppenheimer (2006).

Estimated value of β_3 was negative.

Further research considering the contract length to be required.

Incentivised Contracts

- Ichiro Suzuki, Outfielder, 4-year contract with Seattle Marinars (2004-'07)
  - signing bonus- $6M
  - fixed payment- 04:$5M, 05:$11M, 06:$11M, 07:$11M
  - performance bonuses- $1.25M in performance bonuses for plate appearances
    - $50,000 each for 400 PAs, 2004-06
    - $0.1M each for 500 & 600 PAs, 2004-06
    - $0.1M for 400 PAs, 2007
    - $0.2M each for 500 & 600 PAs, 2007
  - award bonuses: $50,000 each for Gold Glove, All Star selection
  - trade-Protection (Veto for moving the team without his acceptance): limited no-trade clause (may block deals to 10 clubs)
  - Other
    - housing allowance: $28,000 in 2004, $29,000 in 2005, $30,000 in 2006, $31,000 in 2007
    - interpreter, trainer, transportation for spring & regular season
    - 4 annual round-trip airline tickets from Seattle to Japan

Incentivised Contracts

- Eric Sogard, 2nd-baseman, single-year contract with Milwaukee Brewers (2018)
  - fixed Payment- $2.4M
  - performance bonuses- : $0.15M each for 30, 50, 70, 90 games. $50,000 for 120 games
- Alex Avila, Catcher, two-year contract with Arizona Diamondbacks (2018, 2019)
  - Fixed Payment- 18:$4M, 19:$4.25M
  - annual performance bonuses: $25,000 each for 350, 400 plate appearances. $50,000 each for 450, 500 PA. $0.1M for 550 PA.

- We obtained details of the contracts about the active players in 2018 season from *Cot's*.
- Players receive additional performance-dependent rewards: Award bonus and index-dependent bonus.
- Few position players sign the contract with index-dependent bonus, and all of them are related to the number of attendance: Plate-appearances, games-attended