

Hitting with Runners in Scoring Position

Jim Albert

Department of Mathematics and Statistics

Bowling Green State University

November 25, 2001

Abstract

Sportscasters typically tell us about the batting average of a particular baseball hitter when runners are in scoring position. This quoted statistic is supposed to make us believe that the hitter performs unusually well in clutch situations during a baseball game. We first question whether a batting average is a good measure of hitting effectiveness and define an alternative measure of hitting success based on run values. A random effects model is fit to hitting data from National League batters in 1987 to learn about the batters' abilities and the true situational effects. Although players may have large observed situational effects for a particular season, there appears to be little evidence that players have different abilities to perform well in clutch situations.

1. Introduction

Baseball fans, sportswriters, and game announcers are generally fascinated with a player's ability to perform "in the clutch". In a baseball game, there are particular critical situations late in a baseball game where the winner of the game is still in doubt, and we are interested in the performance of players in these situations. The ability of a player to "hit in a pinch" has been an important subject for a long time, as indicated by Dick Rudolph's comment about the importance of batting averages in Lane (1925):

"To my mind, there is nothing more deceptive. I would much rather have on my team a player with an average of .270 who was a great hitter when hits were needed than a .350 hitter who wasn't much good in a pinch. It's the hits in the

Here we focus on hitting in one clutch situation – the performance of a hitter when there are runners on base in scoring position. Here "scoring position" means that the batting team has base runners on second or third base. These runners are said to be in scoring position since a single hit by the batter will likely score one or two runs for the team.

If you watch a baseball game on television, there will be times when the batting team has runners in scoring position, and the sportscaster will typically report the batting average of the hitter when runners are in scoring position. Suppose that the Indians are batting in an inning, and Roberto Alomar is batting with runners on second and third. We learn that during this season Alomar is batting .443 (31 hits in 70 at-bats) with runners in scoring position.

For a statistically minded baseball fan, this quoted batting statistic should motivate many questions:

1. First, is batting average (AVG) a good measure of the success of a hitter?
2. Is .443 a “large” batting average? Should this number impress us?
3. Does a player’s hitting ability depend on this situation? That is, does a player hit for a higher or lower average when there are runners in scoring position as opposed to when runners are not in scoring position?

2. Review of Previous Work

Albert (1993) and Albert and Bennett (2001, Chapter 4) explored situational hitting data. They focused on a hitter’s batting average and looked to see if a batter’s “true” batting average depended on the common situations, such as home vs. away games, grass vs. a turf field, the pitch count, and the game situation. What these authors found is that situations can be classified into three types. In the “no effect” situations, a hitter’s true batting average is the same for both situational categories. A day/night breakdown was an example of a no effect situation. Hitters appear to have the same probabilities of getting a hit during day and during night games. The second category of situation is a bias situation – here the probability of getting a hit increases by the same amount for all players. A home/away split is an example of a bias situation. Playing at home (as opposed to on the road) increases all players’ true batting averages by the same constant amount. The most interesting category of situations is an “ability effect”. Here the situation does change a batter’s true batting average, and the change in batting average is not the same for all players. An example of an ability split is the pitch count. Some players appear to have the same probability of hitting behind and ahead in the

count; other players' true batting average is significantly smaller when they are behind in the count.

One of the most interesting situations discussed in Albert (1993) and Albert and Bennett (2001) is the runners on base situation. They considered the split “runners in scoring position” vs. “bases empty, no outs” and investigated whether players' probabilities of hitting were dependent on this breakdown. What Albert and Bennett (2001) found was that a bias model was insufficient to explain the variation of hitting splits in these runners on base situation. Specifically, the spread of the differences in observed batting averages in the “runners in scoring position”/“bases empty, no outs situations” was greater than one would expect from a bias model. Although these authors found that there was evidence of an ability split, the evidence was not strong enough to discuss individual players who performed unusually well or poorly in the runners in scoring position situation.

3. The Data

Baseball historical play-by-play data has recently been publicly available due to the efforts of the Retrosheet organization (www.retrosheet.org) and Project Scoresheet. Retrosheet was founded in 1989 for the purpose of computerizing play-by-play accounts for as many pre-1984 major league games as possible. Other organizations, such as Project Scoresheet, have collected play-by-play data for games since 1984. One goal of these data collection efforts is to aid modern baseball statistical analyses that use performance measures that are dependent on this play-by-play information.

We focus on data from the National League 1987 season, since this is one of the most recent seasons for which the play-by-play data is downloadable from the Retrosheet web site. For each play in each game in this season, we have recorded (1) the name of the batter, (2) the number of outs, (3) the runners on base situation, and (4) the name of the play. From these data, we are able to look at the success of a batter's plate appearance as a function of the on-base situation and number of outs.

4. Value of a Plate Appearance

Before we can talk about situational effects, we should clarify what it means for a batter to have a successful plate appearance. When one uses batting average as a measure of hitting effectiveness, this is assuming that the only valuable plate appearances are the ones that result in base hits, and all possible hits are given the same value. Of course, this is not true. Batters can be successful when they receive a walk or when they drive a runner on third home with a sacrifice fly. Also, certainly an extra-base hit such as a double or home run is a more valuable hit than a single. So clearly, the batting average, which measures the proportion of official at-bats that are hits, is not the best batting measure.

George Lindsey (1963) was one of the first researchers to perform a detailed study on the transitions in plays during a baseball game, and these transitions can be used to define a success in a plate appearance. A game situation can be defined by the number of outs (0, 1, or 2) and the runners on base. Since each base (1st, 2nd, and 3rd) can either be occupied or not, there are a total of 8 on-base situations, and therefore there are $3 \times 8 = 24$ possible situations categorized by the number of outs and the runners on base. (We actually have $24 + 1 = 25$ situations if you add the final 3 outs situation at the end of a half-inning.)

Each game situation has an associated potential to score runs. For example, when there are no runners on base and 2 outs, then the run potential is relatively small. In contrast, the opportunity to score runs is high when the bases are loaded with no outs. Lindsey (1963) measured the run potential of a given (number of outs, runners on base) situation by the expected number of runs scored in the remainder of the half-inning. Table 1 displays the expected runs for each of the 24 situations using the 1987 National League data. Note that, when there are no runners on base with 2 outs, the team will score, on the average, only 0.1 runs, and when the bases are loaded with no outs, the expected runs scored is 2.15.

Table 1

Expected runs scored in remainder of inning from each of 24 possible (runners, number of outs) states.

		Runners
--	--	---------

		none on	1 st	2 nd	3 rd	1 st , 2 nd	1 st , 3 rd	2 nd , 3 rd	bases loaded
Number of Outs	0	.49	.85	1.11	1.3	1.39	1.62	1.76	2.15
	1	.27	.51	.68	.94	.86	1.11	1.32	1.39
	2	.10	.23	.31	.38	.42	.48	.52	.65

A player comes to bat in a situation that has a given run potential – we call this situation the “before PA state”. When he completes his plate appearance, the game situation has changed – this “after PA state” has a new run potential. The *transition value*, or more simply, the *value* of the hitter’s plate appearance can be measured by the difference in run potentials in the “after PA” and “before PA” states plus the number of runs scored by the play.

Value of plate appearance =

(Expected runs in end state) – (Expected runs in beginning state) + (Runs scored on play)

This measure, also called the *value added* approach, was suggested by Lindsey (1963), proposed in detail by Skoog in James (1987), and has been used in a series of reports by Ruane (1999).

Let’s illustrate this notion of value for two hypothetical batting plays. Suppose that there is one out and runners on 2nd and 3rd. From Table 1, we see that this situation has a run potential of 1.32 runs. Now suppose that the batter gets an intentional walk (a common scenario) and now the bases are loaded with one out. The run potential of this new situation is 1.39 runs. Since no runs have scored the value of this intentional walk is

$$\text{Value} = 1.39 - 1.32 + 0 = .07$$

This is a relatively small value. Essentially, this intentional walk hasn’t changed the team’s potential to score runs in this half inning. In a second scenario, suppose that there are runners on 2nd and 3rd with no outs. The run potential of this situation is 1.76 runs. The batter hits a sacrifice fly – the runner on third scores and the runner on second moves to third and there is now one out. The run potential of this situation is .94. The value of this play is

$$\text{Value} = .94 - 1.76 + 1 = .18$$

Although the player has created an out, it was a successful plate appearance since the value was positive. (Major League Baseball recognizes the value of this sacrifice fly by not counting this plate appearance as an official at-bat.)

Since there are 24 possible situations when the player comes to bat and 25 possible situations when the player completes his plate appearance, there are 24×25 possible transitions between situations. Table 2 shows the number of transitions using all plays during the National League 1987 season and Table 3 gives the associated values of these transitions. Actually, we see from Table 2 that many of the cells of the table have counts of zeros – these correspond to transitions that are either impossible or very unlikely to occur in baseball.

5. Some General Trends in Situational Hitting

Suppose we define a successful plate appearance as not producing an out. Table 4 displays the observed success probabilities for all 1987 National League players (including pitchers) using this traditional notion of success. In the beginning of the inning situation where there are no runners on and no outs, the success rate is .334. But as runners get on base, we see some large changes in the success rates. When there are runners on 2nd and 3rd with one out, the success rate is .481 – this large value is likely due to the intentional walk that will load the bases. Batters are generally more effective when there are runners on 2nd and/or 3rd and there are 1 or 2 outs. The least effective situations are the bases loaded situations – this is reasonable since the pitcher is reluctant to walk the batter and there are a number of ways of producing an out when the bases are loaded.

Table 4

Observed success rates for all 1987 National League batters where success is not creating an out.

		Runners							
		none on	1 st	2 nd	3 rd	1 st , 2 nd	1 st , 3 rd	2 nd , 3 rd	bases loaded

Number of Outs	0	.334	.328	.328	.376	.293	.309	.365	.271
	1	.322	.335	.362	.387	.303	.341	.481	.304
	2	.328	.329	.384	.381	.292	.323	.434	.273
	Not in scoring position			Scoring position					
	.329			.344					

Let's contrast these situational success probabilities with situational hitting data using the notion of value developed in Section 4. Table 5 displays the mean transition values for all 1987 NL players in the same bases/out situations. A different pattern of situational effects is evident from this table – the unusually small and large means are highlighted. When there are no runners on base and no outs, the mean value (.005) is close to zero. In contrast, the mean value is relatively large with (1) runners on 2nd and 3rd with no outs, (2) bases loaded with 1 out, and (3) runner on 3rd with no out, and there is a large negative mean value when there are bases loaded with no outs.

Table 5

Mean transition values for 1987 National League batters in all out/runner situations.

		Runners							
		none on	1 st	2 nd	3 rd	1 st , 2 nd	1 st , 3 rd	2 nd , 3 rd	bases loaded
Number of Outs	0	.005	.003	-.024	.048	-.014	.008	.141	-.062
	1	-.006	-.008	-.019	.004	-.022	.005	-.037	.082
	2	.000	-.012	.001	.002	-.022	.009	.014	.000
	Not in scoring position			Scoring position					
	-.001			-.004					

We can gain some insight on these observed situational effects by looking at the variation of the distribution of the transition values. When there are no runners on base, then the batter has little effect on the runs scored – an out or a hit produces small transition values and the variation in the values is small. In contrast, when the bases are loaded, there is a great variation in the transition value depending on the outcome of the plate appearance. We can measure the importance of a particular situation by means of the standard deviation of the transition values distribution (Albert, 2001). Figure 1 plots the standard deviation of the transition values against the mean value for all 24 situations

– each point is labeled by the situation (outs, runners) that it represents. Note that there is a fan-shaped appearance in the plot. As one moves from no-runner situations (on the left) to three-runner situations (on the right), there is more variation in the mean transition values. This means that hitters who get many opportunities to hit with two or three runners on base will tend to have more extreme (large or small) transition values.

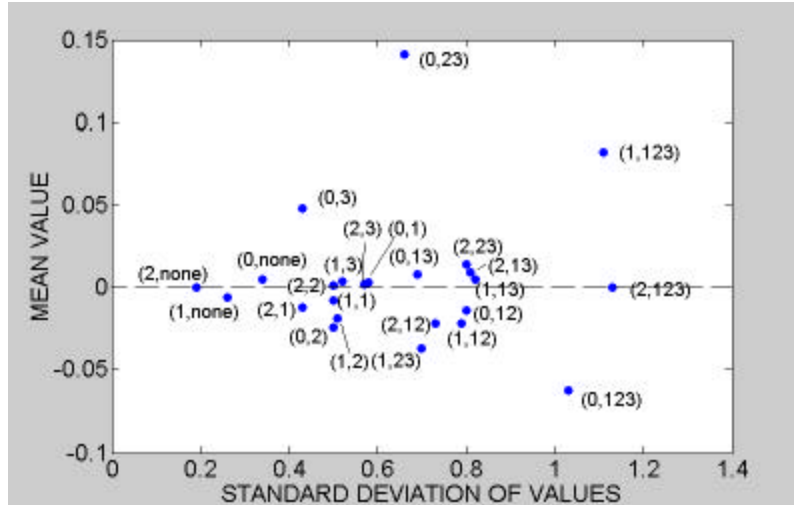


Figure 1

Scatterplot of standard deviation of values against mean value for all situations. Each point is labeled by the situation (number of outs, bases occupied).

Suppose we collapse the table into the two categories “not in scoring position” and “scoring position”. From Table 4, using the traditional notion of success of not creating an out, we see that hitters have a .015 point advantage with runners in scoring position. In contrast, using the notion of transition value, we see from Table 5 that hitters actually do a little worse (-.004 versus -.001) when runners are in scoring position.

Both Table 4 and Table 5 consider the mean situational effects of all batters including part-time players, pinch-hitters, and pitchers. Since the hitting abilities of these players vary greatly, it seems better to restrict our analysis to full-time players who had at least 300 plate appearances in 1987. With this restriction, we reduce our dataset to 105 players. Suppose for each player, we compare the situational effect

$d = (\text{Mean value with runners in scoring position}) - (\text{mean value when runners are not in scoring position})$

Figure 2 displays a dotplot of the situational effects for all full-time players. The median effect of the players is 0.006 and we see a wide range of effects from about -.195 to .187. A few extreme values stand out – Herm Winningham, Mike Aldrete, and Tim Teufel performed better in the “clutch” scoring position situation, and Steve Jeltz performed much worse when runners were in scoring position.

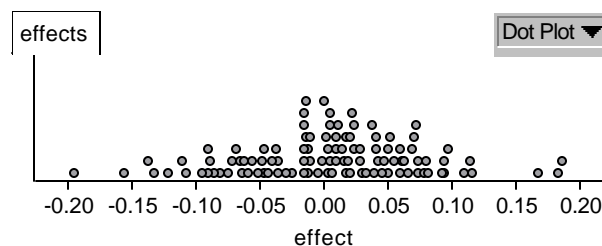


Figure 2

Dotplot of observed situational effects for National League players in 1987 with at least 300 plate appearances.

6. Modeling

To gain a better understanding of the significance of the observed situational effects that we see in Figure 2, we fit a model. For each of the 455 batters in the 1987 NL, we record the number of opportunities and mean value for each of the 24 situations. Table 6 shows the data for Kal Daniels, who will be seen later to be one of the most productive hitters in 1987. We note that Daniels typically came to bat when runners were not in scoring position. Also Daniels had a slightly larger mean value when runners were in scoring position.

Table 6

Number of plate appearances and mean value for the 1987 Kal Daniels in each of the 24 base/out situations.

Plate appearances

	NO	1 st	2 nd	3 rd	1 st , 2 nd	1 st , 3 rd	2 nd , 3 rd	Bases loaded
0 Out	173	16	0	0	3	1	2	0

1 Out	60	24	16	7	8	5	4	4
2 Outs	42	18	16	9	8	5	8	1
	Not in scoring position		Scoring position					
	333		97					

Mean value

	NO	1 st	2 nd	3 rd	1 st , 2 nd	1 st , 3 rd	2 nd , 3 rd	Bases loaded
0 Out	0.12	0.08	0	0	-0.10	0.78	0.64	0
1 Out	0.02	0.00	0.38	0.12	-0.23	0.29	0.45	-0.14
2 Outs	0.05	0.03	-0.05	0.34	-0.05	-0.35	-0.11	-0.65
	0.080		0.084					
Situational Effect	.084-.080=.004							

These data are recorded for all players in all situations – we let y_{ij} denote the sample mean value and n_{ij} the number of plate appearances of the i th player in the j th situation. We suppose that the mean value y_{ij} is normally distributed with mean \mathbf{m}_j and variance \mathbf{S}_j^2/n_{ij} . (As shown in Figure 1, the variability of the transition values depends on the situation, so it would be inappropriate to assume equal variances across situations.) The parameter \mathbf{m}_j represents the batting ability of the i th player in the j th situation. We represent all of the batting abilities by the following matrix.

	situation 1	situation 2	...	situation 24
player 1	$\mathbf{m}_{1,1}$	$\mathbf{m}_{1,2}$...	$\mathbf{m}_{1,24}$
player 2	$\mathbf{m}_{2,1}$	$\mathbf{m}_{2,2}$...	$\mathbf{m}_{2,24}$
\vdots	\vdots	\vdots	\ddots	\vdots
player 455	$\mathbf{m}_{455,1}$	$\mathbf{m}_{455,2}$...	$\mathbf{m}_{455,24}$

We consider an additive model for these data consistent with our beliefs about the basic probability structure of situational data (see Albert (1993) and Albert and Bennett (2001)). First, it is clear that players have different abilities to hit, and it is reasonable to assume that the population of hitting abilities is a normal distribution with unknown mean and variance. Second, we assume the effect of any particular situation, say runners on 2nd and 3rd with one out, is a bias. That is, there may be a general positive or negative

effect of hitting with runners on 2nd and 3rd and one out, and this effect is the same for all players.

The above comments motivate the consideration of an additive model with random effects. We write the batting ability of the i th player in the j th situation as

$$\mathbf{m}_{ij} = \mathbf{a}_i + \mathbf{b}_j,$$

where \mathbf{a} represents the ability of the i th player and \mathbf{b}_j is the effect due to the j th situation. We assume that the player abilities $\mathbf{a}_1, \dots, \mathbf{a}_N$ are random effects – they are distributed from a normal distribution with unknown mean and variance \mathbf{m}_a and \mathbf{s}_a^2 respectively. The parameter \mathbf{m}_a represents a typical batting ability for all batters and \mathbf{s}_a^2 measures the disparity of the abilities across players. The effects for the 24 base/out situations are represented by the terms $\mathbf{b}_1, \dots, \mathbf{b}_{24}$. A situational effect \mathbf{b}_j essentially shifts the normal ability distribution by a constant amount. This means that batters may tend to bat better in a particular situation, say with runners on 2nd and 3rd with no outs, but the benefit in this batting situation is the same for all players.

7. Fitting and interpreting the model

The random effects model described in Section 6 was fit to the hitting data for all 1987 National League hitters. We first describe the estimates for the situational effects, then the estimates of the batters' abilities, and then discuss if this model appears to be a suitable fit to the data.

Table 7 shows the estimates and associated standard errors of the situational parameters $\mathbf{b}_1, \dots, \mathbf{b}_{24}$. The pattern in these estimates mirrors the table of mean values presented in Table 5. The advantage of this model fitting is that we can judge the significance of these estimated effects by use of the corresponding standard errors. The most significant effect appears to be runners on 2nd and 3rd and two outs (the size of the estimate is over double the standard error) – batters do appear to hit better in this situation. Note that the standard errors for the situations “no runners on”, “runner on 1”, and “runner on 2nd” are the smallest, since these are common situations in baseball and the estimated effects are based on relatively large sample sizes. So there appear to be

some situation biases in hitting. There appear to be some advantages (and disadvantages) to hitting in particular situations during a baseball game.

Table 7

Estimates of the situational effect parameters $\{ \mathbf{b}_j \}$ in the random effects model. The standard errors of the estimates are given in parentheses.

		Runners							
		none on	1 st	2 nd	3 rd	1 st , 2 nd	1 st , 3 rd	2 nd , 3 rd	bases loaded
Number of Outs	0	.006 (.006)	.006 (.009)	-.019 (.012)	.031 (.021)	-.008 (.020)	.005 (.023)	.057 (.025)	-.013 (.032)
	1	-.003 (.005)	-.005 (.008)	-.017 (.010)	.002 (.016)	-.015 (.017)	.003 (.022)	-.021 (.021)	.032 (.027)
	2	.002 (.005)	-.009 (.008)	.000 (.009)	.001 (.014)	-.013 (.014)	.008 (.020)	.009 (.022)	.002 (.026)

The estimates at the mean and standard deviation of the random effects distribution are given by $\hat{\boldsymbol{\mu}} = -0.021$ and $\hat{\boldsymbol{\sigma}}_a = 0.035$. With respect to our value measure, the population of batting abilities is estimated to be a normal curve with mean -0.021 and standard deviation 0.035. Although this is not the focus of this paper, it is interesting to look at the estimates of the batting abilities $\hat{\mathbf{a}}_1, \dots, \hat{\mathbf{a}}_{455}$. The basic estimate at a player's batting ability is the mean value over all plate appearances. Figure 3 displays a scatterplot of these basic estimates against the ability estimates using the random effects model. Note that many of the points are in the lower left portion of the plot – these points correspond to the large group of part-time players and pitchers that were relatively weak hitters and had negative mean values. Many of the 1987 NL players had only a few plate appearances and their mean value estimates are based on small sample sizes. These observed means are pulled strongly towards the average value estimate for all players – this behavior of the estimates is a byproduct of the distribution placed on the random abilities. A few points are labeled – there is a cluster of five points that correspond to players with large ability estimates, and there is a lower cluster of three players (all pitchers) who had low ability estimates.

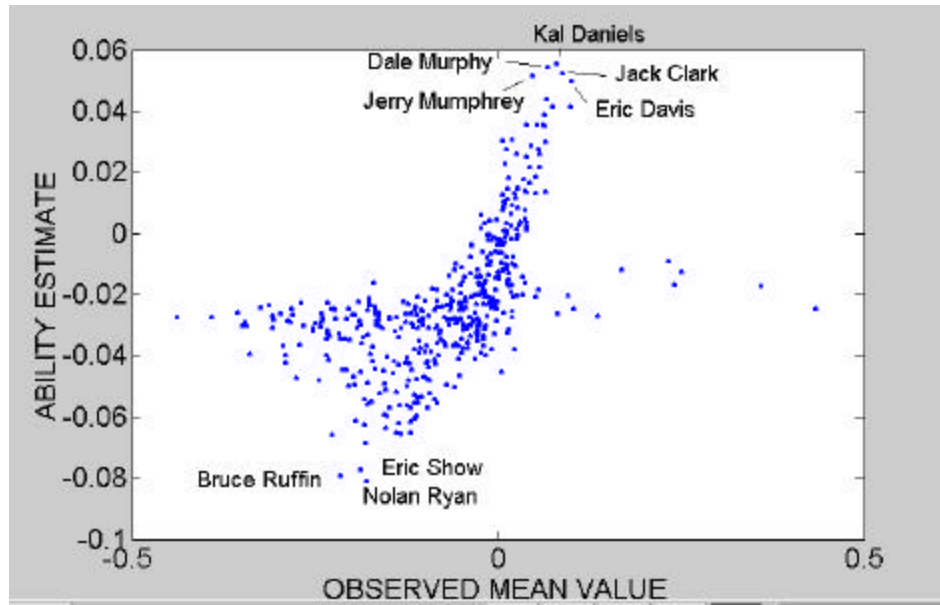


Figure 3

Scatterplot of observed mean values and ability estimates for all 1987 National League players.

This model makes the important assumption that the hitting effects due to runners in particular base/outs situations are biases. But in Figure 2, we saw that some full-time players hit much better with runners in scoring position and other players do much worse in this clutch situation. We wonder if this large variation in situational effects is due, in part, to players' different abilities to take advantage of the "runners in scoring position" situation. If so, this bias model that we fit too simplistic – situational effects do depend on the players. We can measure the variation in the observed situational effects shown in Figure 2 by the standard deviation of the effects $s = 0.0695$. We wonder if this standard deviation value is consistent with the bias model that we fit.

We checked the suitability of this random effects model by means of a posterior-predictive strategy (Gelman et al (1995), Chapter 6). From the fitted model, we simulate sets of datasets from the posterior predictive distribution. In each simulated dataset, we compute transition values for the full-time players when runners are and are not in scoring position and computed a set of situational effects. The intent of this analysis was to see if the spread of the situational effects shown in Figure 2 was unusually large compared to the spreads of the effects predicted from the model. The conclusion from

this analysis was that the distribution of situational effects for the 1987 full-time players was indeed consistent with this model, and therefore the model was a suitable fit.

8. Final Remarks

This paper was motivated by the quote that Roberto Alomar is batting .443 when runners are in scoring position. How should we react to this “clutch” hitting statistic?

1. When one computes a batting average, implicitly one is saying that a success in a plate appearance is a base hit. Since the objective in hitting is to create runs, there are better definitions of a successful plate appearance than a base hit. Here we use a continuous measure of success, a transition value, defined to be the change (from before and after the plate appearance) in run value, where a run value is the expected number of runs scored for the bases and outs situation.

2. If we look at the mean transition values of hitters in the 24 possible outs/bases situations, we find that generally hitters can be more successful in some specific situations, such as runners on 2nd and 3rd with no outs. However, due to chance, there is a large variation in the difference in mean transition values of hitters when runners are and are not in scoring position.

3. We fit a random effects model to explain the pattern in the transition values for all players. This model said that players have different abilities and a particular outs/bases situation has the same additive effect to each player’s batting ability. The model appeared to be a good fit to the 1987 National League hitting data.

In summary, it is likely that the reported Alomar batting average in the clutch situation for a given season does not reflect any meaningful ability of Alomar to perform better in clutch relative to non-clutch situations. Clutch hitting effects, if they exist, are likely small in magnitude and detectable using player data from many seasons.

There is a relatively large literature on the existence of clutch hitting in baseball -- see Bronstein (2001), James (1984), Grabiner (1993), Neyer (1999) and Zaidlin (1999) for some recent work. The conclusions from all of these papers echo the results found here -- the authors find little evidence of clutch ability in baseball data. Moreover, James (1984) questions if it is even meaningful to search for clutch ability in baseball without a clear understanding of this hitting characteristic:

“No one doubts that over the course of a season, clutch performance exists. When the scoresheets are available, and the issue can be studied for a year, we will most certainly find that some players have had an impact beyond what their numbers would suggest. What is subject to question is that this represents an ability. If there is such a thing as “clutch ability,” then exactly what is it? We know what its signs would be, but what is it? How is it that a player who possesses the reflexes and the batting stroke and the knowledge and the experience to be a .260 hitter in other circumstances magically becomes a .300 hitter when the game is on the line? How does that happen? What is the process? What are the effects? Until we can answer those questions, I see little point in talking about clutch ability.”

References

Albert, J. (2001). Using Play-by-Play Baseball Data to Develop a Better Measure of Batting Performance. Technical report, Department of Mathematics and Statistics, Bowling Green State University.

Albert, J. and Bennett, J. (2001). *Curve Ball*, Copernicus Books.

Bennett, J. M. and Flueck, J. A. (1983). An evaluation of Major League Baseball offensive performance models. *The American Statistician*, 37 (1), 76-82.

Bennett, Jay (ed.) (1998), *Statistics in Sport*, London: Arnold.

Bronstein, D. (2001), “Clutching for Straws”,
<http://www.sportplanet.com/som/articles/bronstein02.htm>

Gelman, A., Carlin, J. B, Stern, H. S., and Rubin, D. B. (1995), *Bayesian Data Analysis*, New York: Chapman and Hall.

Grabiner, D. (1993), “Hitting with Runners in Scoring Posit
<http://www.geocities.com/Colosseum/Park/1138/study-risp.html>

James, B. (1984), *The Bill James Baseball Abstract 1984*, New York: Ballantine Books.

James, B. (1987). *The Bill James Baseball Abstract 1987*, New York: Ballantine Books.

Lane, F. (1925). *Batting*, Cleveland: Society for American Baseball Research.

Lindsey, G. R. (1963). An investigation of strategies in baseball. *Operations Research*, 11, 4, 477-501.

Neyer, R. (1999), "Clutch Hitting," <http://www.diamond-mind.com/articles/neyerclutch.htm> Thorn, J. and Palmer, P. (1985), *The Hidden Game of Baseball*, New York: Doubleday.

Ruane, T. (1999), Value added batting data 1980-1998, Baseball Think Factory.

Skoog, G. R. (1987). Measuring runs created: the value added approach. In James, B. *The Bill James Baseball Abstract 1987*, New York: Ballantine Books.

Zaidlin, M. (1999), "Some Help for Team Owners: Ten Questions to ask the Next General Manager," <http://www.thinkingbaseball.com/Articles/99032501.html>