Measurement and Evaluation of Managerial Efficiency in MLB

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June 23, 2004

PRELIMINARY DRAFT: Please do not cite.

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I. Introduction

Managers of a Major League Baseball franchise, like managers and head coaches in other team sports, may contribute to the success of the franchise along several dimensions. These include the making of strategic decisions within a game, allocating talent between positions, coaching or otherwise interacting with players, and occasionally assisting in personnel decisions. To examine all of these aspects comprehensively is beyond the scope of a short paper.

Here, we analyze and document variation across managers and over time in two strategic choices: sacrifice bunts and aggressiveness in running the bases. These elements of the game have been disparaged in recent years as "little ball," yet there are game conditions where base stealing and/or bunting are clearly optimal. We characterize these conditions using standard economic concepts, and explore managerial choices empirically. Although we find that managerial choices to bunt and run are well characterized by economic factors, we also document significant differences among managers in their propensity to bunt and run.

A common interpretation of Michael Lewis' *Moneyball* (2003) is that it puts the final analytical nail in the coffin of little ball. This is not accurate. Lewis did extol the Oakland A's strategic approach of station-to-station, wait-for-the-big-blow baseball. But Lewis also notes that this approach to the game is not a new innovation. The "big ball" strategy "was championed most vocally" (p. 78) by Orioles manager Earl Weaver in the 1970s. Furthermore, the A's eschewing of the running game was not shaped by the idea that taking an extra base is unproductive, but rather because of their finding that "foot speed, along with fielding ability and raw power, tended to be dramatically overpriced"

(p. 33). The *Moneyball* thesis is about winning games at minimum cost, a task at which the A's have been masters.

The strategy of the Oakland A's, as *Moneyball* makes clear, has focused on the acquisition of underpriced inputs. In this paper we hold each team's composition constant, and ask, given inputs, when does it make sense to run, and when to bunt? Which managers bunt excessively, and what is the price they pay? These are the questions addressed in this paper.

We begin in section II by describing the data, and illustrating changes over time in the propensity to bunt and steal bases in professional baseball. Section III applies standard economic concepts to model when it makes sense to bunt and run. These concepts provide the basis for the empirical analysis that follows.

II. Changes in the propensity to bunt and run over time

The data we analyze comes from Project Retrosheet, which provides detailed information for every play in major league baseball for the period 1977-1992.[1] The data specific to each play record the teams involved, the players at each position, the score, inning, number of outs, and the outcome of the play. Most relevant for our analysis, we know if a bunt or stolen base attempt took place, and the origins and destination of all base-runners.

Our focus in this paper is on the use of "little ball" strategy, an important element of which is the sacrifice bunt. In a sacrifice bunt, the batter intentionally bunts the ball in

[1] As per the policy of the Retrosheet organization, the following statement is included with the citation information: "The information used here was obtained free of charge from and is copyrighted by Retrosheet. Interested parties may contact Retrosheet at 20 Sunset Rd., Newark, DE 19711." God Bless Retrosheet.

order to enable a base runner to advance, knowing that he himself will most likely be thrown out at first base. This strategy has come under attack by statistical analysts of baseball, because it intentionally offers the defense the opportunity to make a rather simple out. Outs are the ultimate scarce resource to a batting team – once the third out is obtained in an inning, scoring ceases no matter how advantageous the position of the batting team at the time. Hence, intentionally reducing their number of outs in an inning in order to obtain an advantageous scoring position involves a tricky tradeoff, one that we evaluate in the next section.

For now, we note that sacrifice bunts are ruled out by definition with two 2 outs in an inning, and are a dubious proposition when there is one out prior to the ball being put in play. Hence, we focus on two common instances: a runner on first base with no outs, and runners on first and second base with no outs. Table 1 lists the proportion of plate appearances in these situations that the batter bunted for each year between 1977 and 1992. In calculating the propensity to bunt in these situations we have also limited the sample to instances in which the batter is one of the first seven batters in the lineup, in order to avoid differences between the leagues caused by use of the designated hitter in the American League. In nearly all years, American League teams were more likely to bunt with runners on first and second base, but the situation with a runner on first shows an interesting time trend.

This trend is illustrated in Figure 1. Figure 1a shows the propensities to bunt with a runner on first, using all nine positions in the batting order. After removing the number eight and nine hitters, the trend in Figure 1b shows that bunts dropped sharply in the American League from 1978 to 1983, and have risen only slightly since. In the National

League, the drop in bunt rates was not as pronounced, and rebounded during the 1988-1992 period to pre-1981 levels.

The time trend for bunts with runners on first and second base in Figures 2a and 2b both show the same decline in bunt rates from the beginning of the sample through the early 1980s. The two main differences are that bunt rates increase in the American League in the late 1980s similarly to the National League, and that American League bunt rates generally remain higher than those in the NL throughout the sample.

As bunts and stolen bases are alternative ways to advance base runners without the benefit of a base hit, one might expect stolen base attempts to increase during the years in which bunts were less common. Table 2 lists time trends in stolen base attempts to examine the possibility that bunts and steals are strategic substitutes.

A team technically has an opportunity to steal a base any time that it has a runner on base. But steals of home plate and third base are much more difficult to successfully execute than steals of second. Steals of home are quite rare, and in the modern era are usually accomplished in conjunction with a steal of second in a play known as a "double steal." Stolen bases of third are more common than those of home plate, but not only are much less frequent than steals of second, but seem to be closely correlated with steals of second. Consequently, we limit our analysis to opportunities to steal second base without analytical loss. An opportunity to steal second is defined as any time a runner is on first and second base is unoccupied. This means that the team has either a lone runner on first base, or has runners on 1st and 3rd. An opportunity is considered ended when either the runner attempts a stolen base, or the batter concludes his plate appearance without a stolen base having been attempted. Stolen base attempts have a dichotomous result of either a stolen base (SB) or a caught stealing (CS), so that success percentages are simply SB/(SB+CS).

Table 2 contains three findings of interest. First, the National League (NL) has consistently shown higher rates of stolen base attempts. Some, but not all, of this difference is due to the use of the designated hitter in the American League (AL), which replaces the pitcher's spot in the order with a batter of higher offensive ability. Second, the higher rates of stolen base attempts in the National League are not due to managerial recklessness, in either absolute or relative terms. Looking at the absolute stolen base success rates, the NL has higher rates of successful steals in 14 of the 16 seasons studied. One possible reason for the higher success rate may be the result of roster selection, as teams knowing that they'll need to run more often will choose to sign faster runners, other things equal. Third, both leagues share a distinctive time trend in aggressiveness.

The National League experiences an increase in stolen base attempts just as bunt attempts decrease, suggesting that the two strategies are substitutes. The American League trend, however, is just the opposite, as steal attempts drop over the same 1977-1992 period when bunt attempts dropped, and with the exception of one-year spikes in 1987 and 1992 remain low throughout the remainder of the sample, as did bunt rates.

The overall evidence from the summary statistics in Tables 1 and 2 regarding the substitutability of bunts and steals is inconclusive. Section III will present a model allowing us to control for game context in an attempt to obtain a clearer picture.

III. A Model of Managerial Decision-Making

Our analysis is conducted on a smaller scale than a study of franchise strategies. While the objective of the franchise may be modeled as the maximization of discounted profits, or possibly the utility maximization of its owner, many of the decisions and parameters of those functions are outside the control of the field manager. The manager's objective is to maximize team wins, given the roster of players placed under his charge. Since the play of a baseball game is separable into its offensive and defensive components, and base running and bunting are both relevant only when the team is batting, we shall further reduce our scope to consider the objective of the team while on offense.

At its most basic, the objective of the offense is to score more runs while exhausting its stock or budget of 27 outs – broken into 9 innings of 3 outs each – than it expects its defense to allow while the opponents bat. This is not quite the same as maximization of team's runs scored with a given lineup, as in certain game situations it may be better to "play for one run" with a high probability than take a chance on scoring several runs, but with an increased chance of not scoring at all.

Somewhat more formally, the function is

max p(win) = f(h, d, i, o, b, l, X, s), where (1)

h indicates whether the team is home or away,

d is the current run difference between the team's score and its opponents,

i is the inning number,

o is the number of outs already recorded in the current half-inning,

b is a measure of the runners currently on base, l is the spot in the lineup from which the team is currently batting,

X is a vector of other game conditions, including expectations about the opponent's future ability to score, the relative quality of batters within one's own lineup, field characteristics and other relevant controls, and

s is the choice of strategy by the manager.

With this specification, we decline to consider several managerial decisions which are of potential interest. For the moment we assume that such decisions, which include the selection of the starting lineup and the timing and number of player substitutions during the game, are made equally well by all managers.

As indicated in equation (1), decisions to steal or to bunt should depend greatly upon game context. Table 3 attests to this by presenting cross-tabulations of the use of the bunt by managers in the early and late innings of games. The situations included in the calculations in Table 3 include only those in which the score is within two runs of being tied, and with runners on first or on first and second bases. Within these contexts, the probability that a team will bunt doubles in the late innings, as the benefit from one run becomes more important than the possibility of a big inning relative to their values earlier in the game.

For stolen bases, information on the hitting ability of the batter and the running ability of the man on first base are important determinants of the success of an attempt, and the value of a steal should the attempt be successful. Table 4 breaks down stolen base attempts by outs and lineup position to show how managers work with the heterogeneity of the players in their lineup by adapting their tactics to acknowledge the talents of the runner, the batter at the plate and the upcoming prospective batters.

A prototypical lineup places one or two fast players with high probabilities or reaching base at the top of the order. One of these "table setters" is then more likely to be in scoring position when the more powerful 3-4-and-5 batters come up in the "heart of the order". The weaker hitters, who are less likely to reach base and less likely to drive in a runner, are buried at the bottom of the lineup where they will have fewer plate appearances. The extreme example of this is the "pitcher's spot" at the bottom of the batting order in the National League, as even the best-hitting pitchers typically only hit as well as a marginal position player.

Panel A of Table 4 shows the empirical stolen base attempt rates for a given number of outs and the batter's position in the batting order. The probability of attempting a steal of second base generally increases as the number of outs increases. To oversimplify just a bit, one can think of this as occurring because the likelihood of getting multiple hits to score a runner from first drops faster than the likelihood of getting one hit to score a runner from second as outs increase.

The other clear component of the pattern of stolen base attempts is the much higher probability that a runner will attempt a steal when the #2, 3 and 4 batters are up, despite their generally better ability to advance runners. This is largely due to the even higher difference in the runner speeds as the lineup proceeds. The leadoff hitter is quite often also the fastest runner, and as such will have a higher probability of success. This conjecture is borne out in Panel B, which shows that success rates do not suffer for the additional attempts.

There are only two exceptions to the general pattern of stolen base attempts described above. First, there is more likely to be a stolen base attempt with no outs than with one or two out when the number two hitter is batting. This is because a caught stealing with one or two outs increases the probability that the batters in the middle of the order will come up with no one on base to drive in, and this cost is not worth the potential gain of one runner moved into scoring position, especially when the number two batter is usually selected based upon his ability to get on base and advance runners with his hitting.

The other exception to the pattern of increasing attempt rates as outs increase is when the number nine batter is up with two out. There, the possibility of a runner stranded on first is relatively less onerous than the chance that the runner is caught stealing and the team has to lead off the next inning with their worst hitter at the plate, especially as the probability of the number nine hitter driving in the runner from second would still be quite low.

Another important aspect of game context is the ability of managers to "play to the score." There are game contexts, particularly in the late innings of close games, where one run is marginally very important and may become more important than the prospect of a big inning. To look at the importance of inning and score differential to stolen base decisions, Table 5 presents attempt rates, success rates, and calculated optimal success rates by inning and run difference in a way analogous to Table 4.

Panel A of Table 5 shows that in games where the score is tied, attempted steals remain mostly constant as the game progresses. The reduction in attempts and the increasing success rates for other score differentials as the game progresses suggests that managers become more conservative in the late innings.

Another characteristic of the pattern of attempted stolen bases in Panel A of Table 5 is that attempts to steal decline sharply as the score differential increases[2], and that for a given run difference, the team that is ahead is more likely to attempt a steal than is the team that is trailing. The very high success rates in lop-sided games are likely due to baseball's unwritten rule to shut down the running game to avoid "running up the score" or "running oneself out of the game."

While cross-tabulated success rates are informative to some extent, this analysis does not allow one to control for changes in other variables the way multivariate regression analysis does. Tables 6 and 7 show the results of probit regressions estimating the probability of bunts and stolen base attempts after controlling for game context, batter and runner ability, variation in the propensity to steal bases across time, and managerial preferences. The regression equation then becomes

$$Z(\text{bunt/stolen base attempt}) = \alpha + \beta B + \gamma G + \delta R + \theta L + Y_t + M_i + \varepsilon \qquad (2)$$

where

Z is the Z-score for the standard normal distribution, as an input into the probit function.

B is a vector of batter characteristics measured by

OBP – on base percentage

SLG – slugging percentage,

G is a vector of game situation characteristics (inning, outs, score, home/away),

R is the runner's ability,

L is the league effect,

[2] It is this characteristic that leads to the apparent increase in stolen base attempts in extra innings. This is just an artifact of the necessarily close scores in extra-inning games. Holding run differential constant, the trend towards additional conservatism on the bases continues as the game wears on.

Y is a vector of year fixed-effects,

M is a vector of managerial fixed-effects,

α, β, γ, δ, and θ are coefficients, and

ε is the stochastic error.

Table 6 presents the results of the probit regression on bunt attempts. American League managers, other things equal, bunt more often than National League managers. Bunts are much less likely when a player with a high slugging percentage is at the plate. The positive sign on on-base percentage is due to multicollinearity with slugging percentage. With slugging percentage omitted in Model (2), the estimated effect of on-base percentage is strongly negative (the t-ratio is -33.1). Batters who are less likely to make an out are less likely to bunt, as theory predicts. All other signs of significance are unaffected by the exclusion of slugging percentage.

There are significant batting order effects, as bunts are more likely by the number 8 hitter, and when pitchers are at bat. The measured effect for pitchers likely reflects the noisier signal from the OBP and SLG statistics, given they have far fewer at bats, and may also reflect a desire on the part of managers to rest the pitcher between innings. Compared to the situation in which the team is down by two runs, bunts are 13-16% more likely when the score is between one run down and two runs up. The annual fixed effects verify the dip in bunt attempts in the mid-1980s. Relevant to the discussion in the next section, bunts are much more likely in late inning and extra inning situations. Further, this effect is more pronounced for the home team. We will see that this is consistent with optimal choice of strategies by managers, given an objective of maximizing the probability of winning a game.

The probit model for stolen base attempts presented in Table 7 is constructed similarly. One addition made to this model controls for the speed of the runner, as calculated from his statistics at the end of the season. As will be explained below, the break even stolen base percentage of 66.1% suggests that a player with that success rate is neither helping nor hurting the club with his speed. As our measure of running speed, we take the player's net stolen bases and scale that to a basis of one stolen base attempt per game:[3]

Speed of runner = (SB – (661/339)*CS)*(162/opportunities) (3)

The constructed speed variable provides statistics which are consistent with intuition. Runners who managed large numbers of steals per season while maintaining high success rates, such as Rickey Henderson and Vince Coleman, have the highest speed scores. But aggression is controlled for, so that given two players with the same number of opportunities, the player with 15 steals in 18 attempts has a speed rating similar to a player with 33 steals in 45 attempts.

The regression coefficients for inning, outs, position in the batting order and score differential all match those described in Tables 4 and 5. There are four results, however, which are not indicated in the previous tables.

First, American League managers are less likely to attempt stolen bases than NL skippers, even after controlling for faster base runners, the effect of the pitcher's spot in the order, and differences in on-base percentage and slugging percentage of the hitters.

Second, steal attempts increase as the on-base percentage of the batter increases. This is because the gains from being on second base increase, as the batter is more likely

[3] For runners with fewer than 10 opportunities, Speed of Runner was set to zero to avoid the effects of potential outlier observations.

to drive the runner in from there. The third result, that increases in slugging percentage lead to fewer stolen base attempts, is due to similar reasoning, in that for a power hitter, first base *is* scoring position, and that the potential loss of a runner is more costly when a potent slugger is at the plate.

Finally, faster runners are more likely to attempt to steal. This is less valuable for its confirmation of the obvious than for the assistance this variable adds as a control when looking at other effects, such as inter-league differences, or in differences in attempted steal rates between managers such as those calculated in Section IV.

IV. Managerial styles and strategic efficiency

While the probit results in Tables 6 and 7 demonstrated how managers adjust their strategies to fit the context of a game, in order to determine whether these adjustments are efficient, we need to know more about the alternative strategies and outcomes. To do so, we make use of generic estimates of the probability of winning, given any state of the game. The method used to calculate these probabilities is discussed in detail in Hakes and Sauer (1993). For our purposes here, it suffices to note that the probability of winning is specific to league, team (home or visitor), inning, and runners on base.[4]

Table 8A presents some example situations where bunts are possible and shows how the benefits and costs of a bunt attempt vary by game context. Eight contexts are shown, using all permutations of home team versus visiting team batting, 5th inning

[4] Hakes and Sauer (2003) used data from 1999 and 2000. In this paper, and subsequent work to follow, our probabilities are based on the distribution of scoring in the retrosheet data, from 1977 through 1992. The differences in the distribution of scoring are minor. In addition, our earlier work did take account of the difference in scoring between leagues or between home and away teams. Although differencing probabilities before and after each play tends to mitigate any bias from ignoring these factors, for completeness, our current work incorporates the fact that the AL scores more runs than the NL, and home teams tend to outscore the visitors, yielding a small difference in the probability of winning at the start of the game (and in each inning when the game is tied).

versus 9th inning of the game, and a runner on first versus runners on both first and second. The first column of Table 8A lists the ex ante probability of the batting team winning the game from that context given that there are no outs and the score is tied at the time of the bunt opportunity. Columns 2 through 5 depict the changes in the batting team's probability of winning as a result of a successful sacrifice bunt, a routine out that does not advance the runners (such as a fly out or strikeout), a double play, or a base hit. In each instance, the base hit is unambiguously positive, as it improves the base runner position without the cost of an out, while the out and the double play are both harmful. For the visiting team, either a double play or a single out with a runner on first will lower its chances of winning the game below 0.500. The change in probability as a result of a bunt can either be positive or negative, depending on context, as base position is gained as an out is lost. For each situation listed in which there is only a runner on first, the gross change in winning probability from a bunt is negative, while the effect is slightly positive in three of the four situations with runners on first and second.

A negative sign for the change in the probability of winning in the bunt column does not mean that a bunt is always a bad strategy, as the context does not include variation in batter ability. Taking the first scenario in Table 8A as an example, if the batter was of such poor quality that he would almost surely make an out if allowed to swing away, a loss of 0.018 is preferable to a loss of 0.044. Given information or assumptions about the relative likelihood of double plays as opposed to other types of outs, and the relative likelihood of different types of base hits (single, double, triple, homerun) a critical OBP can be calculated at which the manager is indifferent between bunting and letting the hitter swing away.

We can illustrate the effects of context on the decision to bunt by showing how the critical OBP changes with game context. For simplicity, assume that sacrifice bunts succeed with probability 1, that all attempts to swing away either result in an out with no baserunner advancement (i.e. no double plays or "productive outs) or a hit. In the case of a hit, we assume the minimum: that any runners advance only one base. Hence, a single and a walk change the state of the game in the same way, and we can focus solely on a single index of batter proficiency, OBP, i.e. his ability to avoid making an out.

The critical OBP equalizes the post-at-bat probability of winning the game, and can be easily calculated from the figures in Table 8A. The results of the calculation are listed in Table 8B. Given the assumptions, the critical OBPs themselves should not be taken literally – power hitting in particular is not factored in. The manner in which they change is revealing however. The critical OBP is much higher in the 9th inning than the 5th, thus making a bunt a useful strategic option for more batters late in the game. There is a home team differential as well: the critical OBPs are higher for the home team than the visiting team, with the difference increasing as the game wears on. Finally, the double play (a potential cost of swinging away that is ignored in the critical OBP calculation for simplicity, but still relevant for decision-making), is almost twice as high in the 9th inning as in the 5th. All of these factors make bunting a better strategic choice later in the game.

A similar approach can be taken in the analysis of stolen base attempts, by determining the point at which the team's stolen base attempts only marginally improve its probability of winning a ball game. The stolen base percentage (SB%*) at which this occurs is a function of the probability of winning under three conditions: the probability of winning given no attempt (P_NA); the probability of winning if there is a successful stolen base (P_SB); and probability given the runner is caught stealing (P_CS). The formula is:

$$SB\%^* = \frac{P\_NA - P\_CS}{P\_SB - P\_CS} \tag{3}$$

These probabilities, however, are not an economic optimum. To see this, suppose that all stolen base opportunities are ranked from most to least tempting. Then, as stolen base attempts increase, the expected change in win percentage from the marginal steal attempt will be lower than the average outcome from previous attempts except in the special case where all stolen base opportunities are equally desirable. Similarly, the expected change in win percentage for the marginal stolen base attempt will not necessarily equal the average of previous non-attempts, although whether the direction of the difference is less certain.

If the marginal effect is stronger on the attempt function than the non-attempt function, or if the expected change in win percentage for the marginal non-attempt is higher than the average, the point SB%* will underestimate the win-maximizing stolen base percentage. Managers exhibiting a success rate of less than SB%* can expect to win fewer games than if they didn't run at all.

In general, managers use the stolen base as economic theory predicts. Of the 78 managers who managed more than 40 games in at least two of the seasons in our sample, 67 of them had expected PGPs when attempting a steal that were at least as large as the expected PGP when swinging away, given a stolen base opportunity. Of the eleven exceptions, six attempted to lessen the damage by running significantly less often in any given context than the baseline manager in Table 7, while only two (Jeff Torborg and Bob Lillis) were more aggressive than the baseline manager.

Table 9 has calculated the stolen base success rate that makes a team indifferent between utilizing steals and not running, holding constant batter and runner abilities across situations. The patterns suggested by the probit regression in Table 7 are echoed here, as additional conservatism is warranted in the ninth inning and extra innings, particularly by the home team, and running becomes a less appealing strategy when one's team is trailing in the game. A comparison of Table 9 to Panel B of Table 4 shows that managers' stolen base attempt rates very closely match the pattern of breakeven points.

As a managerial economics exercise, it would be interesting to see if there are systematic differences in the propensity to steal between managers, and if these differences correlate with team success or managerial tenure. But a simple look at the number of team stolen bases, or the team's percentage of successful stolen bases, is not likely to convey that information due to differences in team speed. While over time, a manager might get a chance to help shape a team to fit his managerial style, so that an aggressive base-running manager might petition to sign faster players while a station-to-station style manager might advocate signing slow sluggers, a new hire (and particularly a first-time manager) is less likely to have that kind of control over the roster's composition. But with the inclusion of the runner speed proxy in the probit regression, the estimated fixed-effect coefficients for each manager should be unbiased indicators of their true tendencies and should separate the truly aggressive managers from the ones who are merely making the most of the speedy assets they've been provided.

Fixed effects for each manager with over 40 games managed in any one season in the sample were included in the probit model estimated in Table 7, but space considerations prevented the listing of all 111 coefficients. To illustrate the variation in managerial styles, however, coefficients for several long-serving managers are shown in Table 10, as are examples of the most aggressive and conservative managers in the sample with respect to base stealing. In general, the managers of teams that ran often still have positive coefficients, and managers known for station-to-station offenses have negative coefficients even after controlling for team speed. To the extent that we have avoided measurement error in the speed variable, this means that managers do indeed get to shape their rosters to fit their tendencies, or they were selected to manage because their tendencies fit the team roster.

The coefficients listed in Table 10 are relative to the baseline of all managers who never managed as many as 40 games with any team in any one season. There are slightly fewer managers who are more aggressive than this baseline than there are managers who are more conservative. That said, of the ten managers with the longest managerial records within the sample, five have positive coefficients, and five have negative coefficients, with three of each being significantly different from zero at the 95% confidence level. The aggressive managers are Joe Torre, Chuck Tanner, and Whitey Herzog. Herzog managed the Kansas City Royals in 1977-89 and St. Louis Cardinal rabbit-ball teams of the 80s. Torre took over those Cardinals after stints with the New York Mets and Atlanta Braves, while Tanner managed the Pittsburgh Pirates from 1977-1985 and the Braves in 1986-88. The conservative managers are Tom Lasorda with the

Los Angeles Dodgers, Sparky Anderson with the Cincinnati Reds and Detroit Tigers, and the well-traveled John McNamara.

In the search for "small-ball" versus "big-ball" managers discussed in the introduction, it is implied that sets of managerial traits tend to coexist. Bunting and stolen base tendencies, according to the conventional wisdom, are both higher for small-ball managers who are attempting to "manufacture" runs, and are both lower for managers who have slugger-laden lineups. Contrary to this hypothesis of positive correlation lies the logic of substitutability of these skills. For a team of a given level of hitting ability, runners can be advanced without a base hit either with a bunt or a steal attempt. The manager's choice between these two tactics should depend upon team speed, other things equal, with managers of fast teams bunting less often and managers of slow teams bunting more often.[5] This logic suggests that tendencies to use the two tactics will be *negatively* related.

Table 11 was constructed in hopes of choosing between these two opposing hypotheses. The evidence, however, supports neither camp. The table suggests that the likelihood of attempting stolen bases and laying down bunts are independent.

Beyond the attempt to classify managerial styles remains the original question of identifying successful and unsuccessful strategic managers. To answer this question, we need to determine whether the manager's decisions helped or hurt his team's chances of winning games relative to some baseline alternative manager. This exercise is deferred to the next iteration of this paper.

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[5] In extensions of this research, we will consider additional options, such as having lead runners take an extra base as a substitute for bunting and stealing.

V. Conclusion

We evaluated the effects of game conditions on strategic choices of baseball managers using play-by-play data for the period 1977-1992. Economic thinking links changes in game conditions to changes in strategic choices. Our empirical analysis indicates that baseball managers choose strategies which conform to an economic model of decision-making: changes in game conditions are strongly associated with changes in the probability of choosing to bunt or steal a base in the direction which economics predicts. Although most baseball managers during this period were reluctant to directly refer to - or perhaps even consider – systematic statistical analysis and modeling of the game, their managerial instincts as honed through experience are largely consistent with our characterization of optimal strategy. Nevertheless, some managers appear to have idiosyncratic tendencies to either under- or over-utilize bunts and steals. The next step in this project is to quantify the cost, if any, of departures from what we define as optimal strategy, and to the impact of these departures on a managers' likelihood of being fired.

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Table 1: Propensity to Bunt, by Year

Panel A: Runner on 1st, batters 1-7, pitchers excluded

	AL			NL			
	Chances	Bunt %	Std Dev	Chances	Bunt %	Std Dev	Difference
1977	2533	0.138	0.345	2032	0.111	0.314	0.027
1978	2575	0.173	0.378	1983	0.127	0.333	0.047
1979	2587	0.150	0.357	2137	0.130	0.336	0.020
1980	2623	0.148	0.355	1887	0.112	0.316	0.035
1981	1670	0.129	0.335	1170	0.144	0.352	-0.016
1982	2477	0.118	0.323	1905	0.120	0.325	-0.002
1983	2522	0.077	0.267	1884	0.087	0.281	-0.009
1984	2543	0.081	0.272	1964	0.077	0.266	0.004
1985	2373	0.088	0.283	2173	0.075	0.263	0.013
1986	2555	0.100	0.300	2026	0.095	0.293	0.005
1987	2425	0.086	0.280	2020	0.071	0.257	0.014
1988	2425	0.082	0.275	1949	0.114	0.318	-0.032
1989	2524	0.100	0.300	2069	0.107	0.309	-0.007
1990	2509	0.089	0.285	2060	0.111	0.314	-0.022
1991	2542	0.089	0.285	2065	0.098	0.298	-0.009
1992	2621	0.082	0.274	2022	0.112	0.316	-0.031
Sum	39504			31346			

Panel B: Runners on 1st & 2nd, batters 1-7, pitchers excluded

	AL			NL			
	Chances	Bunt %	Std Dev	Chances	Bunt %	Std Dev	Difference
1977	564	0.207	0.406	480	0.138	0.345	0.070
1978	606	0.215	0.411	468	0.165	0.371	0.050
1979	631	0.212	0.409	486	0.152	0.360	0.060
1980	590	0.186	0.390	476	0.168	0.374	0.018
1981	355	0.186	0.390	277	0.170	0.376	0.016
1982	588	0.146	0.354	430	0.133	0.339	0.014
1983	649	0.134	0.341	484	0.118	0.323	0.016
1984	598	0.127	0.333	455	0.101	0.302	0.026
1985	569	0.135	0.342	500	0.120	0.325	0.015
1986	636	0.118	0.323	464	0.170	0.376	-0.052
1987	575	0.123	0.329	453	0.117	0.322	0.006
1988	578	0.185	0.389	420	0.169	0.375	0.016
1989	620	0.179	0.384	423	0.173	0.378	0.006
1990	617	0.201	0.401	448	0.145	0.353	0.056
1991	622	0.198	0.399	472	0.146	0.354	0.052
1992	636	0.181	0.385	470	0.162	0.369	0.019
Sum	9434			7206			

Table 2: Time trends in stolen base attempts and success, 1977-1992

	American League			National League		
Year	SB opps	Attempt %	Success %	SB opps	Attempt %	Success %
1977	20679	9.72	64.9	17344	11.29	68.8
1978	20377	9.66	67.0	16471	11.23	72.2
1979	20739	9.26	69.5	17027	11.06	70.7
1980	20824	8.71	70.6	16651	13.82	72.9
1981	13744	8.78	67.9	11114	12.82	72.1
1982	20649	8.44	68.7	16992	13.04	72.2
1983	20465	8.72	72.9	16884	13.47	71.7
1984	20907	8.01	66.7	17340	12.65	70.3
1985	20402	8.56	70.1	17202	11.08	72.8
1986	20737	8.72	68.7	17023	13.01	69.6
1987	20760	9.49	72.5	17249	12.27	73.1
1988	19957	8.61	71.4	16442	11.80	73.9
1989	20448	8.28	72.1	16725	10.00	71.5
1990	20383	8.14	70.5	17060	10.90	74.3
1991	20674	8.29	65.8	17069	11.52	66.0
1992	20787	9.60	65.8	17013	10.76	66.8

Table 3: Propensity to Bunt by League, Runners on Base, and Inning

		Batters 1-7, pitchers excluded						
		All Innings				Late Innings (7+) Only		
	League	Chances	Bunt %	Std Dev		Chances	Bunt %	Std Dev
Runner on 1st	AL	39504	0.108	0.310		9852	0.247	0.431
	NL	31346	0.105	0.306		8808	0.243	0.429
1st & 2nd	AL	9434	0.171	0.376		2078	0.307	0.461
	NL	7206	0.146	0.353		1755	0.293	0.455

Notes: Chances include all at-bats in situations where a sacrifice bunt might represent a strategic option: with 0 outs, a run difference of 2 runs or less, and a man on first or men on first and second base. Bunt % is the proportion of these chances in which a sacrifice bunt was attempted. Data are from Project Retrosheet, 1977-1992.

Table 4: Stolen base attempt and success rates, by outs and lineup position, 1977-1992

Panel A: Attempt rates

Lineup Position	Att% 0 out	Att% 1 out	Att% 2 out	Att% ALL
1	5.62	7.04	9.91	7.74
2	22.09	19.64	21.24	21.20
3	10.50	14.68	13.23	13.25
4	8.39	9.78	10.62	9.88
5	5.81	6.83	7.82	6.91
6	6.93	7.49	8.10	7.54
7	6.44	8.34	8.65	7.98
8A	5.68	7.50	7.68	7.09
8N	7.05	7.78	10.09	8.47
9A	5.50	8.73	7.06	7.21
9N	5.16	7.32	3.47	5.27
ALL	10.02	10.24	10.32	10.21

Panel B: Success rates

Lineup Position	Suc% 0	Suc% 1	Suc% 2	Suc% ALL
1	67.4	63.8	68.7	64.2
2	74.5	72.6	75.2	69.1
3	72.9	71.5	75.4	73.9
4	74.3	75.6	75.6	70.7
5	66.0	65.6	73.2	68.1
6	61.9	63.8	71.2	65.6
7	58.6	62.5	68.0	64.1
8A	53.3	55.3	69.3	61.2
8N	63.3	62.5	67.0	61.8
9A	55.2	55.9	68.7	59.3
9N	65.5	62.9	77.6	53.9
ALL	69.7	67.9	72.7	70.2

Table 5: Stolen base attempt and success rates, by inning and run difference, 1977-1992

Panel A: Attempt rates

Inning	Down 3 or more	Down 2	Down 1	Tied	Up 1	Up 2	Up 3 or more	ALL
1-6	4.50	7.59	11.34	14.02	12.43	12.86	10.82	11.29
7	2.35	4.38	9.78	12.08	13.38	13.88	9.45	8.59
8	2.08	3.78	10.11	12.32	13.73	14.66	7.97	8.06
9, Visitor	1.44	2.28	7.82	12.93	13.38	14.74	7.70	7.17
9, Home	1.19	2.61	7.00	12.73				4.70
10+, Visitor				12.41	14.80	13.75	6.86	12.54
10+, Home	1.44	2.01	7.24	11.95				10.06
ALL	3.18	6.07	10.64	13.66	12.70	13.31	9.81	10.21

Panel B: Success rates (optimal rate in parentheses)

Inning	Down 3 or more	Down 2	Down 1	Tied	Up 1	Up 2	Up 3 or more	ALL
1-6	83.2	77.2	69.4	69.2	65.3	66.0	70.4	69.5
7	90.4	84.3	70.4	64.7	65.2	66.9	70.4	69.9
8	91.1	81.5	74.8	67.3	67.6	68.6	74.4	72.4
9, Visitor	97.6	94.3	77.7	68.0	67.8	68.4	75.8	73.7
9, Home	94.8	95.9	80.3	72.1				79.1
10+, Visitor				71.3	66.4	70.3	78.6	70.8
10+, Home	100 (5)	100 (8)	73.8	72.6				73.3
ALL	85.9	79.1	70.6	69.1	65.6	66.6	71.3	70.2

Table 6: Probit Analysis of Managerial Decision to Bunt

		Model 1			Model 2	
Variable	Coefficient	Std Error	T-ratio	Coefficient	Std Error	T-ratio
AL	0.038	0.003	12.06	0.033	0.003	9.91
OBP	0.149	0.025	6.01	-0.641	0.019	-33.09
SLG	-0.710	0.015	-46.81	---	---	---
OBP_next	0.306	0.025	12.46	0.440	0.025	17.36
SLUG_next	-0.014	0.015	-0.92	-0.147	0.015	-9.74
Pitcher batting	0.235	0.016	14.69	0.260	0.016	20.95
8th batter	0.055	0.009	6.36	0.079	0.010	9.62
8th batter _AL	0.057	0.010	5.74	0.066	0.010	7.35
Runners 1st & 2nd	0.093	0.003	33.33	0.088	0.003	36.50
Late Innings	0.180	0.003	62.42	0.181	0.003	73.64
Extra Innings	0.294	0.009	32.67	0.294	0.009	43.04
Last_home	0.071	0.006	12.10	0.071	0.006	14.12
Down 1	0.132	0.005	25.40	0.135	0.005	30.63
Game Tied	0.128	0.004	34.85	0.133	0.004	37.72
Up 1	0.157	0.006	27.59	0.159	0.006	33.85
Up 2	0.145	0.006	23.06	0.147	0.006	28.78
Year_1978	0.005	0.005	1.14	0.017	0.005	3.45
Year_1979	0.010	0.005	1.89	0.013	0.005	2.57
Year_1980	0.009	0.005	1.65	0.014	0.006	2.62
Year_1981	-0.002	0.005	-0.35	0.012	0.006	2.02
Year_1982	-0.002	0.005	-0.46	0.002	0.005	0.36
Year_1983	-0.029	0.004	-6.86	-0.025	0.004	-5.13
Year_1984	-0.036	0.004	-9.09	-0.032	0.004	-6.70
Year_1985	-0.029	0.004	-6.76	-0.024	0.005	-4.79
Year_1986	-0.015	0.005	-3.21	-0.012	0.005	-2.29
Year_1987	-0.008	0.005	-1.59	-0.012	0.005	-2.24
Year_1988	-0.008	0.005	-1.70	-0.002	0.005	-0.41
Year_1989	-0.006	0.005	-1.24	0.002	0.006	0.41
Year_1990	-0.002	0.005	-0.42	0.005	0.006	0.95
Year_1991	-0.002	0.005	-0.45	0.005	0.006	0.96
Year_1992	-0.006	0.005	-1.17	0.003	0.006	0.49

Baseline: Down 2 runs, man on 1^{st}, no outs, NL, 1977. Manager fixed effects included.
Summary statistics: N= 135,085. Model 1: Pseudo-R^2 = 0.223, LR χ^2 = 24446.7;
Model 2: Pseudo-R^2 = 0.203. LR χ^2 = 22241.8.

Table 7: Probit Analysis of Managerial Decision to Attempt a Steal

Variable	Coefficient	Standard Error	t-statistic
AL	-0.0123***	0.0014	-8.79
Speed of runner	0.0031***	0.0000	77.50
OBP	0.2517***	0.0128	19.66
SLG	-0.1408***	0.0076	-18.53
2nd batter up	0.0779***	0.0023	33.87
3rd batter up	0.0348***	0.0020	17.40
4th batter up	0.0098***	0.0018	5.44
5th batter up	-0.0095***	0.0016	-5.94
6th batter up	-0.0011	0.0017	-0.65
7th batter up	0.0035**	0.0018	1.94
8th batter up – AL	0.0086***	0.0023	3.74
8th batter up – NL	-0.0069***	0.0020	-3.45
9th batter up – AL	0.0100***	0.0023	4.35
9th batter up – NL	-0.0319***	0.0019	-16.79
Down 3 or more	-0.0744***	0.0007	-106.29
Down 2	-0.0455***	0.0010	-45.50
Down 1	-0.0112***	0.0012	-9.33
Up 1	0.0087***	0.0012	7.25
Up 2	0.0155***	0.0015	10.33
Up 3 or more	-0.0127***	0.0011	-11.55
Runners on corners	-0.0358***	0.0008	-44.75
0 out	-0.0207***	0.0008	-25.88
1 out	-0.0048***	0.0008	-6.00
7th inning	-0.0119***	0.0011	-10.82
8th inning	-0.0182***	0.0013	-14.00
9th inning – top half	-0.0248***	0.0016	-15.50
9th inning – bottom half	-0.0523***	0.0023	-22.74
10th inning or later – top	0.0057	0.0076	0.75
10th inning or later – bottom	-0.0571***	0.0066	-8.65
down 1, 8th inning	0.0018	0.0037	0.49
down 1, 9th inning – top	-0.0098*	0.0049	-2.00
down 1, 9th inning – bottom	0.0274***	0.0090	3.04
down 1, 10th inning or later – bottom	0.0529**	0.0288	1.84
tied, 8th inning	0.0172***	0.0038	4.53
tied, 9th inning – top	0.0345***	0.0062	5.56
tied, 9th inning – bottom	0.0977***	0.0114	8.57
tied, 10th inning or later – top	-0.0099	0.0072	-1.38
tied, 10th inning or later – bottom	0.1121***	0.0326	3.44

baseline: 1st-6th inning, 2 out, 1st batter up, NL, game tied.
Fixed-effects for manager and year included.
N=588138. Pseudo-R^2 = 0.11. LR $\chi^2(169)$ = 34941.8.

Table 8A. Effects of Various Plays on the Probability of Winning in Bunt Situations

Ex ante p(win)	Change in p(win) as a resulting from				Inning	Base runner(s)	Team at bat
	Bunt	Out	Double Play	Hit			
0.632	-0.018	-0.044	-0.101	0.070	5	First	Home
0.537	-0.018	-0.045	-0.103	0.076	5	First	Visitor
0.714	-0.010	-0.075	-0.178	0.101	9	First	Home
0.587	-0.017	-0.081	-0.187	0.116	9	First	Visitor
0.702	0.001	-0.066	-0.126	0.113	5	First and Second	Home
0.613	-0.001	-0.070	-0.135	0.122	5	First and Second	Visitor
0.815	0.025	-0.102	-0.173	0.185	9	First and Second	Home
0.703	0.020	-0.114	-0.203	0.200	9	First and Second	Visitor

Notes to Table 8a. All contexts are for a situation where the game is tied.

Table 8B. The Effect of Game Context on Critical OBP

Critical OBP	Late/Early	H/V	Bunt-DP	Inning	Base runners	Team at bat
0.228		1.022	0.083	5	First	H
0.223			0.085	5	First	V
0.369	1.619	1.137	0.168	9	First	H
0.325	1.456		0.170	9	First	V
0.441		1.086	0.127	5	First & Second	H
0.406			0.134	5	First & Second	V
0.585	1.328	1.118	0.198	9	First & Second	H
0.523	1.290		0.223	9	First & Second	V

Notes to Table 8b: The critical OBP is the on base percentage (under fairly stringent assumptions) for which the expected value of bunting equals the expected value of swinging away. Late/Early is the ratio of the critical OBP in the 9th inning to that in the 5th, ceteris paribus. H/V is the ratio of the home team's critical OBP to the visitors'.

Table 9: Breakeven Stolen Base Success Rates

	Score difference							
Inning	3 down	2 down	1 down	Tied	1 up	2 up	3 up	Any
1-6	74.4	69.8	68.0	68.0	66.1	64.8	64.5	67.7
7	80.0	74.5	65.7	62.7	62.9	61.9	64.5	66.8
8	78.2	76.2	65.7	61.2	59.8	60.8	62.4	65.4
9, Visitor	88.3	87.9	63.4	61.3	59.7	60.3	59.0	65.0
9, Home	88.8	82.6	63.0	78.1				65.8
10+, Visitor				60.0	66.8	68.8	55.6	59.9
10+, Home	.	.	64.6	61.1				62.7
ALL	77.4	71.3	65.3	65.9	65.5	64.9	65.2	66.7

Table 10. Managerial variation in propensity to steal, 1977-1992

Manager	Coefficient	Standard Error
Most conservative		
Ralph Houk	-0.0480***	0.0023
Yogi Berra	-0.0449***	0.0046
Billy Gardner	-0.0434***	0.0027
Cal Ripken, Sr.	-0.0372***	0.0054
Johnny Oates	-0.0361***	0.0042
Most Aggressive		
Phil Garner	0.0834***	0.0112
Vern Rapp	0.0344***	0.0072
Joe Torre	0.0321***	0.0044
Bobby Mattick	0.0293***	0.0081
Buck Rodgers	0.0246***	0.0044
Most games, 1977-1992		
Tom Lasorda (2538)	-0.0056*	0.0031
Sparky Anderson (2481)	-0.0121***	0.0029
Tony LaRussa (2083)	-0.0090***	0.0031
Whitey Herzog (2036)	0.0074**	0.0035
Chuck Tanner (1757)	0.0129***	0.0039
Dick Williams (1726)	-0.0058*	0.0033
John McNamara (1704)	-0.0287***	0.0026
Bobby Cox (1657)	0.0055	0.0036
Joe Torre (1574)	0.0321***	0.0044
Roger Craig (1475)	0.0080*	0.0039

Baseline: All managerial stints of less than 40 games.
Included: Managers managing at least 40 games in at least one season, 1977-1992

Table 11. Relationship Between Managerial Bunting and Stolen Base Tendencies

		Bunting Tendency			
		Conservative	Neutral	Aggressive	Total
Stolen Base Tendency	Conservative	15	19	8	42
	Neutral	12	28	5	45
	Aggressive	5	14	5	24
	Total	32	61	18	111

Pearson chi2(4) = 3.7461 Pr = 0.441

Correlation coefficient for beta(sb) vs. beta(bunt), weighted by games managed: 0.0334.
p-value against null hypothesis of zero correlation = 0.7281.

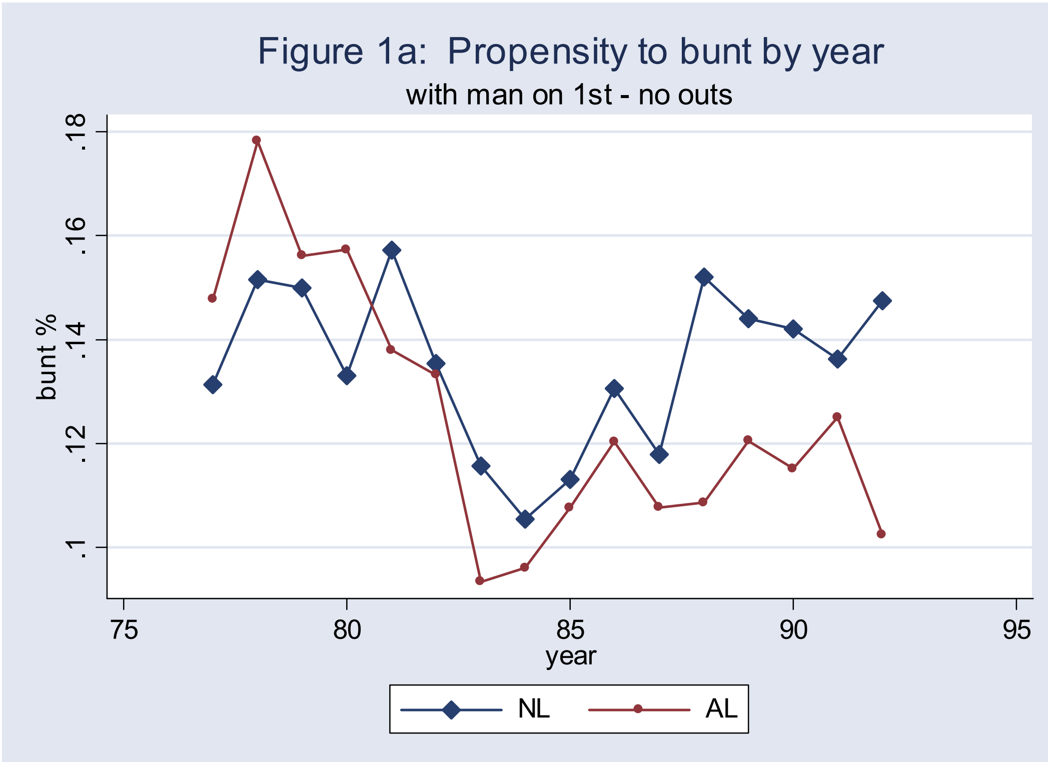
Figure 1a: Propensity to bunt by year
with man on 1st - no outs
bunt %
.1
.12
.14
.16
.18
75
80
85
90
95
year
NL
AL

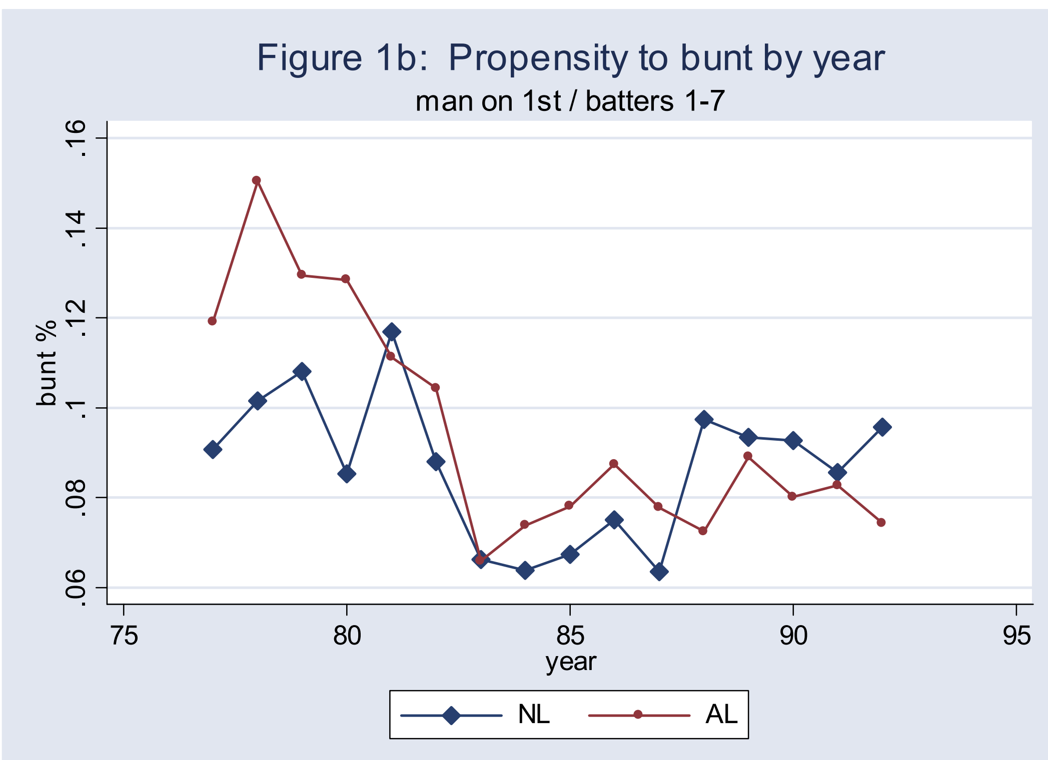
Figure 1b: Propensity to bunt by year
man on 1st / batters 1-7
bunt %
.06
.08
.1
.12
.14
.16
75
80
85
90
95
year
NL
AL

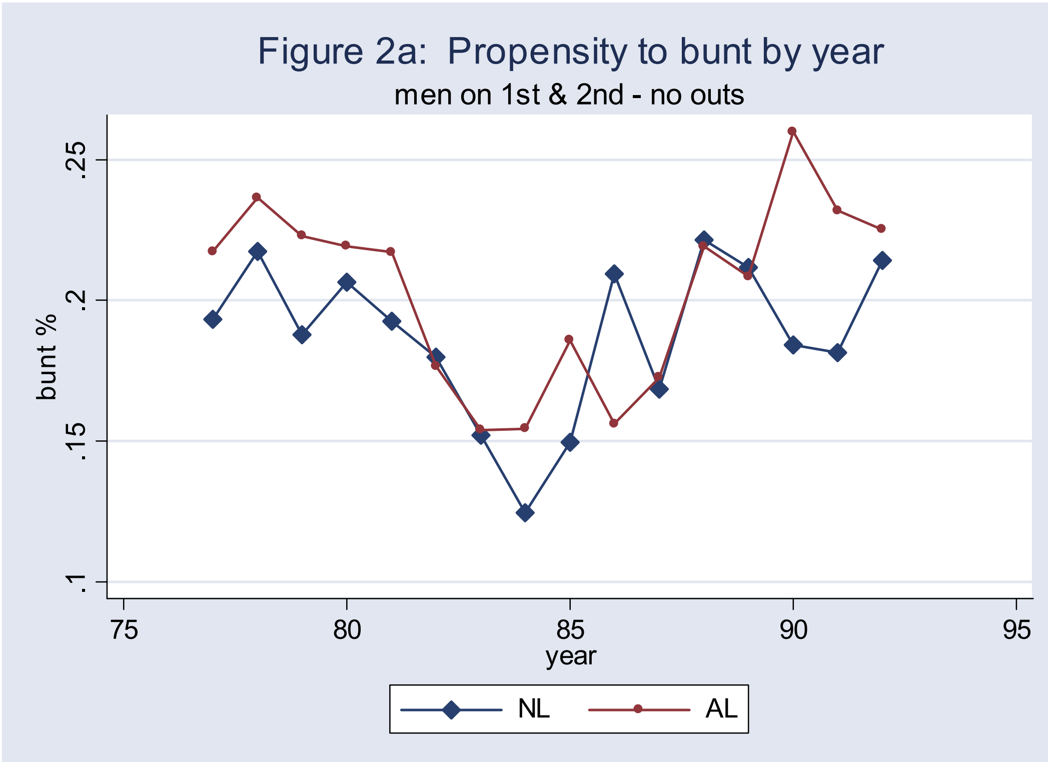
Figure 2a: Propensity to bunt by year
men on 1st & 2nd - no outs
bunt %
.1
.15
.2
.25
75
80
85
90
95
year
NL
AL

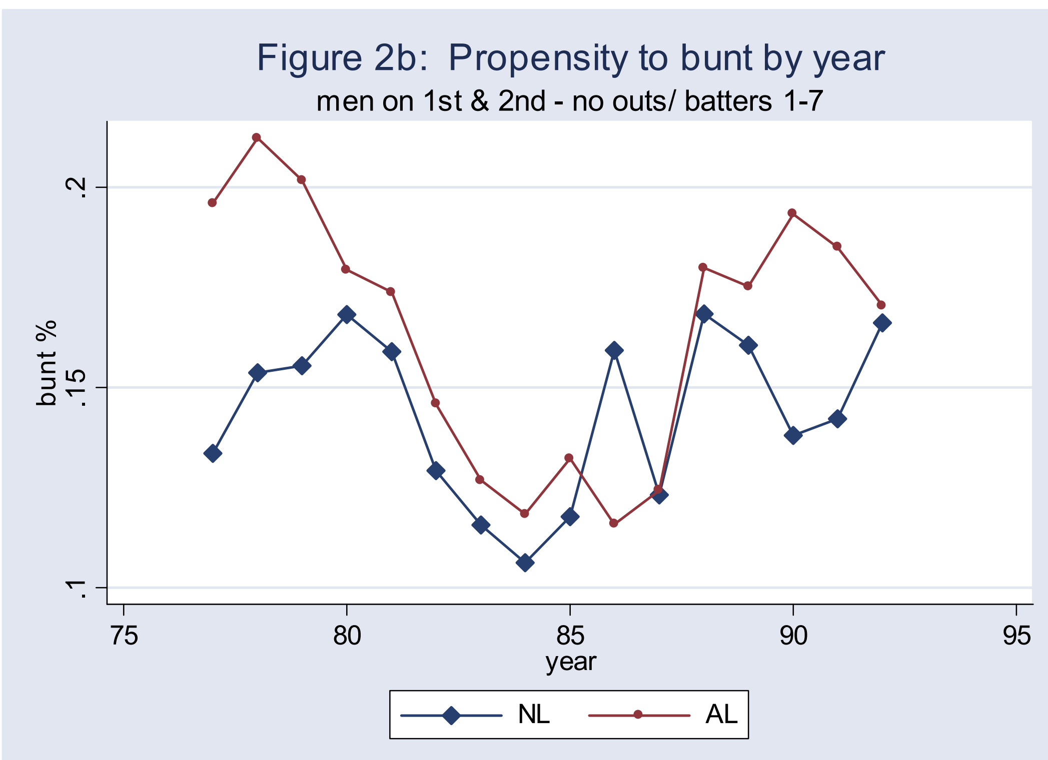
Figure 2b: Propensity to bunt by year
men on 1st & 2nd - no outs/ batters 1-7
bunt %
.1
.15
.2
75
80
85
90
95
year
NL
AL