Understanding The Value of the Next Run

Why Sabermetricians Are Wrong and Traditional Baseball is Right

Abstract

By focusing solely on runs scored and not on winning baseball games sabermetricians miss the impact the context of scoring has on the value of a run. Using a variety of statistical tools, including Markov chains, it is shown that in many situations the value of the next run scored is significantly higher than the subsequent runs. Adjusting strategy to account for this finding results in an overall strategy that is largely congruent with traditional baseball doctrine.

Written by Michael Soper
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Utilizing data from RETROSHEET.org

“A hitter's job is to create runs for his team” *The Bill James Historical Baseball Abstract*

Bill James is wrong. He is wrong on a fundamental concept of baseball. The job of a hitter is the same as the job of a pitcher, a base-runner or a defender: to maximize his team's chances of winning the game. Since every play that scores a run increases the hitter's chance of winning, it may seem that these two strategies are consistent. They are not. It turns out that there are very significant differences in these strategies.

The problem with maximizing runs scored is that the value of a run in determining the outcome of a game varies, a lot. Runs are not fungible. The value of a run is tied to the situation that it occurs in. The easiest way to demonstrate this is to look at an extreme situation: tie score, 2 outs, bases loaded bottom of the 9th. There is no difference between a walk or a home run in this situation. The first run that hits the plate wins the game, any subsequent runs are worth exactly nothing. While this situation is extreme, it is far from an anomaly. I don't think many people would argue that a 3 run double that made the score 8-2 with 1 out in the bottom of 7th inning is as big a hit as a double that drives home a runner from first to break a tie with 2 outs in the top of the 8th. It turns out the 3 run double would increase your chances of winning by 2%, the tie-breaking double increases the hitting team's chances by a whopping 32%. For those scoring at home the tie-breaking run is worth about 50 times each of the 3 runs from the earlier scenario. Runs are not fungible.

Let's have a quick math break. The percentages listed above were derived using a technique called Markov chaining[1] on major league baseball data provided on Retrosheet.org[2]. Retrosheet.org, BTW, is the most awesome baseball site ever and should get serious consideration as one of the niftiest web-sites in the history of mankind. There is a paper by Kyle and Ken Lin[3] that is available on Retrosheet that discusses in great mathematical detail the application of Markov chains to baseball. These references explain the validity of the process, I am more interested in the application of the results so will give just a quick overview here.

I used the retrosheet data for every MLB game from 1970-2009 and parsed into ~6.9 million situational transitions, eg (top 1, tie score, 0 outs) – (top 1, tie score 1 out). Each situation was scored by multiplying the probability of each situation it could transition to times the game equity of that later situation and some over all the possibilities. e.g. The first batter of the game has five possible situations to transition to: he can end up out, on 1st, 2nd or 3rd or he can score. The game equity is calculated by adding up the probability he is retired times the equity of the situation where he is retired, plus the probability of him ending up on 1st times the game equity of the situation where he ends on 1st, etc. By starting at the end we ensure that all the situations that can be transitioned to have already been scored.

The main advantage of this technique is that it is good at handling very rare (6 runs top of 1) and relatively rare (innings with lead-off triples) situations. By analyzing what a particular situation can transition to we aren't limited by the small sample sizes these events can produce. I'll be happy to answer any questions on the process of calculating game equity and share my data, but for now I'll leave it here. What the calculated game equities show is pretty much what you would expect: runs scored in close games impact the outcome more than runs in blowouts and runs scored later in close games have the most impact on the outcome.

Vis Score -			**Start of Inning**			
Home Score	**4**	**5**	**6**	**7**	**8**	**9**
5	91.6	93.6	95.3	97.1	98.5	99.5
4	87.1	89.7	91.8	94.6	96.9	98.8
3	80.6	83.5	86	89.9	93.4	97.2
2	71.6	74.3	77	81.6	86.9	92.9
1	60.1	62.3	64.7	68.7	74.5	84.3
0	47.2	47.2	47.2	46.9	47	46.2
-1	34.3	32.7	30.7	27.1	21.3	13
-2	23.5	21.3	18.7	14.7	10.3	5.2
-3	15.5	13.6	11.1	8.2	5	2.2
-4	9.7	7.8	6.2	4.3	2.5	0.9
-5	6	4.7	3.5	2.2	1.2	0.4

TABLE 1 Visitor's game equity at start of inning

TABLE 1 shows the visiting game equity (Expected Visitor Win %) at the start of each inning given a specific run differential from Visitors up 5 runs to the Home Team up 5 runs. It shows that runs late in close games are worth more than runs earlier in blowouts. In particular, the bigger the run differential the less each run was worth. TABLE 2 shows this even more clearly by computing the value of each run that is added. This is simply the difference of the game equity from TABLE 1 going up the table as each run is added. It is interesting to note that the top half of each column in TABLE 2, starting with the go ahead run, can be modeled as a geometric function. The increase in the Visitors' game equity for each additional run can be modeled by the following geometric functions:

5^{th} inning $15.1*(.75^n)$
6^{th} inning $17.5*(.7^n)$
7^h inning $21.8*(.6^n)$
8^h inning $27.5*(.5^n)$
9^{th} inning $38.1*(.3^n)$ where n is the lead before the run was scored

I'll discuss the significance of these functions shortly.

Sabermetricians ignore these changes in the value of runs, pointing out that so long as you consistently try to score as many runs as possible the percentages will even out and you will score as well when behind or ahead or tied. And they are right to an extent. You score more runs, but you also lose more games. This is because the difference in run values is not random, but rather very predictable.

Vis Score -			**Start of Inning**			
Home Score	**4**	**5**	**6**	**7**	**8**	**9**
4 – 5 run lead	4.5	3.9	3.5	2.5	1.6	0.7
3 – 4 run lead	6.5	6.2	5.8	4.7	3.5	1.6
2 – 3 run lead	9	9.2	9	8.3	6.5	4.3
1 – 2 run lead	11.5	12	12.3	12.9	12.4	8.6
go ahead run	12.9	15.1	17.5	21.8	27.5	38.1
tying run	12.9	14.5	16.5	19.8	25.7	33.2
2 – 1 down	10.8	11.4	12	12.4	11	7.8
3 – 2 down	8	7.7	7.6	6.5	5.3	3
4 – 3 down	5.8	5.8	4.9	3.9	2.5	1.3
5 – 4 down	3.7	3.1	2.7	2.1	1.3	0.5

TABLE 2 Value of additional runs at start of an inning

Baseball is a balance of risk and reward. You can risk an out for the reward of a base. You can do this through stealing bases or aggressive base running. Sabermetricians warn us this is very dangerous because outs are “precious”. If you successfully take a base that runner has a much greater chance of scoring. If that runner is thrown out, however, your chances of a big inning drop drastically. We hear constant laments that teams run themselves out of big innings. Again the sabermetricians are right, by being cautious on the base-paths you will have more big innings. There are many situations where you can increase your chance of scoring 1 run, but lower your expected total runs. This is the “crust of the biscuit”. “Baseball Guys” always seem to be playing for 1 run and not maximizing their total runs. They just don't get it.

Run Exp.	0	1	2
Empty	0.544	0.291	0.112
1st	0.941	0.562	0.245
2nd	1.170	0.721	0.348
3rd	1.433	0.989	0.385
1st_2nd	1.556	0.963	0.471
1st_3rd	1.853	1.211	0.530
2nd_3rd	2.050	1.447	0.626
Loaded	2.390	1.631	0.814

Score at least once	0	1	2
Empty	0.293	0.172	0.075
1st	0.441	0.284	0.135
2nd	0.637	0.418	0.230
3rd	0.853	0.674	0.270
1st_2nd	0.643	0.429	0.237
1st_3rd	0.868	0.652	0.288
2nd_3rd	0.866	0.698	0.280
Loaded	0.877	0.679	0.334

TABLE 3 Run Expectancy and Chance of scoring at least one run. From TangoTiger[4]

We can use the data in TABLE 3 to demonstrate the problem. The data on the left shows how many runs on average a team will score from any given situation in an inning. The data on the right shows the probability of a team scoring at least one run. Some people think that sabermetricians don't think you should steal bases at all; this is incorrect. The true sabermetricians think you can steal a base, but

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4 http://www.tangotiger.net/re24.html data for 1993-2010

only if it increases your expected run total.
For example, if the lead-off hitter in an inning reaches 1st the team is expected to score .941 runs that inning. If he steals 2nd the expected run total increases to 1.17. If he is thrown out, however, the expected runs drops to .291 (1out, bases empty). By stealing 2nd the runner is risking .65 runs to gain .229 runs. You can calculate the threshold of success by dividing the runs risked by the total of the runs risked and the runs possibly gained. In this case .65/(.65+.229) = .739, in other words the correct strategy is to steal 2nd if you will be successful more than 73.9% of the time. In this case you would gain .229 runs * 73.9% and lose .65 runs * 26.1% and would break even.

But if you only need 1 run, say it's tied in the bottom of the 9th, you just want to focus on the first run. We can use the right side of TABLE 3 to calculate threshold of a runner stealing 2nd in the bottom of the 9th after a lead-off walk. From 1st his team will score 44.1% of the time. From 2nd his team will score 63.7% of the time. If he is thrown out his team's scoring chance drops to 17.2%. So by attempting to steal he is risking .269 to gain .196. We compute the threshold the same way: .269/(.269+.196) = 57.7%. “Holy Tony La Russa, Batman!” We knew that maximizing runs didn't make sense in the bottom of the 9th, but still that is a big drop.

Now let's go back to our old friend the top of the 8th and examine the situation where it's tied, with no outs and a man on 1st. We know that we can increase our chances of scoring the go-ahead run if we can successfully steal 2nd more than 57.7% of time, and we really want that run! On the other hand , additional runs are certainly not worthless and being too aggressive can cost us those extra runs. In order to make a good decision we need a method that accounts for the relative importance of each run. Fortunately the geometric functions described above do just that. In the 8th inning each additional run after the go ahead run is worth ½ of the preceding run. The relative values of these runs is then 1 for the go-ahead run, .5 for the 2nd run, .25 for the 3rd, etc. Using TABLE 3 we can separate the go-ahead run from the subsequent runs, by subtracting the chance of scoring at least one run from the expected total runs. In our case the .941 expected runs can be broken into the 1st run .441 and additional runs of .5. The additional runs are a blend of runs 2, 3 and beyond, so it is necessary to discount them more than the 50% of the 2nd run. Considering that a large majority of the additional runs will be the 2nd run estimating the value of the additional runs at 40% of the go-ahead run is reasonable. Now we can calculate our threshold for stealing 2nd.

The .229 runs we gain include scoring the first run .196 and .033 additional runs. By discounting the additional runs we get an adjusted gain of .196 + .4*.033 = .209 more runs by stealing 2nd. We risk losing .65 runs (.269 first run + .361 additional). Our adjusted risk is .269+.4*.361 = .413. Our threshold is then .413/(.413+.209) = 66.4%. You maximize your runs by stealing 2nd in this situation if your success rate is over 74%, but you increase your chance of winning if your success rate is over 67%. In other words, following the sabermetric run-centric strategy and failing to attempt steals in these situations will decrease your chances of winning games.

These situations are not rare. Because the additional run discounts can be modeled with geometric functions, the same calculations can be used whether the score is tied or the batting team is up by 1 or more runs. For example, in our 8th inning scenario if the visitors had a 2 run lead, scoring the one more run would be worth ¼ of the go-ahead run, but it would be worth twice the value of the run that put them up 4 and 4 times the value of the run pushing the lead to 5. Therefore the same 64.4% threshold would apply.

Other situations will have different discounts, but the key feature is that if the batting team is tied or ahead after the 4th inning the value of the next run is significantly more than subsequent runs. These subsequent runs need to be discounted appropriately if you want to maximize your chance of winning the game. The later in the game it is the higher the value of the next run and the steeper the discount on those additional runs. This, in turn, requires a change in strategy stressing the importance of the next run.

A strategy focused on winning the game varies from the sabermetric strategy of maximizing runs scored in several ways. If you are tied or ahead you should increase use of the following tactics:

- the stolen base
- going 1^{st} -3^{rd} on singles
- scoring from 2^{nd} on singles and from 1^{st} on doubles
- bunting for base hits
- sacrificing runners along
- the contact play with runner on 3^{rd} and less than 2 outs

We could call this new strategy, “Winning Strategy.” I think we'd be better served by referring to this strategy the way the people who employ it refer to it, and simply call it “BASEBALL.” One hundred years of baseball corporate knowledge isn't wrong after all. That's right, it turns out that traditional baseball doesn't undervalue outs; sabermetrics undervalues the next run.

I am a fan of Bill James and he has been a driving force in bringing the use of statistical analysis into baseball. But he got this one wrong. Once you accept that winning is the objective and not scoring runs (which I don't think anyone can really argue) it becomes clear that modeling wins on runs is a bad idea. From a mathematical point of view you are using a secondary measure (runs) that's correlation to primary measure (wins) varies widely and in a non-random manner. The predictable result of this is the strategy created using this model is flawed.

This is a real opportunity for sabermetrician's to focus on game equity. We have the tools necessary to evaluate plays on how they impact the outcome of a game. Modeling the values of different situations that arise in a baseball game is a difficult task that will require a lot of refinement, but the applications game equity models offer tremendous insights into the game. I plan to write more on potential applications of game equity shortly. I welcome any comments positive or negative and any questions about this paper or game equity in general. You can contact me at the address below.

I have written a small Java app that evaluates every position that has occurred in MLB in the last 40 years and performs the same type of calculations described in this paper. You can enter any starting situation and it will tell you the home team's game equity. You can then select a secondary event such as a single or SB and the app calculates the game equity for possible successful and unsuccessful outcomes and then calculates the appropriate threshold in which stealing or taking an additional base make sense. If nothing else it provides an interesting new way to view a baseball game. If you would like a copy of the app just request it at the address below. BTW it is only about 300 KB in size.

Michael Soper
TonyLaRussa.NotAnIdiot@hotmail.com