CSc 496, Homework #3: Analyzing sacrifice bunting.

Due date: Tuesday, September 24th, 2024. **No late assignments will be accepted.**

This assignment requires programming as well as a little bit of math. As discussed in class, run expectancy tables provide an expected number of runs scored from a given state. Typically, this is given as an 8x3 matrix, where the rows are the 8 possible baserunner situations and the columns are the number of outs. This site, however, additionally provides the ball-strike count: `https://docs.google.com/spreadsheets/d/1DRUAT4AMLxIWlNq_XIvurA4vIiXmBXHw-2u4NjZZ9dA/edit?gid=1108175138#gid=1108175138` (leftmost tab).

Using this table, carry out a mathematical analysis of *sacrifice* bunting when the team at bat has a runner on 1st, 0 outs, with an 0-0 count. Here are the various possible outcomes of sacrifice bunting.

- With probability X, the bunt attempt results in a strike (a missed bunt or a foul bunt).
- With probability 1-X, the bunt attempt results in a bunt in fair territory. Here, the possible outcomes are (note that $Y + Z + W = 1$):
  - With probability Y, the runner is out at second and the batter (bunter) is safe at first—i.e., an unsuccessful sacrifice attempt.
  - With probability Z, the runner advances to second, and the batter (bunter) is out at first—i.e., a successful sacrifice.
  - With probability W, the runner advances to second, and the batter (bunter) is safe at first—i.e., a bunt for a base hit.

Note that for simplicity, you should assume the following:

- A bunt is a sacrifice attempt whenever there are less than two outs and any runner(s) are on base.
- A batter never squares to bunt and takes a ball. Note that the Baseball Reference play-by-play makes it impossible to determine if this occurs.
- If the batter ever fouls or misses a bunt, you should interpret it as the batter fouling/missing the *first* pitch of the at bat.
- If a bunt is executed in fair territory, there is never an error that results in runners advancing more than one base, and there is never a double play turned.
- The run expectation table itself necessarily includes bunts; do not make any attempt to unskew this.

This will require careful analysis on your part. You need to find X, Y, Z, and W. To do this, you will extend your previous assignment in which you collected play-by-play data. (With Baseball Reference play-by-play, there is a code for basically everything a batter can do, for every pitch; use this to find the values of the variables.) Make sure you are using 2023 data; your results will not properly apply to MLB today if you use a season in which pitchers "hit", because pitchers also are terrible bunters.

Once you have completed this, redo the analysis in two ways:

- Assume that X is zero and that W is determined by the success rate of bunts intended to be base hits. This serves as an optimistic upper bound on bunting as a strategy. For this recalculation of W, consider only bunts when no one is on base. Scale Y and Z (downward) equally to keep the sum of the three variables at one.
- Then, re-do it again, returning X to what it was in the first part, but changing W (and therefore Y and Z) as in the previous part.

Finally, do an analysis, starting from a runner on 2nd and 0 outs, of how bunting affects the *probability of scoring at least one run*—**not** the expected number of runs scored. Here, in your data, consider only the following situations to compute Y, Z, and W:

- there is a runner on 2nd, or there are runners on 1st and 2nd;
- there are no outs; and,
- it is the 8th inning or later.

For the probability table, use this: `https://www.reddit.com/r/baseball/comments/pmcms8/oc_i_made_a_printable_run_expectancy_pocket_guide/?rdt=47766`. Note that each integer is the percentage chance of scoring at least one run. Because this table does not include the count on the batter, you should assume that X is zero.

You should submit your assignment on lectura using the `turnin` command; for this program, use the assignment name `csc496-f24-hw3`. Submit your code along with instructions for how it should be run. Separately, submit your written analysis in a PDF file to Gradescope.